Standard Operating Procedures

Version 1

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Community Flow Monitoring Network

Vancouver Island

Pilot program

BRITISH COLUMBIA CONSERVATION FOUNDATION

BRITISH COLUMBIA
Supported by the Province of British Columbia

Table of Contents

Preface

This manual of Standard Operating Procedures (SOP) is intended for members of the Community Flow monitoring Network ("Flow-Mo") – Vancouver Island Pilot Program.

The Flow-Mo Network supports community groups with long-term surface flow monitoring as part of a coordinated, regional effort. The pilot and volunteer support will focus on monitoring during the low-flow season (May through October), but the goal of the project is to support long-term, year-round Flow monitoring and have the data uploaded to the publicly accessible provincial database

Community groups wishing to join the Network to receive training, equipment sharing and data support for Flow monitoring will be required to follow the standard procedures outlined in this SOP manual.

- Please review this manual in full to understand what is required to collect accurate, defensible flow data for a community monitoring station.

- Many of the contents of this manual are derived from the 2018 Resource Information Standards Committee (RISC) *Manual of British Columbia Hydrometric Standards*: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/man_bc_hydrometric_stand_v2.pdf. The RISC manual is the definitive guide to hydrometric monitoring in BC.

- The contents of this manual are kept as simple as possible, but flow monitoring is a complex science. Throughout the document, words in ***bold italics*** can be found in the Glossary of Terms (page iii). Further details about topics in this manual can be found in the RISC manual or online.

- There are blank check boxes throughout this manual to help with tracking accomplishments and progress for your community station.

After reviewing this document in full, please contact the Flow-Mo Network coordinator who will be able to assist you with station initiation. We strongly suggest that you have clear objectives, a defined monitoring plan, local community support, adequate funding, permits and access agreements, and a commitment to the desired timeframe of monitoring in place prior to establishing your Flow monitoring station within the Network.

Funding to produce this SOP was provided by the BC Community Gaming Grant, the British Columbia Conservation Foundation, Pacific Salmon Foundation, Habitat Conservation Trust Foundation, Freshwater Fisheries Society of BC, and Province of British Columbia.

Check out our project website for more tips and resources! https://www.cfmnvi.com

Glossary of Terms

area	refers to the area of a stream cross-section (length x width), in units of m^2 (square meters); measured to two decimal places
barometric	referring to air pressure in units of kPa (kilopascals)
benchmark	a survey point used for referencing station elevation to an established or assumed datum
compensation	the process of correcting a time-series dataset for barometric pressure
continuous	meaning a long-term data record, with readings spaced at regular time intervals; also frequently called “time-series” data
control	the sum of features, usually downstream of the gauge, that describe the relationship between stage and discharge
datum	a known or assumed vertical plane of elevation (y-axis) used to establish the elevations of gauging station features such as benchmarks, points of zero flow, and stage
discharge	another word for streamflow, also written shorthand as “Q”, in units of m^3/s (cubic metres per second)
discrete	meaning a single measurement taken at a defined point-in-time
gauging station	a station on a stream where hydrometric data is collected
gauge pool	the specific section of a stream where a gauging station is situated
logger	an instrument left in place to record time-series data at a specified time interval (e.g., barologger (measures barometric pressure and air temperature), levelogger (measures pressure and water temperature))
low-flow	referring to the flow in a stream during prolonged dry weather; the period of time during which baseflow is the dominant portion of streamflow. Often considered the limiting factor for fish habitat suitability.
point of zero flow	the elevation, relative to the datum, at which the gauge pool which is monitored by the stage sensor transitions to zero flow; often located near the thalweg of the gauge pool
rating curve	a mathematical equation to describe the stage-discharge relationship at a site
reach	a specific stretch of stream, often referring to the region where a discharge transect is completed
staff gauge	a reference gauge for confirming surface water elevation, usually in units of m
stage	describes the height of water above a specific point (e.g., the streambed or the zero datum) in the vertical plane (y-axis)
thalweg	the part of the stream cross-section that is deepest and carries the most velocity, often located near a riffle point
transect	a cross-section of the stream where a discharge section is performed
velocity	the speed of water movement downstream, in units of m/s (metres per second)
zero datum	an assigned station elevation (0 m) in the vertical plane (y-axis) to which all other elevations at the site are referenced. Often set 10 metres below the primary benchmark

Introduction

Imagine a small stream on Vancouver Island, surrounded by trees in the forest and filled with salmon fry. When it rains, the stream swells and rises; when it dries, the stream shrinks and shallows. The depth and width of the stream, as well as the speed of its water, are constantly changing.

Streamflow, also known as ***discharge***, describes the amount of water moving through a stream. If you imagine a stable, fixed point on a streambank looking across to the other side (Figure 1), the amount of water flowing past this point over time is the total ***discharge***. We calculate stream ***discharge*** by combining the speed of moving water – also known as ***velocity***, V –with the total amount of water in two-dimensional space – or ***area***, A.

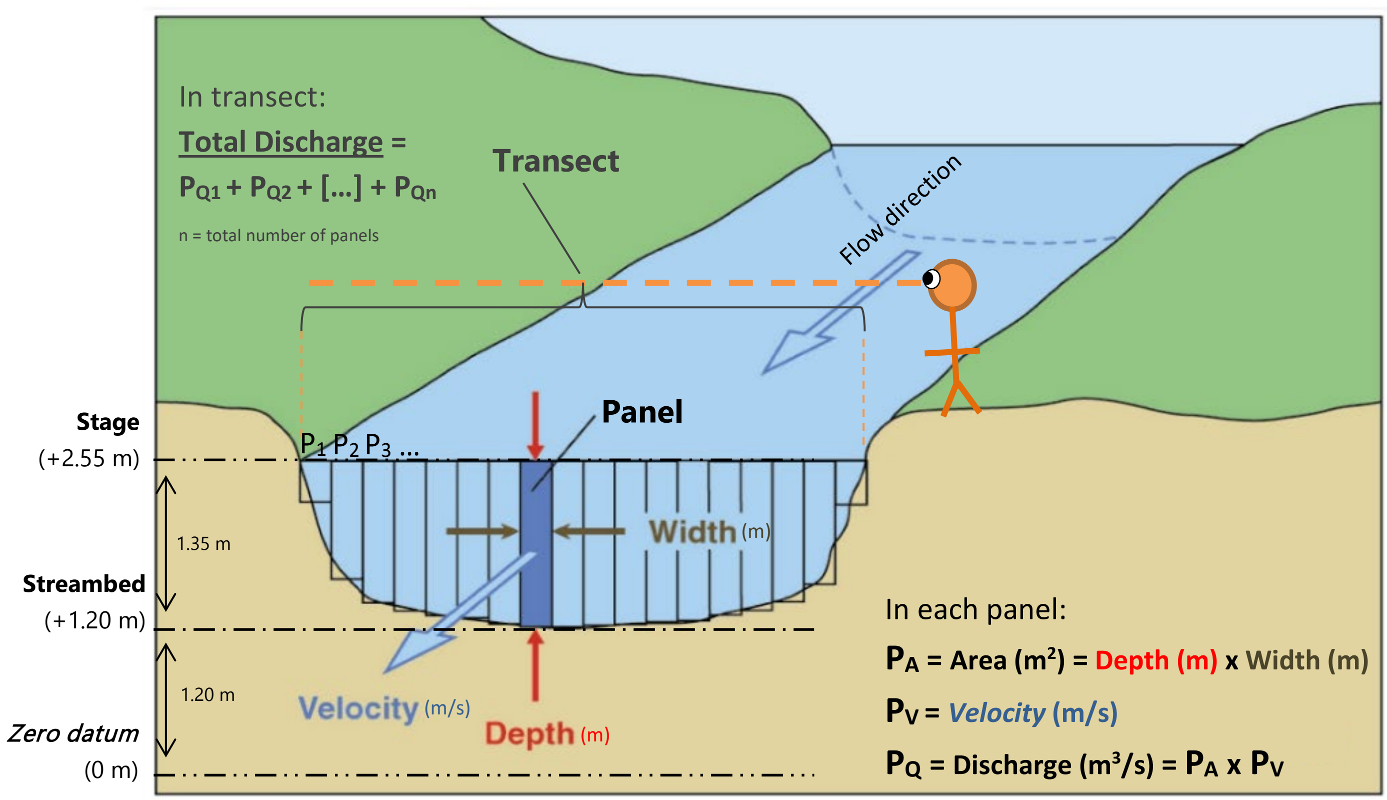


*Figure 1. Diagram of example **discharge** calculation for a stream cross-section (adapted from US Geological Survey, 2011).*

The calculation of total ***discharge*** depends on several different parameters (the depth, width, and speed of the water). Because of this, it is challenging to monitor all of the changing conditions in a natural stream at the same time with one single sensor. It is unfortunately not as easy as placing a logger into the stream, "setting it and forgetting it", and returning a few months later to understand the patterns of streamflow. Much more work is required!

The general approach to streamflow monitoring is to assess just one of these changing parameters over time: water depth. Water depth is a top-to-bottom measure, but water height (a bottom-to-top measure) is easier to work with in stream calculations. We refer to this as ***stage***, another term for the height of the water surface above a known point of reference (also called a ***zero datum***) (Figure 2).

Measuring stream ***stage*** can be done autonomously using a battery-operated logger that records a value at every specified time interval. This generates a ***continuous*** record of stream ***stage*** (or height of water) over time.

Individual (also called ***discrete***) measurements of total ***discharge*** can then be strategically collected across a range of stream conditions using specialized equipment and safety gear that are not possible to operate continuously.

These two distinct observations, along with a description of the conditions that physically determine the height of water in the vicinity of the logger, can all be combined to produce a mathematical relationship for the stream: a ***stage-discharge*** relationship, also known as a ***rating curve*** (Figure 2).

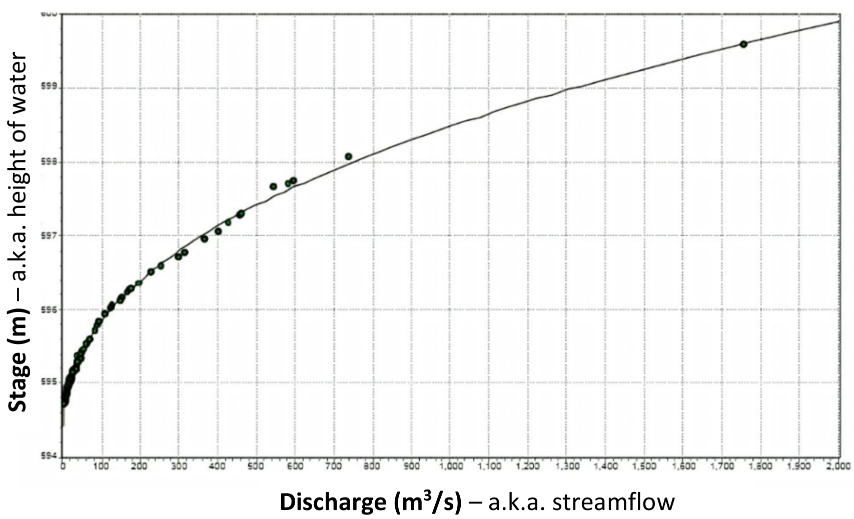


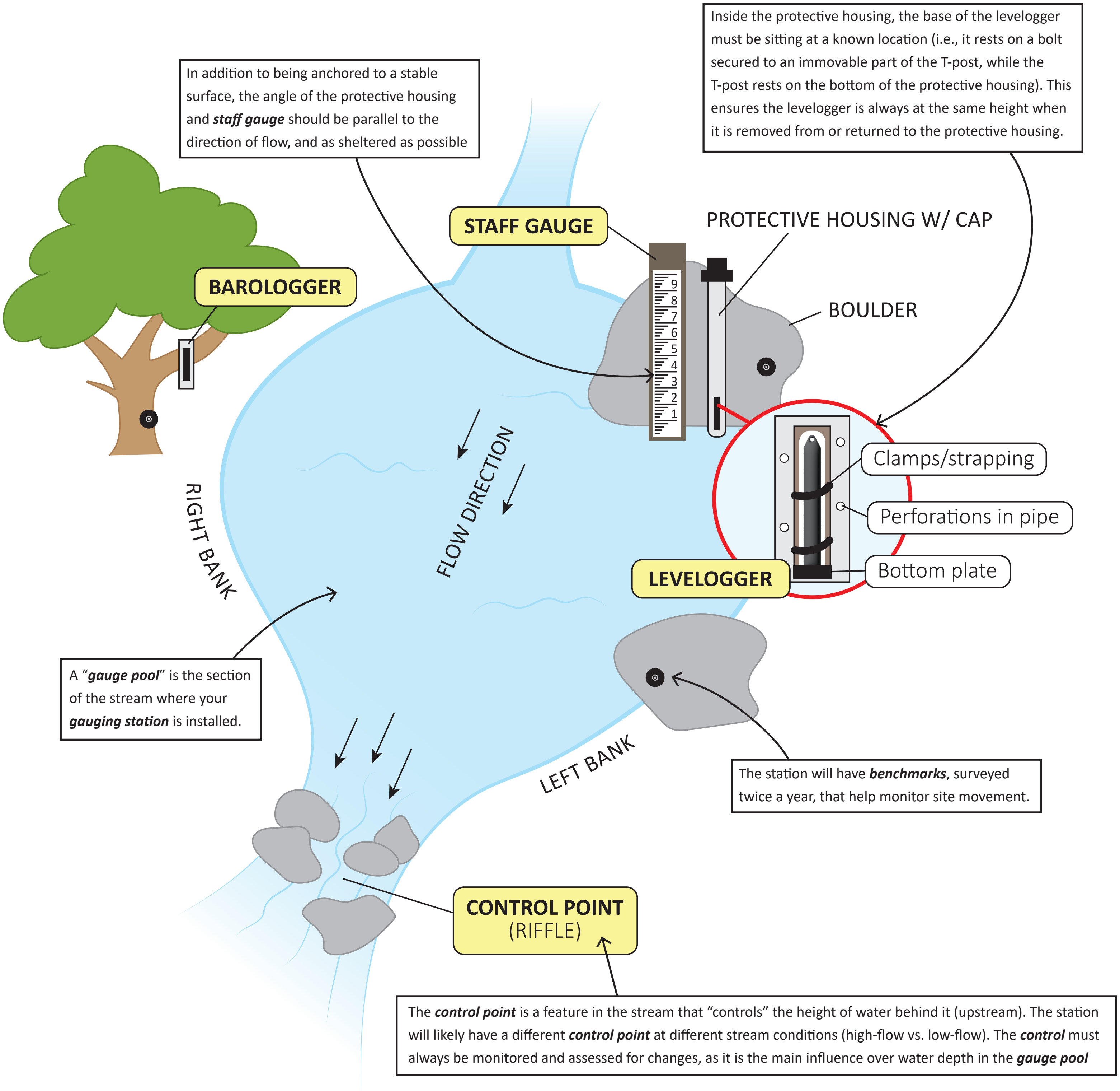
*Figure 2. Example of a stage-discharge relationship for a stream (a.k.a. the **rating curve**) (adapted from Braca 2008).*

Flow-Mo Network community stations will use this same approach for long-term surface Flow monitoring:

- ***Continuous*** loggers installed at each station will collect readings of ***stage*** (water height) every 15 minutes.
- Meanwhile, each group's field technicians will keep watch over their site through the year, and mobilize to collect ***discharge*** measurements at specific water heights.
- During the winter season, the Network staff can help your group develop a ***rating curve*** for your station and assist with quality checking and sharing your data.

All of this will allow your group to estimate ***continuous discharge*** for the low-flow season, despite having only collected a few field measurements in-person.

A location in a stream where ***continuous*** stage and ***discrete discharge*** data are collected together is called a ***gauging station***. A ***gauging station*** is used to conduct long-term and ***continuous*** streamflow monitoring. A typical community ***gauging station*** is pictured in Figure 3.


Inside the protective housing, the base of the levelogger must be sitting at a known location (i.e., it rests on a bolt secured to an immovable part of the T-post, while the T-post rests on the bottom of the protective housing). This ensures the levelogger is always at the same height when it is removed from or returned to the protective housing.
In addition to being anchored to a stable surface, the angle of the protective housing and ***staff gauge*** should be parallel to the direction of flow, and as sheltered as possible
STAFF GAUGE
PROTECTIVE HOUSING W/ CAP
BAROLOGGER
BOULDER
9
8
7
6
5
4
3
2
1
Clamps/strapping
Perforations in pipe
Bottom plate
LEVELOGGER
FLOW DIRECTION
RIGHT BANK
LEFT BANK
A "***gauge pool***" is the section of the stream where your ***gauging station*** is installed.
The station will have ***benchmarks***, surveyed twice a year, that help monitor site movement.
CONTROL POINT
(RIFFLE)
The ***control point*** is a feature in the stream that "controls" the height of water behind it (upstream). The station will likely have a different ***control point*** at different stream conditions (high-flow vs. low-flow). The ***control*** must always be monitored and assessed for changes, as it is the main influence over water depth in the ***gauge pool***

Part 1 – Establishing a Station

Photo Credit: Shutterstock.

Groups with a pre-existing stations can *skip* most of the steps within this section; however, you might benefit from reading it anyway!

1.1 - Identify monitoring goals

All stations participating in the Flow-Mo Network must have a clear monitoring objective. Some of the most important questions to answer before beginning data collection are:

- ☐ What will this data be used for?
  (e.g., setting standards, observing trends)

- ☐ Who will be all of the desired end user(s) of this data?
  (e.g., local stewardship group, local government, private homeowners, policy-makers)

Begin by identifying your group's goals for data collection and monitoring. Why do you want to collect flow data, and what purpose will it serve? Your goal may be different from other groups in the network.

Information that can be used to guide goal-setting includes:

- Project theme (e.g., evaluation of fish habitat, water balance, pollution, land use impact, climate change, restoration project, etc.)
- Target species of interest (e.g., water depth & ***velocity*** requirements, riparian planting prescription, etc.)
- Organization or partnership mandate

Refer to Appendix 1 for a goal-setting worksheet.

1.2 - Station equipment needs

Before your group begins purchasing or sourcing station equipment, it is important to identify the specific equipment needed. This will help you with project budgeting and grant applications.

A typical budget for a new community station installation ranges from $1,500 – 3,000, but the specific equipment and data sources used will depend on the monitoring goals, desired data quality, and the end users of the data. The Network has a lending library of equipment that can help support community station installations and upgrades.

The equipment listed in Table 1 is the Network standard (cost provided as an estimate). This may be purchased by groups directly, or a loan request may be completed. Using the same make and model of equipment across all stations greatly improves the speed and accuracy of data quality control. In certain circumstances, alternate brands or versions of equipment than those listed here may be used.

Some stations may already be established with equipment but wishing to incorporate into the Network. Changes to any of the standard equipment must be approved and documented. Substitutions may not necessarily meet the same data grade as the standard equipment listed in this SOP. Review Tables 1 & 2 in Appendix 1 for examples and price ranges of alternate instruments and equipment that may be used.

*Table 1. Community **gauging station** equipment requirements.*

Quantity	Equipment	Typical cost (CAD) in 2022
1	Solinst Levelogger 5 Junior, with accuracy of +/- 5 mm	575-675
1	Solinst Barologger 5, with accuracy of +/- 0.05 kPa or 5 mm	450-550
1	Communication device for ***logger***, e.g. USB optical reader or Bluetooth adaptor	150-550
1	Solinst Levelogger software, Version 4.6.2 or higher	0
1	Download and data sharing device (e.g., smartphone or laptop) compatible with above devices & software	500-1,000
1	Reference gauge*	25-75
1	***Logger*** housing with 2" diameter (e.g., steel, aluminum, PVC pipe) and installation materials	20-50
3	***Benchmark*** anchors with identifying markers	10-15

** <u>Note:</u> At least one reference gauge per site is required. This is typically a 1m metric **staff gauge**. However, a submerged, or overhanging reference point such as a bolt (i.e., a surveyed low-profile station **benchmark**) can also be used.*

Safety equipment (e.g. PFDs, waders, first aid kit) is also an important consideration and should be factored into the budget of your station installation. The cost and type of safety equipment needed for each station will vary depending on the site location and conditions. See Section 1.6 for more information and a list of recommended field safety equipment.

1.3 - Station location

Choosing a location is recommended to be undertaken with support from the Network coordinator, a provincial hydrologist, or qualified professional. The basics of site selection are provided here to help your group with preliminary site identification before organizing a site visit.

The location of your ***gauging station*** will be determined by the specific goals and objectives of your monitoring program, and has a significant influence on data quality. The perfect station site rarely exists, but you can select a location that optimizes the channel features present in order to reduce the noise (irregular fluctuations) relative to the signal (i.e. ***stage***, **discharge**) that you are interested in measuring.

Shortlisting 3-4 candidate sites allows you to consider potential challenges at each site. Key points to consider when shortlisting candidate sites for a ***gauging station*** include:

- ☐ Land access: Public vs. private?
- ☐ Stability of ***control*** feature (see below)
- ☐ Seasonal variation in depth of ***gauge pool***
- ☐ Stability of banks and surrounding area for mounting equipment

- ☐ Stability of surrounding area for placing survey ***benchmark***s
- ☐ Annual patterns of sediment transport
- ☐ Seasonal safety concerns

The main aspect of a good site is a stable ***control*** feature (Figure 3). This is typically something like a bedrock outcrop, a large rip-rap riffle or cascade, or an engineered weir or flume. The ***control*** is always located downstream of a levelogger and reference gauge. Stable ***control*** features are not as prone to movement during high flow events, but must still be monitored.

An unstable ***control*** (such as a natural riffle) should be identified and surveyed at least bi-annually to help reduce error associated with high flow events or human interference. Because the ***control*** directly impacts the ***stage-discharge*** relationship, any changes to the ***control*** need to be quantified and accounted for, and this should be considered during site selection (see Section 4.6 for more details about monitoring the station ***control***).

An ideal gauging site also has safe access year-round, relatively little sediment build-up, a pool or eddy with a protected and stable location for installing the ***logger*** standpipe, and a suitable ***discharge transect*** or measurement location nearby (see Section 4.7 for more details about selecting a good location for measurement).

Visually monitoring candidate sites from the high-flow period (winter or early spring) through to the ***low-flow*** period (late summer) prior to installing equipment is strongly recommended, since this will allow you to assess how conditions vary at the sites. This also allows you to monitor for changes to the ***control*** condition during that time.

It is also beneficial to determine if there are existing flow monitoring stations on your stream(s) of interest. The Water Survey of Canada search tool (https://wateroffice.ec.gc.ca/search/real_time_e.html) and the Province of BC's hydrometric database, Aquarius (https://aqrt.nrs.gov.bc.ca/) are good resources that can be used to search for hydrometric stations in your area.

1.4 - Timeframe

Six months to one year of pre-installation monitoring is recommended to help identify site conditions that may need to be mitigated for during installation (for example, sediment accumulation or large impact forces on the station equipment due to woody debris transport). Existing stations wishing to incorporate into the Network should already have a record of site conditions and challenges, thus pre-incorporation monitoring may not apply.

New station installs or existing station upgrades should occur during the ***low-flow*** period (July – August), while streams are safe to wade and the in-stream work window is open for fish protection (see Section 2.2 for more information about work windows and timing). Small coastal stream hydrographs for East Coast Vancouver Island typically have the lowest flows from July-September, moderate flows in October and March-June, and peak flows during storm cycles in November-February, although it depends on the degree of snowpack contribution to the watershed.

During the first year of operation, collecting between 6–10 ***discharge*** measurements at varying ***stage*** heights is required to establish the ***rating curve***. These measurements will typically be collected throughout the year, though the period of interest will depend on monitoring goals. A minimum of 6 visits per year is required.

At least 2 site visits to monitor survey ***benchmarks*** are required each year (e.g., late summer just before rains begin, and late spring as soon as the stream is safe to wade). These surveys can be combined with a normal ***stage-discharge*** site visit.

To accommodate all necessary work required for a station installation (or incorporation), ***stage-discharge*** monitoring, maintenance, and surveying, please plan to visit a newly installed (or newly incorporated) station at least 10 times within a full calendar year. The Network coordinator and Provincial staff can assist with coordinating a monitoring plan for your station as well as provide support for ***benchmark*** surveys and higher flow measurements.

1.5 - Group requirements

A community group taking part in the Flow-Mo Network must be able to commit the following:

<u>Administrative:</u>

1. A minimum of 2 years' participation in the Network.
2. At least 1 group member to attend a minimum of 2 Network meetings per calendar year.
3. Develop, revisit, and share your group's Flow monitoring objective or mission statement with the Network.
4. Designate 1 main contact person for the Network.

<u>Logistical:</u>

1. Station equipment and monitoring protocols followed in accordance with this SOP.
2. A minimum of 3 organization members assigned to a streamflow sub-committee (more is encouraged).
3. All streamflow sub-committee members must complete and pass a measurement audit performed by the Network coordinator or provincial staff each calendar year.

<u>Monitoring:</u>

1. Conduct a minimum of 6 station measurement visits per year, 2 of which must include ***benchmark*** surveys.

1.6 Field Safety

In addition to sourcing station equipment and necessary permits, groups must be able to provide their own insurance coverage for group members, and their own field safety equipment:

- ☐ Minimum 2x PFDs and/or high-visibility vests (depending site conditions).
- ☐ Minimum 2x pairs chest waders, hip waders, or rubber boots (depending site conditions).
- ☐ 1x cell phone, VHF radio, GPS locator beacon and/or satellite phone (depending site conditions).
- ☐ 1x First Aid kit with emergency blankets.
- ☐ Trip plan template & field check-in procedure (see Appendix 1).
- ☐ Personal PPE (gloves, hat, sunglasses, warm clothing).

All field work, including station installations, ***benchmark*** surveys, and flow measurements should only be conducted when the site is safely accessible. The ***discharge*** and weather patterns for the year will dictate when it is safe for stream wading. Smaller streams can usually be measured year-round, but larger streams require special consideration for monitoring at higher ***stage***s, thus the focus is on ***low-flow*** conditions. Always have a minimum of 2 people when taking a measurement. It can be hard to communicate when in a stream; make sure everyone understands how best to communicate and what you will be doing before entering the water.

Individuals working in the field should have proper PPE including waders with a wading belt, proper wading boots, a high-visibility vest, and a PFD. It is recommended that eye protection and gloves be worn during station installations when working with power tools. It is also important to be mindful of weather conditions: wear appropriate clothing, bring water and snacks if necessary, and be cautious of hazardous trees in high-wind conditions.

Ensure your team has a safety tailboard or field safety plan (see Appendix 1.6), on-site first aid kit, and a designated check-in person. Some sites may not have cell phone service, so be prepared with a radio or GPS emergency locator beacon if necessary, and know who to call ahead of time in case of emergency. Training for working with power tools and working in or near swiftwater is also recommended.

Part 2 - Installing a Station

Photo Credit: T. Rodgers

2.1 - Preliminary considerations

It is recommended that station installation be completed only after a suitable site has been assessed with support from the Network coordinator, provincial hydrologist, or qualified professional.

Ensure you have researched the site thoroughly, and accounted for any species-at-risk present in the stream or other special permitting requirements specific to your installation site. The Fisheries and Oceans Canada webpage (https://www.pac.dfo-mpo.gc.ca/) is a good resource for identifying species-at-risk and other considerations for your local area.

Additional consideration should be given to the status of existing monitoring stations present in the vicinity, as data may be more easily obtained from existing stations. See Section 1.3 for more information on locating existing federal or provincial monitoring stations.

Community groups are responsible for securing all the necessary permits for installation of a ***gauging station*** (see below). The Network coordinator can assist groups with permitting logistics.

2.2 - Permitting

For Vancouver Island & Gulf Islands, the fisheries work window is generally from June 15 – September 15. The reduced risk window for Rainbow and Cutthroat trout is limited to August 15 – September 15 (see Ministry of Forests website for more details).

Under the *Water Sustainability Regulation*, a Notification of Authorized Change in and about a stream is required at least 45 days before beginning a station install. Station installs will typically have minimal impact on the environment and third parties, though these factors should be considered when submitting the Notification. This Notification is submitted to your local FrontCounterBC office, or online at: https://portal.nrs.gov.bc.ca/web/client/-/notification-of-authorized-changes-in-and-about-a-stream (current as of December 2022).

The following information is required to be prepared and submitted for the Notification:

- ☐ Stream name
- ☐ Proposed location
- ☐ Start and end date of install
- ☐ Details of tools used and methods for installation
- ☐ Written consent from the landowner (if applicable), and contact
- ☐ A map showing the stream and the location of the proposed station may be required

If you do not hear from the habitat officer within 45 days of submitting a notification of authorized changes application, this means that your work meets the regional terms and conditions, and you may proceed.

If the station is located within a public park, additional permits may be required from landowners (such as BC Parks *Scientific Research Park Use Permit*, or a Regional District/local government park use permit). BC Parks waives the fees for non-profit scientific research: https://portal.nrs.gov.bc.ca/web/client/-/research-parks-use-permit (current as of December 2022).

2.3 - Equipment needs

The Network coordinator and provincial hydrometric staff are willing to assist with station installs. A general list of equipment is provided in Table 2 for reference, and further details are available in the RISC manual.

*Table 2. General list of equipment used for a manual **gauging station** install.*

Equipment	**Purpose**	**Details**
Station instruments: levelogger, barologger, ***staff gauge***	Heart of the station.	These can either be loaned or purchased outright. See section 1.2.
2” diameter vertical pipe	1. To protect the levelogger. 2. To provide a stable point on which the levelogger rests.	Depending on site conditions, usually either perforated PVC or steel pipe with a locking cap. Height of pipe will depend on site conditions, usually these are custom fabricated for the site.
Lockable pipe or well cap	Protect ***logger*** inside pipe; restrict vandalism or theft	Steel caps should be painted to prevent rusting shut. Expanding well caps can become fouled without proper maintenance and cleaning.
Rock drill & bits	Attaching items to boulders, rip-rap, or concrete.	Ensure you have a rock-specific drill bit that is compatible with the length and diameter of the anchors in use.
Reciprocating saw & blades	Cutting in the field.	Helpful for trimming wood shims, rebar, anchor bolts, etc.
Expanding wedge/bolt or hammer anchors, & washers	1. Attaching items to boulders, rip-rap, or concrete. 2. Station ***benchmarks***.	The length and diameter of anchors in use will depend on site conditions. Anchors should be long enough to match your drill bit length (1/2 to 2/3 of anchor bolt should be embedded). See section 2.3 for more details about ***benchmarks***.
Compressed air	Cleaning rock dust out of holes.	Spray compressed air in drill holes to ensure anchor embeds securely.
Stainless steel T post, aircraft cable & cable clamps, 0.75” PVC, rebar, hose clamps or metal strapping, etc.	Mounting the levelogger to sit within the protective housing.	Method of choice is a T-post with an immovable seat screw installed where the levelogger will rest. T-post should fit inside the protective housing and be cut to length. The method of mounting must ensure the ***logger*** returns to the same vertical location after each download.

Misc. mounting supports: treated wood, rebar, T-posts etc.	Provide stability to the protective housing and ***staff gauge***.	The ***staff gauge*** will be mounted near the protective housing and ***logger***. Using a 1x6 treated board provides a stable surface for the gauge. A flat culvert face or weir wall can also be used.
Mallet or hammer	Installing T-posts or rebar.	Also helpful for tapping hammer anchors into place after install.
Wrenches	Tightening hose clamps.	Also helpful for setting and tightening wedge anchors after install.
Bubble level	Levelling ***staff gauge***.	Simple mason's level works great.

2.4 - Install Guide

The Network coordinator and/or provincial staff can assist with station installation; please use this guide for reference prior to install when visiting candidate station locations. This guide can also be used to evaluate an existing station wishing to incorporate into the Network, in order to determine any station changes required (see Appendix 2 for more details about station installation).

In general, the following must apply to a ***gauging station***:

- ☐ The levelogger and a reference gauge (***staff gauge*** or submerged reference point) must be mounted within the same ***gauge pool*** and upstream of a suitable ***control*** feature*.

- ☐ The reference gauge must be mounted level, with the bottom of the gauge sitting below the lowest point of ***low-flow***.

- ☐ The levelogger must sit at a known, stable point within its protective housing, with the pressure sensor sitting below the lowest point of ***low-flow***. There should be a strategy to ensure the levelogge***r*** is returned to the exact same location after download. The protective housing should have a locking cap that prevents tampering. The location of the protective housing should be placed so as to avoid significant debris accumulation or sedimentation beneath the ***logger***.

- ☐ The barologger must sit protected from sunshine, rain or wind; must be situated near the levelogger; and logging on the same interval as the levelogger.

- ☐ At least 3 ***benchmarks*** must be installed at the site, with at least one ***benchmark*** located on the reference gauge and/or ***logger*** housing.

- ☐ Station equipment must be braced and adequately mounted so as not to be washed away during a high flow event.

** <u>Note:</u> If site conditions prevent attaching a* ***staff gauge****, a submerged, or overhanging reference point can be installed instead (e.g., a* **benchmark***). This requires measuring the height of the water surface above or below the reference point with a meter stick or survey rod during site vis*

Part 3 – Benchmarking a Station

Photo Credit: K. Wasiak

3.1 - Preliminary considerations

The Network coordinator or provincial staff can assist groups with station ***benchmark*** installation and surveying, although once adequate training is received the surveys can be done independently.

Benchmarks can be as simple as hammer- or wedge-anchors (preferred) installed in to stable materials such as boulders, bridges, or weirs using a rock drill; or as wood screws (less preferred) attached to mature trees at a stable part of the trunk. Washers should be labelled with the ***benchmark***'s identifying number using a metal stamping kit.

Benchmark surveys must be completed twice a year. Surveys must be completed using the data sheet template provided in Appendix 3, and must follow the protocols laid out in Section 3.4.

3.2 - Equipment needs

Access to specific equipment is required to do a ***benchmark*** survey (Table 3). The Network coordinator and provincial staff can help supply equipment when on-site. A price is provided for reference if groups would like to purchase their own equipment.

It is imperative that clear, legible notes are taken using the data sheet template, as these must be submitted as validation of the survey.

Table 3. General list of equipment used for a station benchmark survey.

Quantity	Equipment	Typical cost (CAD) in 2022
1	Builder's level (also called an automatic level or dumpy level) with extendable tripod base	500-1,000
1	Extendable metric survey rod	75-150
1	90-degree rod bubble level	20-30
1	Waterproof notebook and pencil	20-30
1	***Benchmark*** survey data sheet template (see Appendix 3)	
1	Smartphone, or camera & field calculator	

3.3 - Benchmark survey protocol

Purpose

Benchmark surveys confirm the stability of a ***gauging station*** over time. This protocol is intended as a refresher for groups already trained in survey methods. Further details and training can be found in the RISC manual, or provided during a hands-on workshop with the Network coordinator or provincial staff. Depending on site conditions and crew experience, ***benchmark*** surveys can take anywhere from 30 minutes to 1.5 hours. ***Benchmark*** surveys must be completed twice per year.

In this example, Person 1 is the rod holder while Person 2 is the surveyor (reading through the eyepiece and recording notes) (Figure 4). Use the template provided in Appendix 3 to record data.

Protocol

1. Identify ***benchmarks***.
   - ☐ Familiarize your crew with the locations and numbers of all site ***benchmarks*** (BMs) prior to starting survey.

2. Set up tripod and eyepiece.
   - ☐ Set tripod legs where all benchmarks can be viewed without moving the level. Choose a location that is slightly higher than all of the benchmarks. Check for line-of-sight issues (e.g., vegetation) that may interfere with rod reading. Sink tripod legs in so they will not shift if bumped.
   - ☐ Mount eyepiece securely to the baseplate, and level the eyepiece using the three levelling screws while checking the bubble level mounted on the eyepiece.
   - ☐ Check the level is stable by rotating the eyepiece 180 degrees and re-checking the bubble mounted on the eyepiece.

3. Survey BM1 and establish Height of Instrument (H.I.).
   - ☐ BM1 is the primary (established elevation) ***benchmark*** for your station.
   - ☐ Person 1 places rod precisely on ***benchmark*** measurement point (e.g., threads of screw) and holds rod level using 90-degree bubble level.
   - ☐ Person 2 reads rod value at the center crosshairs through eyepiece, to three decimal places. Focus the eyepiece using the knobs on the side. Double check the rod reading before writing down.
   - ☐ Add BM1 established elevation (e.g., 10.000m) to rod reading. This is H.I.

4. Survey water level (***stage***).
   - ☐ Person 1 places rod on a stable point of streambed and holds rod level. Person 2 reads and double check rod value, records value, then subtracts this value from H.I. This is the Streambed elevation.
   - ☐ Without Person 1 moving the rod, Person 2 steps toward rod until they can read the level of the water on the face of rod. If water is surging, watch water level for a few moments to confirm average water level.
   - ☐ Take a photo, record Rod Reading (R.R.), and the time of reading. Add R.R. to Streambed elevation. This is the Height of Water (***stage***).

5. Survey all other BMs.
   - ☐ Person 1 places rod on next ***benchmark*** measurement point and holds rod level. Person 2 reads and double checks rod value, records value, then subtracts this value from H.I. Continue for all BMs.
   - ☐ On last BM surveyed (e.g. BM4), Person 1 holds rod steady and does not move rod after measurement is completed.

6. Change Height of Instrument.
   - ☐ Person 1 continues holding rod level and takes great care not to shift the rod.
   - ☐ Person 2 adjusts leg height of tripod to change the H.I. Re-level the eyepiece using the three levelling screws while checking the bubble level mounted on the eyepiece. Check the level is stable by rotating the eyepiece 180 degrees and re-checking the bubble. Focus the eyepiece using the knobs on the side.
   - ☐ Person 2 reads rod value at the center crosshairs through eyepiece, to three decimal places. Double check the rod reading before writing down.
   - ☐ Add rod reading to previously recorded elevation for the last ***benchmark*** (e.g. BM4). This is the new H.I.

7. Survey all other BMs.
   - ☐ Proceed through survey in a backwards direction, measuring each ***benchmark*** again. Person 1 places rod on next ***benchmark*** measurement point and holds rod level. Person 2 reads and double checks rod value, records value, then subtracts this value from H.I. Continue for all BMs

8. Calculate Closure Error (C.E.)
   - ☐ Compare the first elevation measurement to the second elevation measurement for each ***benchmark***. The largest difference between all measurements is the C.E.
   - ☐ If any benchmarks have a difference greater than 0.003 m, the survey must be re-done.

9. Confirm elevation for the last ***benchmark*** surveyed before H.I. was changed (e.g. BM4)
   - ☐ Re-survey BM1. Add rod reading to established elevation, and determine H.I.
   - ☐ Survey the unconfirmed ***benchmark*** (e.g. BM4). Keep rod steady and change H.I. Re-level the eyepiece using the three levelling screws while checking the bubble level mounted on the eyepiece. Check the level is stable by rotating the eyepiece 180 degrees and re-checking the bubble. Focus the eyepiece using the knobs on the side.
   - ☐ Re-survey the unconfirmed ***benchmark*** (e.g. BM4). Add rod reading to previously recorded elevation, and determine the new H.I.
   - ☐ Close the circuit by surveying BM1. Compare the first BM1 elevation measurement to the second BM1 elevation measurement. The difference between measurements is the C.E.
   - ☐ Compare the first survey's unconfirmed ***benchmark*** elevation (e.g. BM4 from first survey) to the second survey's unconfirmed ***benchmark*** elevation (e.g. BM4 from second survey). If elevations have a difference greater than 0.003 m, the survey must be re-done.

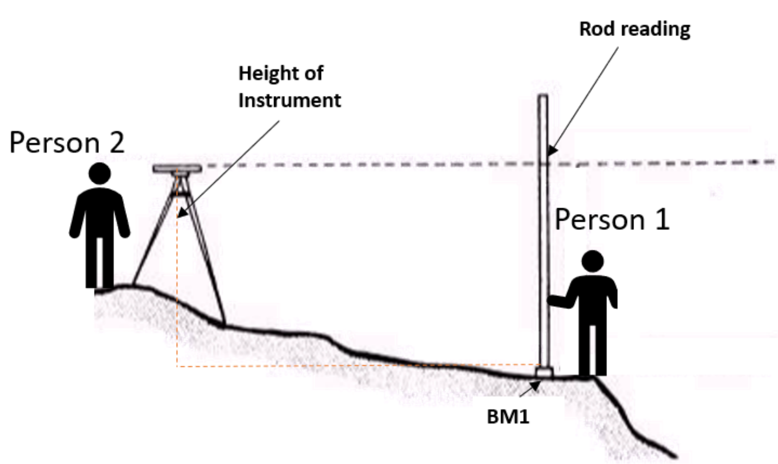


*Figure 4. Diagram of a **benchmark** survey.*

Part 4 – Collecting Field Data

Photo Credit: J. Craig

4.1 - Preliminary considerations

The Network coordinator or provincial staff are available to provide field training sessions. If a group or individual is new to Flow monitoring and has never received training before, at least one training session should be held in-person at the station location with a qualified person prior to beginning monitoring.

One measurement audit must be completed in each calendar year by each group member involved in monitoring (see Appendix 4 for the measurement audit template). An audit result of “Pass” must be achieved for a group member to monitor their station unsupported. This process helps ensure data quality assurance and ***control*** for field data collection!

4.2 - Establish monitoring frequency

A minimum of 6 paired ***stage-discharge*** measurements must be taken each year at varying stream conditions. Except in cases where the station has been involved in the Network for more than 2 years and the station ***control*** is highly stable (e.g. an engineered structure). If this is the case, a minimum of 3 paired ***stage-discharge*** measurements each year is acceptable.

Depending on the goals and objectives of your Flow monitoring program, you may choose to monitor your station more than the minimum amount each year. Increased monitoring is very helpful for correcting ***stage*** values, monitoring ***control*** changes, and describing the time period for any shifts that must be applied to the ***rating curve*** (e.g., due to seasonal debris accumulation or vegetation growing in the ***control***).

Rather than pre-determined dates for ***discharge*** measurement, it is more useful to observe the station for changes in ***stage*** and choose your ***discharge*** monitoring dates based on ***stage*** height. Due to the dynamic nature of streams, specific measurement times are best set just a few days or hours in advance. Special consideration should be given to monitoring around ***stage***-dependent changes in ***control*** condition (e.g. overtopping weir, submerging riffle).

4.3 - Metadata

Metadata is information that describes a field visit, and is important for interpreting details about site conditions or any possible influences on measurement results. In addition to the three basic field measurements and observations taken at each site visit (***stage***, ***discharge***, and ***control*** condition), every visit must also include the following metadata:

- ☐ Date
- ☐ Time arrived & time zone (PST (winter; Nov-Mar) or PDT (summer; Mar-Nov))
- ☐ Crew
- ☐ Weather (brief description)

- ☐ Visit purpose
- ☐ Whether ***logger*** was downloaded, and details
- ☐ Any station maintenance conducted, and details
- ☐ Device used for photos, and description of photos taken
- ☐ Time left

The data sheet template provided in Appendix 4 covers all of the required metadata. Please use the data sheet template provided; if you require a different data sheet for a specific project, please ensure the sheet contains all of the same fields that are in the attached template.

Record all site visit details in the same field notebook or binder to create a long-term paper record of the site and its field measurements.

4.4 - *Stage* measurement

Purpose

A ***stage*** measurement is taken to compare actual stream ***stage*** with the ***stage*** recorded by the leve***logger***. It is also used to develop the ***stage-discharge rating curve***.

The ***stage*** measurement (always recorded to three decimal places) should be taken twice during a site visit: at the start and at the end. This confirms whether stream ***stage*** was actively changing during the visit. Taking the ***stage*** measurement at or near the same time as the ***logger*** records (e.g., on the hour) is preferred. Because ***stage*** measurements are simple to collect, it is extremely valuable to take additional ***stage*** measurements beyond the minimum 6 paired ***stage***-discharge visits per year.

Equipment needed

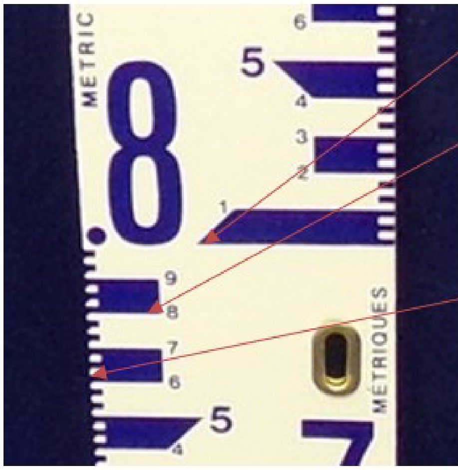
- ☐ ***Staff gauge*** or submerged reference point at site
- ☐ 1x Waterproof notebook and pencil
- ☐ 1x Smartphone or camera
- ☐ 1x metric meter stick or survey rod
- ☐ 1x 90-degree rod level

Procedure

If a *staff gauge* is present at the site: **(See Figure 5 *left*)**

1. Note the time (and time zone) of observation.

2. Note the ***staff gauge*** reading to three decimal places:



- Each large number represents the first number after the decimal place (0.1 m). Each increment begins at the longest edge of each thick blue bar.
- Each smaller number represents the second number after the decimal place (0.01 m). Even numbers begin at the bottom of the thick blue bars, while odd numbers begin at the top (see photo for reference).
- Each small hatch mark on the side is the equivalent of 2mm in height. Hatch marks represent the third number after the decimal place (0.001 m), but do keep in mind that one full hatch mark = 0.002 m.

- ☐ Record this value as "observed ***stage***".

See Appendix 4 for additional examples and more details about accurate ***staff gauge*** readings to three decimal places.

3. Add the observed ***stage*** to the local elevation determined for the bottom of the ***staff gauge*** during the last ***benchmark*** survey.
   - ☐ Note the value used for bottom ***staff gauge*** elevation.
   - ☐ Record the combined value as the "***stage*** corrected to local ***datum***".

4. Estimate and record the accuracy (+/-) of your ***stage*** reading*.

If a different type of reference gauge is present (e.g. a submerged benchmark): (See Figure 5 *right*)

1. Note the time (and time zone) of observation.

2. Place a meter stick or survey rod on the ***benchmark*** point and read the value at which the water level crosses the rod to three decimal places.
   - ☐ Make sure the rod is held level during the reading by using a 90-degree rod level.
   - ☐ Record the value where the water crosses as "observed ***stage***".

3. The observed ***stage*** is added to the elevation determined for the submerged ***benchmark*** during a ***benchmark*** survey.
   - ☐ Note the value used for submerged ***benchmark*** elevation.
   - ☐ Record the combined value as the "***stage*** corrected to local ***datum***".

4. Estimate and record the accuracy (+/-) of the ***stage*** reading*.

** <u>Note:</u> Accuracy is a subjective measure of how closely the water level was able to be read off the gauge. The standard level of accuracy for flat water read by a human eye is +/- 0.003 m (3 mm). Stream conditions such as rippling or surging will decrease the accuracy.*

*Estimate the amount of deviation caused by ripples or surging by comparing the difference between the high and low points of the water on the **staff gauge**, and report this as the accuracy. Measurement accuracy must be at least +/- 0.01 m (1 cm) or better. If accuracy is worse than 0.01 m, make a note of this in the measurement comments, and the measurement will be graded "U".*

*Figure 5. A typical **staff gauge**, displaying a **stage** of approximately 0.355 m (Left). Reference point reading using a portable stadia rod placed on a submerged **benchmark**, displaying a **stage** of approximately 0.200 m (Right).*

4.5 - *Control* conditions

Purpose

The condition of the station ***control*** dictates the ***stage-discharge*** relationship that is measured by the levelogger. Understanding the ***control*** condition helps validate the data collected by the levelogger. An evaluation of ***control*** condition should always be done when visiting a site. Some groups may find a trail camera helpful to monitor station ***control*** conditions at sites with mobile ***controls***.

The ***control*** is always located downstream of the ***gauge pool*** (where the levelogge***r*** and reference gauge are located), but the exact location of the ***control*** may change depending on flow conditions. Even if a ***discharge*** measurement is collected at a different location upstream or downstream of the station's ***gauge pool***, a crew must still visit the station to evaluate the ***control*** condition.

Equipment needed

- ☐ 1x Waterproof notebook and pencil
- ☐ 1x Smartphone or camera

Procedure

1. Identify the ***control*** feature.
   - ☐ Find the point downstream of the ***gauging station*** that ***control***s the height of water in the ***gauge pool***. Describe the feature: riffle, cascade, weir, etc.

2. Describe the condition of the ***control*** feature*.
   - ☐ Indicate whether the ***control*** is clear, submerged, dry, or obstructed using the list in the field data form. Add additional comments if needed.
   - ☐ If the ***control*** is visibly different since the last site visit (e.g. fill, scour, or other change noted), document this on the data sheet.

3. If obstructed, note whether the ***control*** feature was cleaned.
   - ☐ Note time of cleaning. Take a ***stage*** reading before and at least 10 minutes after to evaluate change after cleaning.

4. Take photos of the ***control*** feature from several angles.
   - ☐ From upstream, from downstream, from above, and side view.

5. Add a site drawing to indicate distance from the ***gauging station*** to the ***control*** feature, and the approximate depth/cross section of the ***control*** relative to the ***gauge pool***.

** <u>Note:</u> Knowledge about the factors influencing* ***control*** *condition at a particular site are built up over time and with experience. This is where pre-installation monitoring becomes useful. See Appendix 4 for more examples of* ***control*** *conditions and notes. Care must be taken to avoid moving rocks or disrupting the station* ***control*** *during site visits. If any change is made to the* ***control****, notes must be recorded and photos should be taken before and aft*

4.6 - Discharge measurement

Discharge in wadeable streams will typically be measured using the Mid-Section method (see Figure 1). The standard instrument to be used for Mid-Section measurements is a FlowTracker2. Other options are listed in Tables 1 & 2 in Appendix 1.

If site conditions facilitate the use of a bucket and cylinder (volumetric method) or an engineered structure such as a flume, these instruments may be used to estimate ***discharge*** during ***low-flow*** conditions. At minimum, equipment for at least one method of ***discharge*** data collection must be available for the site.

The most appropriate method for your site may vary, based on the stream condition and time of year. Some sites may not suit the standard methods. Further details about other possible measurement methods (e.g., salt dilution) can be found online or within the RISC manual.

Review the protocols below for a summary of three different methods for ***discharge*** measurement.

UNITS

In our daily lives, we often think of water volume in terms of liters (L). Keep in mind, when we talk about water in cubic meters (m^3), we are talking about the same thing (i.e., volume of water). You can easily convert from cubic meters to liters of water:

$$1\,m^3 = 1{,}000\,L$$

$$0.1\,m^3 = 100\,L$$

$$0.01\,m^3 = 10\,L$$

$$0.001\,m^3 = 1\,L$$

DATA GRADES

The overall “grade” (or quality rating) of your station data will largely depend on following the protocols laid out in this SOP manual, as they are based on achieving a minimum Grade “C” station data (RISC, 2018). However, data grades are also assigned to individual measurements.

Discharge measurement grading is mainly influenced by site selection, equipment handling, and proper note-taking. If a measurement is taken as Grade “A”, but improper field notes were kept, the measurement is automatically downgraded to Grade “U”!

See Appendix 4 for more details about data grading.

4.6.1 Method 1: Discharge section (Mid-Section method) protocol

Purpose

This method describes how to collect field data with a FlowTracker2 (FT2) using the mid-section method of ***discharge*** estimation. The guide below is intended as a refresher for groups already trained in-person in measurement protocols. A hands-on workshop is recommended prior to conducting a ***discharge transect*** using the Mid-Section method.

Equipment

- ☐ 1x FlowTracker2 (acoustic doppler velocimeter*)
- ☐ 8x AA batteries for flow meter
- ☐ 1x 30- or 60- m (metric) fiberglass ***transect*** tape
- ☐ 2x tent pegs
- ☐ 1x Micro-USB cable for flow meter
- ☐ 1x laptop or desktop computer with FlowTracker2 software installed
- ☐ 1x Waterproof notebook and pencil
- ☐ 1x Smartphone or camera

** <u>Note:</u> Other digital velocimeters may be used (e.g. FlowTracker1, OTT MF Pro), as long as a digital output summary file is able to be saved for quality **control** purposes. This protocol only covers specifics related to use and operation of the FT2. Propeller-based velocimeters (e.g. Swoffer, Global Water) can be used as an alternative, but these will require a modified measurement protocol and are more challenging to validate measurement quality, resulting in measurement data grade "U".*

Procedure

1. Conduct safety assessment.
   - ☐ Prior to setting up site, identify all safety hazards upstream and downstream (e.g., tripping hazards, water hazards, danger trees, potential wildlife hazards).
   - ☐ Ensure a trip plan has been left with a reliable person who will check-in with you at a specific time.

2. Select ***transect*** site.

A ***transect*** is essentially a cross-section of the stream (see Figure 1). The ***transect*** characteristics have a strong influence over the quality of the ***discharge*** measurement. If a ***transect*** has too many eddies or obstructions, it could result in an inaccurate estimation of total ***discharge***.

The ***transect*** location should be determined by the crew on the day of measurement, after thorough evaluation of the stream conditions in the vicinity of the ***gauging station***. Specific ***transect*** sites will vary throughout the year and under different flow conditions.

An ideal ***transect*** location should be in a straight stretch of the stream, such as a run/glide or at the tail-out of a pool, and should have:

- ☐ Laminar flow (e.g. evenly spread across the channel and non-turbulent)
- ☐ No braids or side-channels
- ☐ Uniform substrate on the streambed (e.g. fine gravel, no big boulders)
- ☐ No back-eddies
- ☐ No obstructions (e.g. logs, structures, or vegetation)
- ☐ Safe depth for wading (<1m)

It is OK to clear a section of the streambed of large rocks or sticks within the ***transect*** to improve the measurement conditions for the velocimeter probe. However, be careful that you are not impacting the station ***control*** if you disturb the streambed near the ***gauging station***. Any clearing of rocks must be done before the measurement begins, as the streambed cannot be altered during measurement.

The ***reach*** (or the stretch of stream that includes the ***transect*** where you will be measuring ***discharge***) should ideally be 5 times the width of the ***transect*** upstream, and 2 times the width of the ***transect*** downstream (Figure 6).

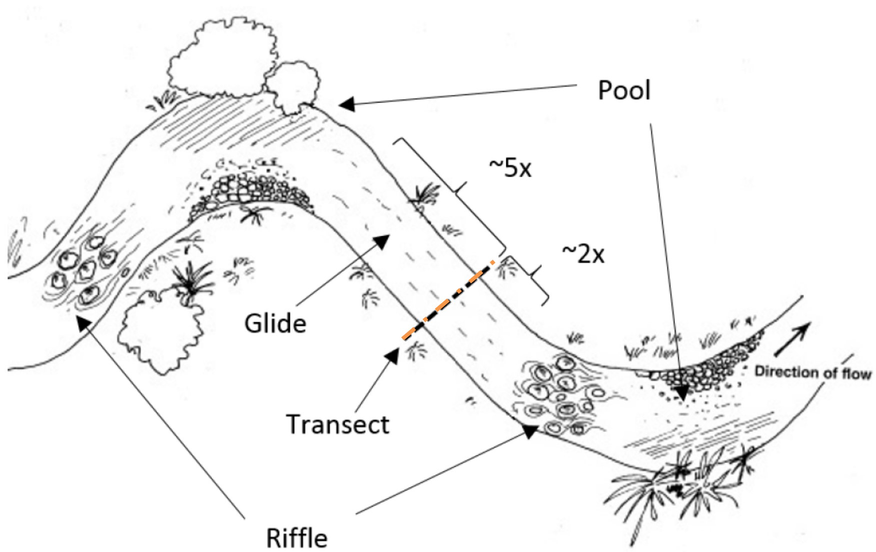


Figure 6. Diagram of an ideal survey ***reach****.*

Aim to keep the ***transect*** location within 30-40 metres of your ***gauging station*** (upstream or downstream). It is important to check the site to make sure there are no inputs or withdrawals of water between the ***transect*** location and the ***gauging station*** (e.g., side-channel, pump, stormwater input, etc.).

Finding the ideal site for a ***discharge*** measurement ***transect*** will take time! If a site has multiple possible ***transect*** locations, be sure to visit and evaluate each ***reach*** to discuss the pros and cons of measurement under the current conditions with your crew.

Site selection is arguably one of the most important parts of the ***discharge*** measurement process, and a good eye for ***transect*** selection takes plenty of practice.

3. Set up ***transect*** tape.

At the desired ***transect*** location, a 30- or 60-m metric ***transect*** tape must be strung across the stream perpendicular to the direction of streamflow. Secure the tape to the banks using rocks or tent pegs, or by tying the tape to a tree branch on shore. The tape must be completely taught, with no sags or twists.

- ☐ Record the RWE, LWE, and Wetted Width in your field data sheet.

The right wetted edge (RWE) is located on your right-hand side, and the left wetted edge (LWE) on your left-hand side, when standing in the water facing downstream. Assess the RWE and LWE by standing directly above the tape and looking down to note where the tape crosses the transition from water to land (Figure 7). Subtract the smaller value from the larger value; this is the stream's total wetted width.

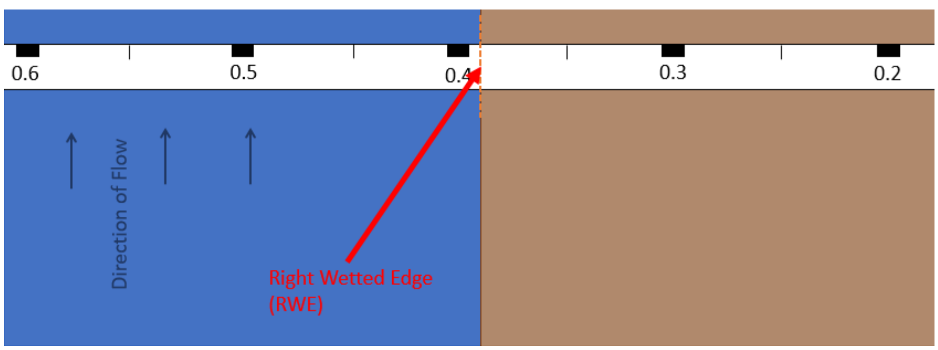


Figure 7. How to determine the wetted edge.

4. Determine where to measure along ***transect***.

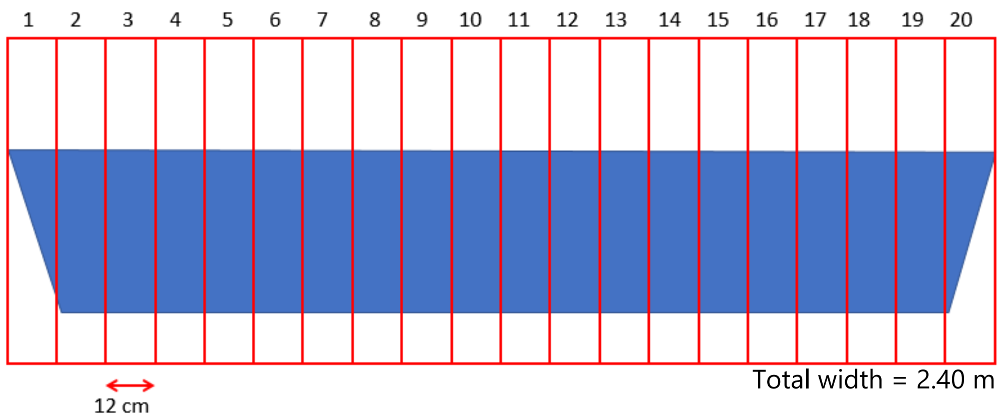
A good rule of thumb is to aim for 20 measurement locations across the ***transect*** width (one measurement location is referred to as a "panel"; see Figure 1 for illustration). Each panel must be a minimum of 10 cm wide. Ideally, less than 10% of total ***discharge*** should be measured in each panel.

Assess both stream depth and water ***velocity*** across the desired ***transect***. If depth and ***velocity*** are equal and uniform and the ***transect*** is greater than 2 m wide, a simple approach is to divide the total width by 20 and use this as the spacing between panels (Figure 8a).

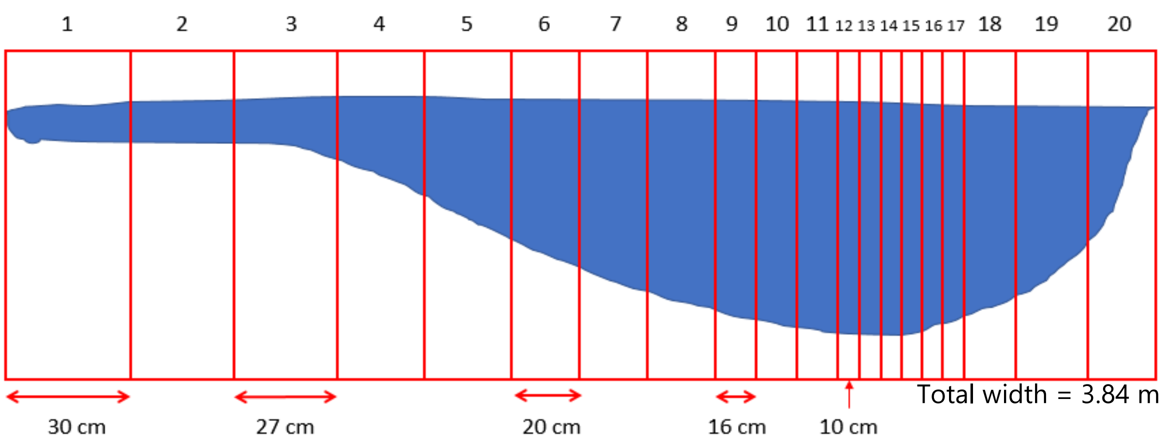
However, if depth and ***velocity*** vary across the ***transect***, dividing equally into 20 panels may <u>not</u> be the best approach. Areas with deeper water and faster flow velocities will require more closely spaced panels. Identify the ***thalweg***, or the region where the stream is deepest and fastest, and group panels more closely together in this part of the ***transect*** (Figure 8b) still keeping at least 10 cm between each panel.

Streams less than 2 metres wide will not fit 20 panels due to the 10 cm panel width limit. In this case, fit only as many panels as possible into the < 2 m ***transect*** while keeping at least 10 cm between each panel (Figure 8c). It is very likely some panels will exceed 10% total ***discharge***, but it is preferable to select proper panel width over ***discharge*** spacing.

a) Uniform *transect*, stream width > 2 m:



b) Non-uniform *transect*, stream width > 2 m:



c) Stream width < 2 m:

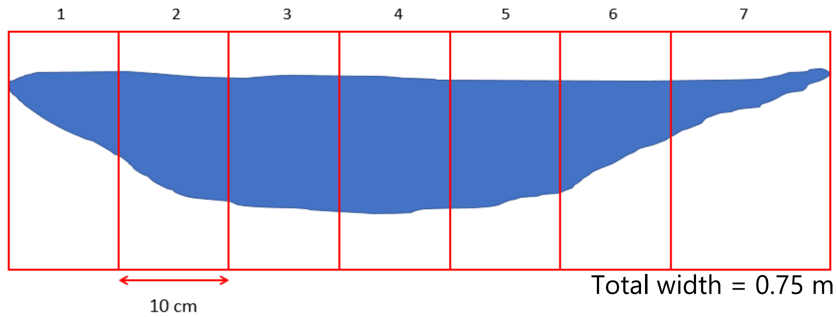


*Figure 8. Example determining **transect** panel spacing in three different **transect** types.*

5. Set up the FlowTracker2 (see Appendix 4 or SonTek website for illustration and more details).

Assemble metric wading rod and attach the metal ADV probe end to the rod base tightly, using the screw provided. Ensure probe end does not wiggle when gentle pressure is applied.

Remove head unit from case, attach the probe cable to the base of the head unit, and mount the head unit to the top of the wading rod. Install battery pack into head unit and power the unit on*. Confirm the date and time on the instrument are correct.

- ☐ From the “System Information” menu, note the make, model, serial number, current time (and time zone) of the instrument in your field data sheet.

** Note: If at any time the battery dies during the measurement, simply exchange the used battery pack for the alternate battery pack in the carrying case. The FT2 will save your progress as of the last completed panel. Ensure you remove and recycle any used batteries, and replace with 8x fresh AA batteries.*

6. Customize and confirm FlowTracker2 operation.

Select “1. Device Configuration”

- Under the “User Interface” menu, you can change the font size (requires restart)
- Under the “Application Settings” menu, you can change units, naming conventions, etc.
- Under “***Discharge*** Templates” menu, you can save desired settings for a particular project to use quickly again next time (this can also be done in the office)

Select “2. Utilities”

- If needed: under “1. System clock”, update the time/date.
- If needed: under “2. Recorder”, check remaining memory.
- If needed: under “3. Battery Data”, check battery status.

Place probe in water and select “4. Raw Data”. If you receive a probe error warning, check that the pins of the cable at the base of the head unit are securely inserted.

- Observe velocities – are they reasonable, and being graphed in real-time?

- Scroll using the down-arrow soft key, and assess whether the Signal-to-Noise Ratio (SNR) is reasonable (Ideal: >10 dB, Min.: 2-3 dB). The clearer the water, the lower the SNR. If <10 dB, measurement may not be accurate (see below for amendments needed).
- Scroll down, and assess water temperature – is it reasonable, and graphed in real-time?
- Scroll down further, and assess tilt (shift unit back and forth) – does it update in real-time?

7. Begin measurement.

From the main menu, use the Right soft key to begin a Measurement. Enter the Site Name, Operator, “Mid Section” for ***Discharge*** Equation, and any Comments. Add the ***stage*** reading from the start of the site visit as a comment. Click “OK” to proceed.

8. Perform Automated Beam Check.

Read instructions on-screen and use the soft key to select “Start”. The instrument will check several parameters over the next few seconds, and will tell you if the check passed or failed.

☐ Indicate on data sheet that Beam Check was completed.

9. Select starting edge.

Stand downstream of the FT2 at either the RWE or LWE. Use the left soft key to “Add Station”. Enter the “Location” as the value you recorded in Step 3 for RWE or LWE in your field notes.

10. Note the starting edge depth.

If the starting edge is dry, depth is “0”. If there is some water depth at the edge, measure the depth by placing the wading rod firmly on the streambed as close to the edge as possible, and reading the notch at which the water rises to (in cm) off the side of the rod*. If needed, review Appendix 4 for a guide to interpreting metal wading rod depths.

Enter the depth (in m) for the edge. Toggle between Left Bank or Right Bank. Keep Correction Factor as “1”. Proceed using the soft keys.

** <u>Note:</u> the FT2 requires units entered in m, but the wading rod measurement is made using units of cm. Make sure to use the correct unit conversion when measuring depth (1 cm = 0.01 m).*

11. Add first panel.

Using the panel widths estimated when preparing your ***transect*** in Step 4, move to the desired location on the ***transect*** tape and align your wading rod with the tape value. The probe will be slightly offset to the right of the rod. Use the left soft key to “Add Station” again. Enter the value (in m) from the ***transect*** tape as the “Location”, and the “Depth” (in m) as read off of your wading rod (in cm) while placed firmly on the streambed. Do not move the wading rod after the depth and location have been entered.

The FT2 will use the depth to determine which ***velocity*** method in use. Panels shallower than 50 cm use the 0.6 method, while panels deeper than 50 cm use the 0.2/0.8 method (Figure 9). Confirm the desired method is in use on the display screen, then proceed to the next screen using the right soft key.

12. Adjust rod and prepare to take measurement.

Follow the directions on-screen to align the wading rod to its proper position (match the large rod number with the small rod number, as shown on screen, by squeezing the rod handle and sliding the rod up and down). The probe should sit at 0.2, 0.6, or 0.8 the panel depth after adjustment.

Ensure the probe is stable, is away from any underwater objects (rocks, logs, etc.), and is aligned with the ***transect*** tape (do not move the probe to a different angle from the tape in order to better angle into the direction of streamflow). The red band should be on the downstream side of the probe, with the probe facing open to the right.

Visually inspect the panel from above and compare the SNR*, tilt, and ***velocity*** angle** settings to ensure they are reading correctly (see Appendix 4 for more details).

** <u>Note:</u> in situations where the SNR is below 10-15 dB, the SNR can be artificially increased by disturbing the streambed upstream of the **transect** tape to stir up sediment and algae. The particles will drift downstream and raise the SNR for a short time, improving the accuracy of the ADV probe measurement. If this is done, ensure: A) the upstream partner disturbing the streambed is far enough upstream that the particles will drift past the probe during the entire measurement, B) they are not disturbing any redds or spawning beds, C) the upstream partner moves back to the side of the stream and allows any ripples to settle before the downstream partner begins measurement.*

*** <u>Note:</u> the **velocity** angle may jump around if flow is not laminar and perpendicular to the probe. The **velocity** angles along the **transect** are a condition of the site, and can only be changed through site selection or slight clearing of any rocks and sticks along the streambed, which would need to be done prior to starting a measurement. Do not adjust the angle of the probe during measurement in order to improve the **velocity** angle, <u>unless</u> it is obvious that the probe is out of line with the **transect** tape as a result of the way the instrument is being operated.*

13. Take panel measurement.

After confirming the rod height is adjusted and the ***velocity*** angle and tilt have been checked, select "Start" to begin collecting the measurement.

The minimum measurement interval is 40 seconds. Keep yourself and the instrument still for the entire 40 seconds.

14. Review measurement.

When the FT2 has finished the panel measurement, review the results and note any warnings or errors. Review Appendix 4 for a list of possible measurement errors, and how to interpret errors.

If measurement is acceptable, select "Accept Measurement". If there were several Warnings that require fixing and would like to Redo your measurement, use the Left soft key to select "Redo".

At any time, you can exit the review menu to see an overview of the panels measured so far, their depths, and total % ***discharge*** (Q).

15. Continue adding stations until you ***reach*** the other edge of the stream.

Record the depth of water at the edge, or “0” if the bank is dry. Change the type to Left Edge or Right Edge as needed. Keep correction factor as 1. Add ending gauge height as comment. Select “Done” to end the measurement.

16. Review measurement summary on the main screen.

Compare measurement panels to ensure they meet the specifications in Step 4. If a panel is greater than 10% ***discharge*** (coloured red) and you are able to fit another ≥10 cm wide panel between it and the next nearest panel, select “Add Station”. Adjust the Location using the keypad, and position the FT2 at the new panel. A Station Order warning will pop up; ignore the warning and proceed with Steps 11-14.

It is best practice to have all stations < 10% ***discharge*** (green and yellow); however, some sites and stream conditions will prevent this. If you have selected the best possible ***transect*** location, mitigated all boundary issues and and added as many 10 cm panels as possible, but are still seeing red bars, it is OK to end the measurement.

If any changes need to be made to individual measurements, you may scroll left and right using the soft keys to select a measurement. You can view and make edits to the Location, Depth, or comments.

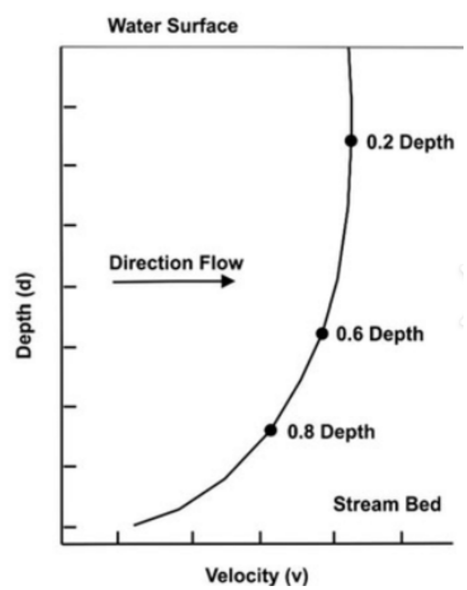


Figure 9. Example of ***velocity*** *change with depth (Pietroniro* et al. *2019).*

17. End measurement.

From the measurement summary menu, press the right soft key Menu and scroll down to “Complete Measurement”. You will receive a warning that no changes may be made after ending measurement. Accept this warning and proceed to save.

Do not power the unit off while it is saving the measurement!

- ☐ On the summary screen, note the total ***discharge*** (m^3/s) on the field data sheet.
- ☐ Use the soft keys to scroll through the summary menu. Also note the total ***area***, mean ***velocity***, and water temperature as comments on the field data sheet.

After finished reviewing and returning to the main menu, power the head unit off by pushing and holding the Power button for three seconds.

Disassemble and store the FT2 in its carrying case. If probe is still damp, leave case open to prevent mildew/mold growth.

Download the FlowTracker2

The digital measurement summary file must be downloaded and submitted with the field data sheet. This digital file can be downloaded with a laptop or desktop computer and a Micro-USB cable.

1. Connect FT2 head unit to PC via USB cable. Turn unit on by pushing and holding the power button for 3 seconds. Wait while it powers up.

2. When the main menu appears, navigate to the “3. Communication” menu.

3. On your PC, open the FlowTracker2 software.

4. In the software, click on “Device” in the top menu bar. Then select “Connect via USB”.

5. The instrument memory should appear if connection is successful. If there are issues connecting, you may need to try updating the PC drivers for the USB cable or the FT2 (must be connected to internet); or, power off/unplug the FT2 head unit, restart, and re-plug into PC again. If cable attachment still fails, you can try connection via Bluetooth if your device is compatible.

6. Highlight the files of interest you would like to download to your PC. The FT2 software groups multiple different measurement dates under the same site name. You may need to click on a stream name to open the folder and view all measurement dates saved, before you can select the specific file you need.

7. Select the folder path on your PC where you would like to save to. Files will automatically download as a “.ft” file. Save files with the following naming convention: “StreamName_MeasurementDate(yyyy-mm-dd).ft”

8. You can disconnect from the FT2 head unit and power off once files have been downloaded.

9. In the software, click “View Data” and open the saved .ft file to review. In the top center menu, on the right-hand side, select the “PDF” header tab. Export a copy of the measurement as a “.pdf” file, with the same naming convention.

Please see Part 5 – Data Saving & Sharing for instructions about final .ft and .pdf file submission.

4.6.2 Method 2: Volumetric discharge (Bucket/Cylinder) protocol

Purpose

This method describes how to collect ***discharge*** (in liters per second) using a "volumetric" method of estimation. Bucket fills require a perched culvert or weir, where 100% of the flow can be captured in a bucket or tote. This method requires a minimum of 2 people, and works best with maximum 3 people.

Equipment

- ☐ 1x Stopwatch capable of recording milliseconds (00:00:00)
- ☐ 1x Large Rubbermaid hard-sided tote (40-60 L) or a 5-gallon paint bucket
- ☐ 1x High-volume graduated cylinder (2 or 4 L capacity)
- ☐ 1x Field calculator
- ☐ 1x Waterproof notebook and pencil
- ☐ 1x Smartphone or camera

Procedure

1. Prepare the stopwatch timer (Person 1) and your tote, bucket or other hard-sided container (Person 2). Gather your camera and notebook (Person 3*). Ready the tote or bucket just beside the ***discharge*** point. This works best with a perched culvert or weir, where all the flow gathers to a single point.

2. Person 2 verbally confirms when they will start measuring (e.g., countdown 3-2-1-"GO"). Person 1 starts the timer as soon as the tote or bucket enters the stream of water. Time how long it takes to fill the container. Person 2 holds steady during filling and ensures the tote does not fold/bend along the lip of the structure, or that the bucket waver out of the entire stream of water, which could cause some flow to be missed.

3. After approximately 5-10 seconds, Person 2 verbally confirms when they will remove the tote or bucket (e.g., countdown from 3-2-1-STOP). Person 1 stops the timer immediately when it exits the stream of water. Person 3 records the Trial # and the total fill time to the millisecond.

4. Person 1 & 2 carefully and methodically pour all bucket water into a graduated cylinder (4 L capacity recommended for speed). Be careful not to lose any drops of water from the bucket.

5. Person 1 & 2 both read and confirm the cylinder value to estimate volume to the nearest 25 mL. Person 3 records the cylinder volume. Ensure you completely empty the cylinder before next refill. Repeat until all water is gone from bucket.

6. Person 3 adds all cylinder measurements together to get total volume in mL. Divide by 1,000 to get volume in L.

7. Repeat at least three times. Calculate % error between measurements. If error is >5-10%, repeat more measurements until error is <5-10%.

** <u>Note:</u> Person 1 & Person 3 tasks can be done by the same individual, if only two people are on site.*

Bucket fill error calculation

Total ***discharge*** is calculated as the mean of the three closest measurements. Keeping measurements within 5% of each other is best practice, but up to 10% error is permitted*.

1. Do first bucket fill and calculate ***discharge*** e.g., 5.14 L/s
2. Do second bucket fill and calculate ***discharge*** e.g., 4.03 L/s
3. Do third bucket fill and calculate ***discharge*** e.g., 4.12 L/s
4. Compare the percentage error between the largest and smallest fills, using the following formula:

$$\frac{(Largest\ fill) - (Smallest\ fill)}{(Smallest\ fill)} * 100$$

e.g., ((5.14 – 4.03) / 4.03) X 100 = <u>27.5%</u>

5. Do fourth bucket fill and calculate ***discharge*** e.g., 4.47 L/s
6. Identify which three of the four measurements are closest together → 4.03, 4.12, 4.47
7. Repeat the process, using the new “largest” measurement (effectively discard the furthest outlying (e.g., 5.14 L/s) measurement)

e.g., ((4.47– 4.03) / 4.03) X 100 = <u>10.9%</u>

8. Do a fifth bucket fill and calculate ***discharge*** e.g., 4.21 L/s
9. Identify which three of the five measurements are closest together → 4.12, 4.21 4.47
10. Repeat the process, using the new “largest” and “smallest” measurements (effectively discard the furthest outlying (e.g., 5.14 L/s, 4.03 L/s) measurements), until adequate % error is ***reach***ed.

e.g., ((4.47– 4.12) / 4.12) X 100 = <u>8.5%</u>

** <u>Note:</u> Even if you have three measurements very close together, you can always take more measurements to improve accuracy. The bucket method is very crude, so the more measurements you can do to show a similar value, the better the reliability of your data point.*

You must still record, keep and upload data for all of the measurements. We need to see the erroneous (high & low) measurements to better understand the overall variation in your measurements. It’s helpful if you can put some notes (e.g., “still learning”, “perfect fill”, “spilled a little bit”, etc.).

4.6.3 Method 3: Engineered structure (Flume/Weir) protocol

Purpose

Engineered structures (also known as 'rated structures') such as flumes or weirs perform well in low flow streams where precision in the measurement of ***stage*** and ***discharge*** is difficult. The main advantage of engineered structures is that only the height, or ***stage***, of water immediately upstream needs to be recorded in order to derive ***discharge***. Reference of ***stage*** can be done from the flume itself at regular intervals or logged using an embedded pressure transducer.

Considerations

Correct installation of flumes and weirs is necessary in order to achieve the hydraulic conditions required for their proper function. A ***discharge*** equation is associated with the structure and its parameters will vary based on the design. Engineered structures are not fool proof solutions and still require validation of the ***stage-discharge*** equation annually in order to assign a standard RISC grade to the data. Installation of ***benchmarks*** and a standard reference gauge is also recommended. Further, engineered structures are still subject to the same alterations as natural ***controls*** and are usually prone to shifting via movement, deposition, or debris catching on the structure. Alterations of this type will bias the derived ***discharge*** dataset and should be documented with detailed field notes, ***stage*** observations, and photos.

It is important to note that installation of a flume or weir could pose an obstacle to fish passage. Installation of flumes can also disturb stream sediment which may alter water quality. A qualified environmental professional should be consulted prior to installing a weir or flume.

For more information on the design of rated structures and operational best practices, please consult the RISC manual Section 4.5, Appendix III.

Equipment

- ☐ 1x Engineered structure with known ***discharge*** equation (e.g., marked 3" flume)
- ☐ 1x Waterproof notebook and pencil
- ☐ 1x Smartphone or camera
- ☐ Shovel*
- ☐ Tarp(s)*
- ☐

**Note: only required for the initial installation of a flume or weir.*

Procedure

1. Identify a location to install the flume; a constriction where flow is unlikely to bypass the structure is preferred.

2. Install the flume.
   a. Ensure that no flow may bypass the structure, this may require the installation of a tarp skirt or other barrier. Note that flow may bypass the structure at the edges or via the sub-surface exchange.

3. Confirm that 100% of the flow is passing through the structure.

4. When referencing ***stage***, note the time (and time zone) of observation and where it is referenced from.*

5. Note the height of water on the marked edge of the structure.

6. Use the ***discharge*** equation provided for the structure to calculate total ***discharge***.

7. Verify the efficacy of the ***discharge*** equation at least once annually either by volumetric measurement (bucket fill) or with assistance from the Flow Network coordinator or provincial staff.

**Note: It is important that the stability of the reference gauge/flume structure be confirmed bi-annually.*

4.7 - *Logger* downloads

Purpose

The station levelogger records ***stage*** continuously at a set time interval. The station barologger records air pressure continuously at the same time interval. Both ***logger***s are very precise, and must be returned to the same location after each download.

Downloading ***logger***s requires a close review of protocols to ensure instruments are handled, downloaded, and launched correctly.

Equipment

- ☐ Levelogger and barologger
- ☐ 1x Optical USB communication device or Bluetooth adapter (depending on station conditions)
- ☐ 1x laptop or desktop computer, compatible with ***logger***s and communication devices and with Levelogger 4.6+ software installed
- ☐ 1x Waterproof notebook and pencil
- ☐ 1x Smartphone or camera

Procedure

1. Move the levelogger from protective housing.
   - ☐ Note the time when ***logger*** was moved. Take photos of station and ***logger*** for reference.

2. Inspect ***logger*** for damage and last position.
   - ☐ Check outer surface for dents and scrapes. Open cap and check O-ring seals for nicks or scratches.
   - ☐ Confirm where ***logger*** sensor was sitting in housing, and note in data sheet comments.

3. Connect ***logger*** to device.
   - ☐ Open Levelogger software on computer.
   - ☐ Plug USB communication device in to computer (or power on Bluetooth adapter).
   - ☐ Attach ***logger***'s optical eye sensor face to the communication device.

4. Review ***logger*** status.
   - ☐ Note and confirm Serial Number of ***logger*** on field data sheet.
   - ☐ Record ***logger***'s last Start Time, Stop Time, Battery %, and Used/Free Memory status.
   - ☐ Record ***logger*** current time & computer current time, and calculate drift.

5. Download current ***logger*** data.

- ☐ Open Data Control menu using header tabs. Select the blue & green download arrow to Download All Data.

- ☐ When data has loaded, select the floppy disk icon to Save File As with naming convention "StreamName_yyyy-mm-dd to yyyy-mm-dd.xle". See Section 5.1 for more information on file naming conventions.
- ☐ Return to Levelogger software and select the spreadsheet icon to Export Data with same naming convention, but as .csv.

6. Stop & re-launch ***logger*** (OPTIONAL).
   - ☐ If clock drift is greater than 5 minutes or if memory is near full, it is recommended to stop and re-launch both ***logger***s.
   - ☐ From the Datalogger Settings tab, select "Stop Now".
   - ☐ Select the button to "Synchronize" ***logger*** time with computer time.
   - ☐ Check the Memory Mode "Slate" and check the "Future Start" box.
   - ☐ Enter the next 15-minute (or on-the-hour) time interval (hh:mm:ss) in the Future Start time box. Double check the correct AM/PM is entered.
   - ☐ Click the button to Future Start the ***logger***, and wait for status to update.

7. Indicate whether ***logger*** was just downloaded, or stopped and downloaded, on field data sheet.

8. Return levelogger to protective housing.
   - ☐ Disconnect ***logger*** from communication device and re-attach cap.
   - ☐ Note the time when ***logger*** was replaced and the anticipated time of next "good" reading.

9. Repeat Steps 1-8 for the barologger.
   - ☐ If levelogger was stopped and re-launched, do the same for the barologger.
   - ☐ Ensure barologger time is also synchronized to the computer time.
   - ☐ Ensure the "Future Launch" time stamp is the same for both ***logger***s (e.g., every 15 minutes or on-the-hour) (hh:mm:ss).

Part 5 – Data Saving & Sharing

Photo: VectorStock.

5.1 - Site visit files and naming conventions

Before you leave a field site, ensure you have collected the following:

- ☐ Personal field notes and site description (metadata)
- ☐ ***Stage*** measurement
- ☐ ***Discharge*** measurement files, if applicable (.ft and .pdf)
- ☐ ***Control*** condition description and details of cleaning, if applicable
- ☐ Photos
- ☐ ***Logger*** files, if applicable (.xle and .csv)

It is helpful for data management and quality checking if all site visit files are saved with the same naming convention. When saving files related to your site visit use the format:

yyyy-mm-dd_visit-type_stream-name_crew-initials

For example, if Susie Smith visited Bluebird Creek station on October 7th, 2023, to do a ***staff gauge*** (SG) reading, the photo or scan of the data sheet would be saved as: "*2023-10-07_SG_Bluebird_SS.pdf*"

Using the same naming format allows multiple users of the data to quickly and easily find and keep track of files, which is important for long term flow monitoring records.

5.2 - Accessing shared drive

The data collected during field visits is shared between community groups and the Network coordinator through the use of a Google Drive.

The Flow Network coordinator will share an access link to the drive with you via email.*

Each station involved in the Flow Network has its own folder within the drive where data collected from field visits is saved and stored. Nested within each station folder is a "*Site visits*" folder where data sheets, flow measurement files, and site photos can be uploaded, as well as a "*Logger downloads*" folder for saving files associated with ***logger*** downloads. Data from every field visit is saved in its own folder labeled with the date of the visit.

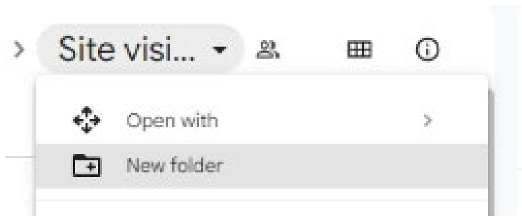
The drive also contains helpful how-to documents ("Read Me" files) for file naming, uploading, and saving protocols.

*<u>*Note:</u> Once you have received access, it is recommended that you save the Flow Network Drive as a Bookmarked link on your web browser for easier future access.*

5.3 - Uploading files to shared drive

In order to upload files to the shared drive:

- ☐ Select the station folder you are uploading data for.
- ☐ Select either the “*Site visits*” folder or “*Logger downloads*” folder depending on which type of data you are uploading.
- ☐ Click on the “Site visits” label the top right corner of the page and select “New folder” from the drop-down menu. Alternatively, you can right click on any blank space on the page to access the same menu:



- ☐ Label the new folder with the date (yyyy-mm-dd).
- ☐ Select the new folder you have just created.
- ☐ Drag and drop files into the new folder, or right click anywhere inside the new folder and select “File upload”. From here you can navigate to the files you would like to upload, and multiple files can be uploaded at the same time.

References

Braca, G. 2008. Stage–discharge relationships in open channels. Practices and problems. FORALPS Technical Report, 11. Università degli Studi di Trento, Dipartimento di Ingegneria Civile e Ambientale, Trento, Italy, 24 pp.

Resources Information Standards Committee (RISC). 2018. Manual of British Columbia hydrometric standards, Version 2.0. Knowledge Management Branch, B.C. Ministry of Environment and Climate Change Strategy, Victoria, B.C.

Appendices

Available at http://www.cfmnvi.com

Appendix 1: Station establishment

Section 1.1 – Goal-setting worksheet

Section 1.2 – Tables 1 & 2 (alternate monitoring equipment tables)

Section 1.6 – Trip plan template & field check in procedure

Appendix 2: Station installation

Section 2.5 – Station install guide & checklist

Appendix 3: Benchmarking a station

Section 3.2 – Level survey data sheet

Appendix 4: Collecting field data

Section 4.1 – Audit template

Section 4.4 – Station visit data sheet

Section 4.5 – ***Stage*** measurement - ***staff gauge*** reading protocol

Section 4.6 – Examples of ***control*** conditions and example notes about ***control***

Section 4.7 – RISC data grades

Section 4.7.1 – ***Discharge*** measurements

- Setting up FlowTracker2
- Interpreting metal wading rod depths
- SNR, Tilt, ***Velocity*** angle interpretations
- List of FT2 errors & how to interpr

Appendix 1.1 Gauging Station Mission Statement

a.k.a. the "WHY"

The purpose of this worksheet is to develop a brief description of the gauging station's main purpose – **what is the conservation issue to be addressed? How do you intend to use the data gathered?**

This will help guide the data collection at your station, and any amendments to be made to the station location.

Streamkeeper group name: Creek or river name:

____ ____

Specific site name (if applicable):

____

Please identify the main theme(s) you are interested in pursuing for your adopted stream:

____
____
____

(e.g., water quality, allocations of use, water balance, fish habitat, riparian restoration, etc.)

Please identify a specific conservation issue you hope to address by collecting streamflow data at this site (if you require more space, please attach a separate sheet):

____
____
____
____
____
____

A strong conservation issue will also have an actionable task or goal associated!

(e.g., if you are interested in fish protection, then fry salvage or habitat mapping & enhancement is an actionable goal. If you are interested in community water balance, then outreach and education in the community is an actionable goal).

Please identify at least one actionable goal you hope to achieve, using streamflow data collected from this site, that will help address the conservation issue(s) outlined above:

____

____

____

____

____

____

____

____

____

Please list contact information for 1-3 individuals from your organization who can be responsible for data submission to the shared Google Drive folder:

Name: ____

E-mail address: ____

Name: ____

E-mail address: ____

Name:

____

E-mail
address:____

Please submit this completed worksheet to abadger@bccf.com, and keep a copy on hand for your organization

Appendix 1.2 Alternate Flow Monitoring Equipment

Table 4. Brands and makes of common loggers used in surface stream gauging applications on Vancouver Island.

Brand	Make	Maximum depth	Accuracy	Other data recorded	Clock drift	Battery life	Memory	Computer connection	Bluetooth compatible	Software	Approx. cost
Solinst	Levelogger 5	5 m	+/- 3 mm	Water temperature (+/- 0.05 ºC)	+/- 1 min per year	10 years (based on 1 reading/minute)	150,000 readings	Requires purchase of a USB Optical base (Single eye), e.g. *Field Reader 5* or *Desktop Reader 5*	Yes - requires separate purchase and installation of a *Levelogger 5 App Interface* ($500) using either a L5 Direct Read cable ($115), or L5 Slip-Fit adaptor ($110)	Levelogger (Free)	$ 850 CAD (w/o software or accessories)
Solinst	Levelogger 5 Junior	5 m	+/- 5 mm	Water temperature (+/- 0.05 ºC)	+/- 1 min per year	5 years (based on 1 reading/minute)	75,000 readings				$ 575 CAD (w/o software or accessories)
Solinst	Barologger 5	N/A (do not submerge)	+/- 0.05 kPa	Air temperature (+/- 0.05 ºC)	+/- 1 min per year	10 years (based on 1 reading/minute)	150,000				$ 450 CAD (w/o software or accessories)
HOBO	U20L-04 (Plastic)	4 m	+/- 4 mm	Water temperature (+/- 0.44 ºC)	+/- 1 min per month	5 years (based on 1 reading/minute)	21,700 readings	Requires purchase of an Optic USB Base Station (BASE-U-4) with coupler for U20L (~$325), or Waterproof shuttle (~$650)	Not applicable to these models	HOBOware (Free Trial) or Pro ($110)	$490 CAD (w/o software or accessories)
HOBO	U20L-01 (Plastic)	9 m	+/- 10 mm	Water temperature (+/- 0.44 ºC)	+/- 1 min per month	5 years (based on 1 reading/minute)	21,700 readings				$490 CAD (w/o software or accessories)
HOBO	U20-001-04 (Stainless Steel)	4 m	+/- 3 mm	Water temperature (+/- 0.44 ºC)	+/- 1 min per month	5 years (based on 1 reading/minute)	21,700 readings				$850 CAD (w/o software or accessories)
HOBO	U20-001-01 (Stainless Steel)	9 m	+/- 5 mm	Water temperature (+/- 0.44 ºC)	+/- 1 min per month	5 years (based on 1 reading/minute)	21,700 readings				$850 CAD (w/o software or accessories)
HOBO	MX 2001-04-SS	4 m	+/- 3-6 mm or kPa	Water temperature (+/- 0.44 ºC)	+/- 1 min per month	1 year (based on 1 reading/minute) Note: user-replaceable batteries. 2x AA alkaline	30,000 readings	Optional Optic USB Base Station or Bluetooth connection	Yes, Bluetooth Low Energy within approximately 100 ft line of sight	HOBOware (Free Trial) or Pro ($110) or HOBOconnect app (Free)	$1000 CAD (w/o software or accessories)

Appendix 1.6 – Trip Plan Template and Field Check in Procedure

All volunteers are encouraged to work in pairs (minimum 2 people) when conducting field visits and taking measurements. Individuals working in the field should have proper personal protective equipment (PPE) including waders with a wading belt, proper wading boots, a high-visibility vest, and a PFD (review Section 1.6 for a full list of field safety equipment).

A Trip Plan contains contact information and an itinerary for your field visit that can be left with a designated check-in person. The designated check-in person should be someone who is able to respond to messages and/or phone calls during the timeframe of your field visit. For a routine measurement, checking in when you leave for a site visit and when you return is usually sufficient, but for longer field days or at higher risk sites you may want to check in more frequently (e.g. every 2 hours).

At sites where cell phone service is limited, it is recommended to bring a radio, satellite communicator, or GPS emergency locator beacon, and check in with your designated person before you leave coverage and as soon as you return.

Use the Trip Plan template provided on the following page or ensure your trip plan contains the information below:

Contact Information:

- Names of persons conducting field work
- Cell phone number of at least 1 person in field
- Emergency contact numbers for persons working in field
- Licence plate, colour, make and model of at least 1 vehicle parking on site

Trip details:

- Date of visit
- Timeframe of visit (planned start and end time)
- Location of gauging station (and measurement/transect location if distant/not easily visible from gauging station)
- Location of parking
- Walking route from parking lot to station

*The GPS coordinates of your gauging station and or parking location are helpful to include, as well as a rough map of your site and/or route in. Include details or landmarks that would help Emergency Services get to you quickly in case of an accident or emergency.

Names: ____

____

Cell number(s): ____

____

Emergency contacts:

Name ______________________Phone:____________________________

Name ______________________Phone:____________________________

Vehicle on site:

Make______________Model___________________Colour_________________

Licence plate ____

Date: ____

Start time:____________________ Expected end time:____________________________

Location of field work:

____

____

____

____

Parking Location:

____

____

Sketch of location, including route in/out:

Appendix 2.5: Station Install Guide and Checklist

Equipment checklist

- ☐ Levelogger
- ☐ Barologger
- ☐ Staff gauge
- ☐ 2" diameter vertical pipe - *height of pipe will depend on site conditions. Usually perforated PVC or steel pipe.*
- ☐ Lockable pipe or well cap
- ☐ Rock drill and bits
- ☐ Expanding wedge/bolt or hammer anchors, & washers - *length and diameter of anchors in use will depend on site conditions (1/2 to 2/3 of anchor bolt should be embedded).*
- ☐ Stainless steel T post, aircraft cable & cable clamps, 0.75" PVC, rebar, hose clamps or metal strapping – *for mounting levelogger within protective housing.*
- ☐ Treated wood, rebar, T-posts – *for mounting logger housing and staff gauge (1x6" treated board works well for most staff gauges).*
- ☐ Mallet or hammer
- ☐ Wrenches
- ☐ Bubble level

Additional equipment:

- Reciprocating saw & blades **helpful for trimming wood shims, rebar, anchor bolts etc.*
- Compressed air **helpful for cleaning out drill holes to ensure anchors embed securely*

Install Guide

The Network coordinator and/or provincial staff can assist with station installation; please use this guide for reference prior to install when visiting candidate station locations. This guide can also be used to evaluate an existing station wishing to incorporate into the Network, in order to determine any station changes required.

In general, the following must apply to a gauging station:

- ☐ The levelogger and a reference gauge (staff gauge or submerged reference point) must be mounted within the same gauge pool and upstream of a suitable control feature*.

- ☐ The reference gauge must be mounted level, with the bottom of the gauge sitting below the lowest point of low-flow.

- ☐ The levelogger must sit at a known, stable point within its protective housing, with the pressure sensor sitting below the lowest point of low-flow. There should be a strategy to ensure the levelogger is returned to the exact same location after download. The protective housing should have a locking cap that prevents tampering. The location of the protective housing should be placed so as to avoid significant debris accumulation or sedimentation beneath the logger.

- ☐ The barologger must sit protected from sunshine, rain or wind; must be situated near the levelogger; and logging on the same interval as the levelogger.

- ☐ At least 3 benchmarks must be installed at the site, with at least one benchmark located on the reference gauge and/or logger housing.

- ☐ Station equipment must be braced and adequately mounted so as not to be washed away during a high flow event.

* Note: If site conditions prevent attaching a staff gauge, a submerged, or overhanging reference point can be installed instead (e.g., a benchmark). This requires measuring the height of the water surface above or below the reference point with a meter stick or survey rod during site visits.

Appendix 3.2 – Level Survey Data Sheet

Station benchmarking

Site Name: ______________ Date: ______________

Site Number: ______________ Time start: ______________

Crew: ______________

	BS (+)	HI	FS (-)	Elev	Notes
BM 1				10.000	
HI					
		Reset HI			
BM_					
HI (new)					

CE =

Water level

	BS (+)	HI	FS (-)	Elev	Notes
BM 1					
HI					
Streambed					RR = ______________ at __________
BM __					
		Reset HI			
BM __					
HI					
Streambed (optional redo)					RR = ______________ at __________
BM _1_					
				CE =	

Water elevation (m) = streambed + RR

Compare water level value by finding Bottom SG elevation, then add SG reading (usually Bottom SG = Top SG - 1 m; unless SG is a different height).

Time end: ______________________

Appendix 4.1 - Station Audit Template

Date:

Auditor Initials:

Crew:

Start time:

End Time:

Audit purpose: Discharge/Benchmarking/Downloads

Location:

Weather:

Site access & safety awareness:

	Low/Poor (needs improvement)	Moderate/Good (some room for improvement)	High/Excellent (All expectations met)
Phones landowner or adjacent property owners ahead of time (if applicable)	1	2	3
Appropriate PPE for conditions	1	2	3
Access route safe for conditions	1	2	3
Has tailboard or safety plan in place	1	2	3

Equipment handling & awareness:

Assembles equipment correctly and without assistance	1	2	3

Has all essential equipiment on hand for day of sampling	1	2	3
Understands each piece of equipment's purpose and function **(QUIZ)**	1	2	3
Can diagnose and interpret errors	1	2	3
Uses equipment in a way consistent with RISC protocols	1	2	3

Site selection:

Chooses a suitable transect location	1	2	3
Explains criteria for site selection **(QUIZ)**	1	2	3
Explains connection between discharge site and long-term stage gauging site (if applicable)	1	2	3

Discharge measurement

Performs transect or measurement with minimal error	1	2	3
Understands procedure and delegates personnel to task efficiently	1	2	3

Appendix 4.4 – Station Visit Data Sheet

Station Name: ___________________________ **Date:** ________________________________

Time Arrived: ____________________ **Time Left:** ____________________ **PST** **PDT**

Crew: ____ (circle time zone)

Weather (recent rain, air temp, etc)**:** ____

____

____

Visit purpose (select all that apply)**:**

- ○ stage measurement
- ○ discharge measurement
- ○ logger download
- ○ station maintenance – note what was done in comments

STAGE MEASUREMENT: Control Cleaned? (circle) NO YES – Time: ___________________ (Note details in comments)

1st reading: ____________ (3 decimal places) Time: ____________________ ☐ Photo taken

2nd reading: ____________ (3 decimal places) Time: ____________________ ☐ Photo taken

PHOTOS: *photos should be taken at every site visit - best if taken from same locations each time

- ☐ Staff gauge
- ☐ Facing downstream from gauge pool (control)
- ☐ FT2 transect location (if applicable)
- ☐ Entire site
- ☐ Facing upstream from gauge pool

DISCHARGE MEASUREMENT: Transect location: ______________________________________

Time start: ______________________________

Time end: ______________________________

Total discharge: _____________________ (L/s or m^3/s)

- ○ Volumetric (bucket fill) – attach stopwatch/fill details on separate page when uploading
- ○ Mid-Section (FT2) – attach FT2 file when uploading
- ○ Engineered structure
- ○ Other

LOGGER DOWNLOAD: Levelogger Barologger (circle all that apply)

Time moved from housing:________________________

Time returned to housing:________________________

☐ .xle file saved ☐ .csv file

- ○ Logger not stopped (download only)
- ○ Logger stopped and relaunched (download + re-launch)
- ○ Synchronized logger time to computer time – note time difference (drift) before synchronization

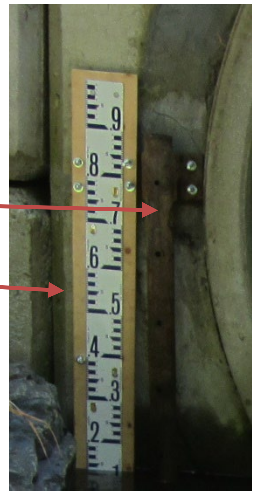
COMMENTS:____

____

____

____

Appendix 4.5. Staff gauge reading Protocol



"Stage" is another term for describing the height of water above a point of reference.

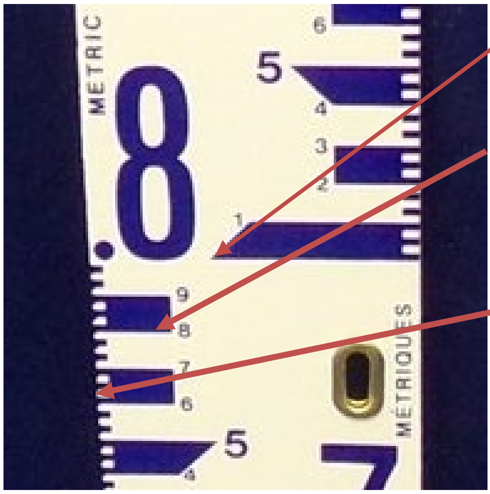
The point of reference used (elevation) is determined using level surveys.

We use two methods to monitor Stage:
1. the logger (in steel tube)
2. the staff gauge.

How to read staff gauge:

The staff gauge is 1 meter tall. The reading must be recorded to **three decimal places**

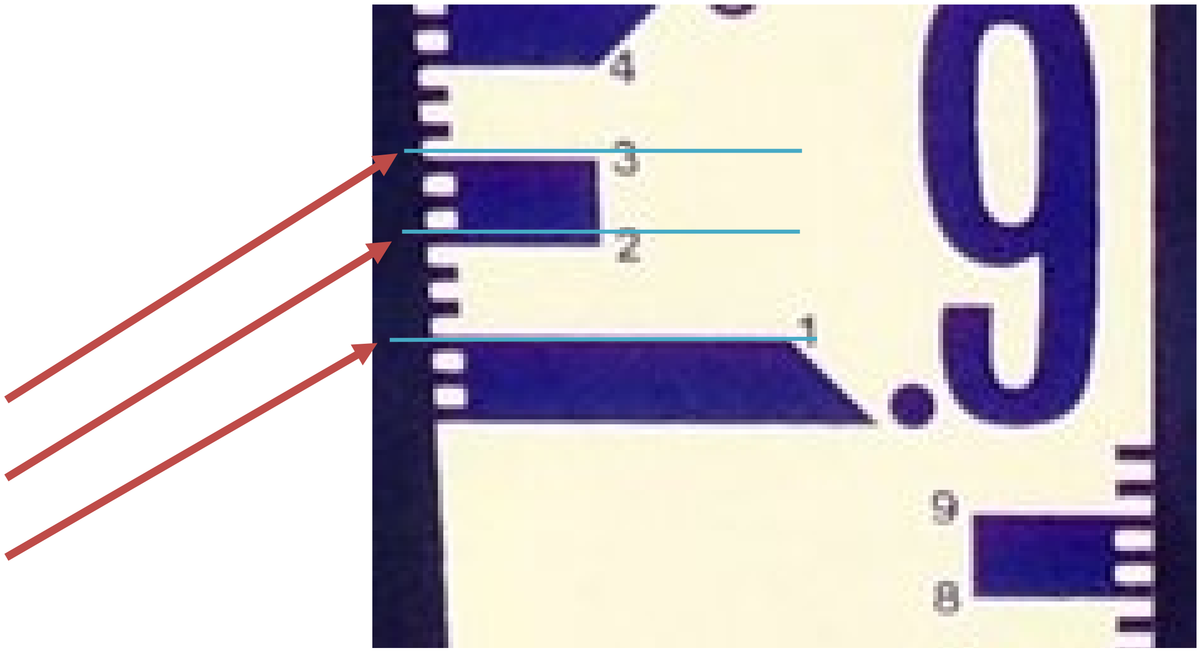
The first two decimal places will be known with good accuracy, while the third is estimated (see below).



- Each large number represents the first number after the decimal place (0.1 m). Each increment begins at the longest edge of each thick blue bar.
- Each smaller number represents the second number after the decimal place (0.01 m). Even numbers begin at the bottom of the thick blue bars, while odd numbers begin at the top (see photo for reference).
- Each small hatch mark on the side is the equivalent of 2mm in height. Hatch marks represent the third number after the decimal place (0.001 m), but do keep in mind that one full hatch mark = 0.002 m.

To clarify: For the small hatch marks, all even numbers sit at the top or bottom of the hatch mark. Odd numbers sit in the middle of each hatch mark.

Imagine the thin blue lines below are equivalent to the surface of the water.



E.g., **0.931**

0.922

0.910

Appendix 4.6 Examples of Control Conditions

• What is a Control?

The control is term commonly used to refer to a set of features in a stream that describe the relationship between stage and discharge. Control features have a direct effect on the rating curve equation parameters the ability to reliably produce a discharge hydrograph from a stage hydrograph. Tracking and noting control features during site visits with photographs and notes is strongly recommended since this meta data can lead to insights in the validity of the rating curve and contribute to an overall improved data quality.

• How to Observe the Control

In most cases the control can be most easily observed by standing near the stage sensor or gauge (where your logger is installed) then orienting yourself to face downstream. The next riffle observed downstream will be the approximate control location. The set of features (shape, roughness, point of zero flow (PZF)) encompassed near the riffle are what comprise the control. Changes in these features will cause changes to the control (and thus the rating equation).

- **Shape:**
  - Alters control dynamics by changing how much water can empty from the gauge pool at a given stage.
  - Point of zero flow (PZF) is an aspect of this. If the PZF gets scoured, then you can expect more water to empty out at lower gauge heights.
  - Rectangular, parabolic, and triangular cross-section shapes all change how water will empty from the gauge pool and how the slope of the rating curve appears.
- **Roughness:**
  - Alters control dynamics by slowing down the water, causing it to back up and rise relative to the discharge.
  - Caused by vegetation, algal growth, ice, snow.
  - Bed substrate size also alters roughness. E.g., Roughness could be altered following a high-water event if the cobble deposited is much larger or much smaller than previous substrate.

Point of Zero Flow (PZF):

This is the elevation at which the stream will cease to flow (relative to the local datum determined during level surveys). The PZF can be easily found by finding the deepest part of the riffle that forms the control. This parameter is easiest to observe using a wading rod or stadia rod. Simply place the rod in the deepest part of the control and measure the depth. Subtract this value from the current gauge height and this should yield the approximate elevation of the point of zero flow. The elevation of this value could also be surveyed using differential leveling.

Rough measurements of the PZF during field visits may also help determine if any changes to the control such as scour or fill are occurring. The PZF value does not have to be precise since the accurate location of it is extremely difficult to determine. These are especially useful following periods of high flow, such as in the spring.

A photograph is the easiest method to assess control features. **Oftentimes, a photo taken facing downstream from the location of the stage sensor will sufficiently capture all control features**. Supplementary photos may also help in assessing control features and site dynamics:

- Photo facing upstream from the stage sensor
- Photo facing cross-stream from the stage sensor (facing opposite bank)
- Photo facing cross-stream from the stage sensor but at the opposite bank (facing stage sensor)
- Photo from location downstream of the control facing upstream
- Timelapse or trigger/remote camera photos of the control to assess control dynamics when not on site

Examples of controls:

A stable natural control (Figure 1) may be a:

- bedrock outcrop, or other stable riffle (shoal) for measuring during low flow,
- channel constriction for measuring at high flow,
- falls or cascade that is not submerged at any water level,
- long reach of stable bed.

A stable artificial control (Figure 2) may be a:

- rated structure (flume, weir, etc.),
- fish barrier (drop structure),
- streambed sill (log, concrete, etc.).
-

Figure 1. Examples of natural riffle controls during low flow

Figure 2. Examples of stable artificial controls during low flow.

• Control Features

Controls may vary depending on the flow or stage of river (Figure 3 & 4). In addition to a picture, site notes may also be helpful for interpreting and communicating information about the control features. Understanding how control changes affect the rating curve will help identify anomalies in stage and discharge measurement.

Some helpful control feature notes are:

- Deepest part of the riffle that forms the control;
    - Also referred to as the point of zero flow (PZF),
- Presence of vegetation growing on the control,
- Debris such as stick, logs, or leafy litter caught on the control.

Control features may also change or alter with time. Common control feature changes to note are:

- Overall shape or velocity line pattern of the riffle,
- Change to the size of substrate at the control or in the channel,
- Slumping banks or overhanging vegetation,
- Evidence of deposition or scour in areas near the control,
- Alterations to submerged features such as gravel bars or islands,
- Evidence of beaver activity or tampering.

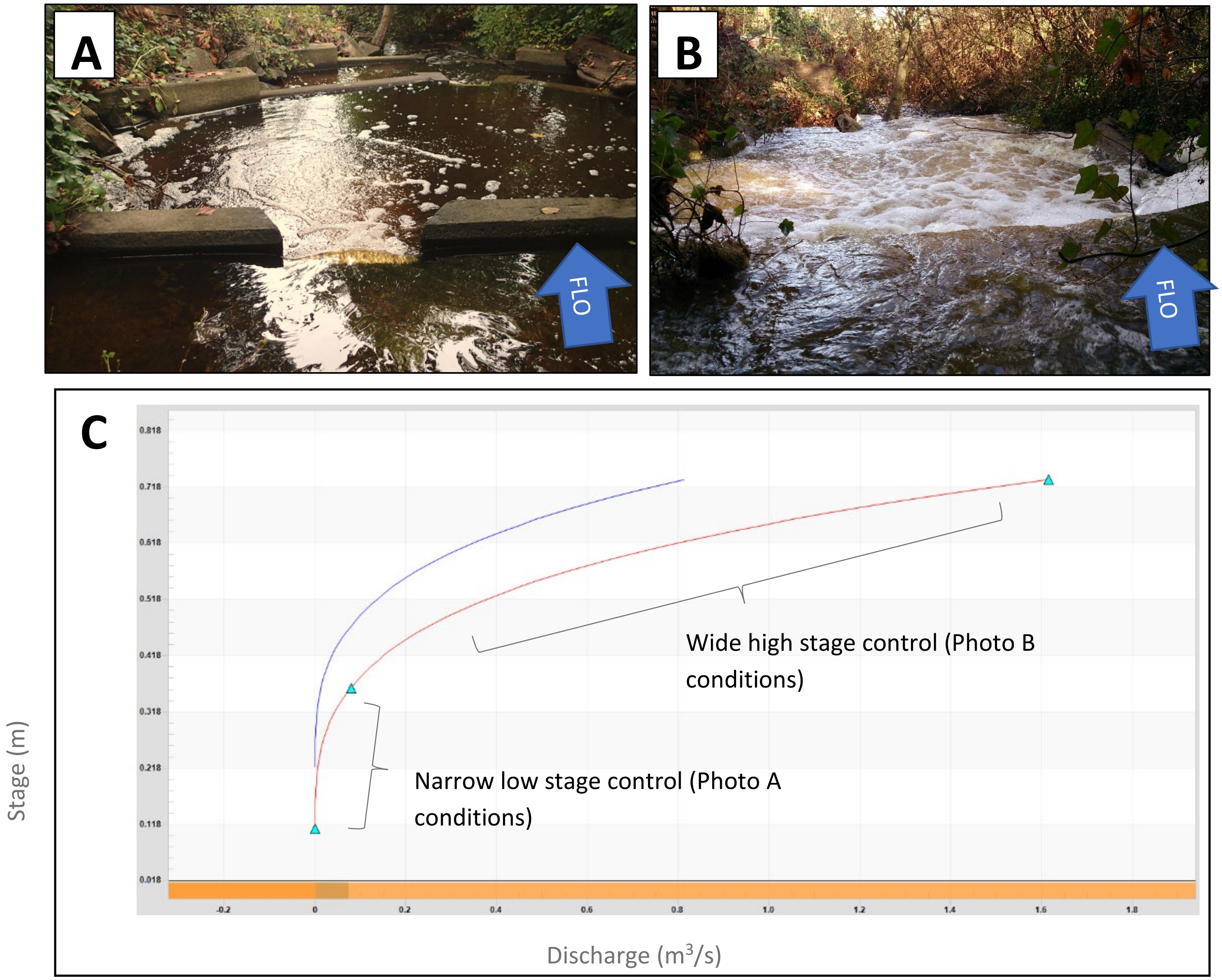


Figure 3. Changes in control features for an engineered weir at varying flow conditions. During low flow (A) water flows through the center notch only. At high flow (B) the side wing walls are overtopped. These changes to the features controlling the water level in the pool greatly influence the stage-discharge relationship and can be observed in the rating equation (C). Note how different segments in the rating curve correspond to the changes in control.

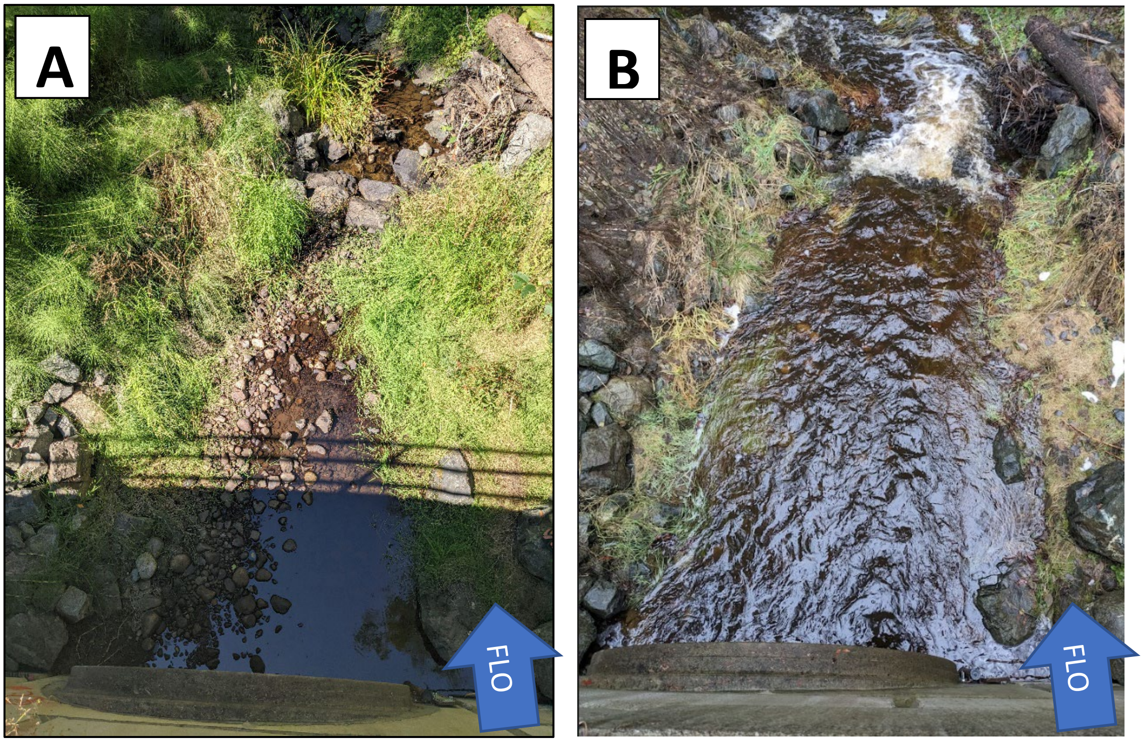


Figure 4. Changes in control features to a natural control at varying flow conditions. During low flow (A) the section control is a small natural riffle. Note the in-stream vegetation growing on both banks, as well as the unsubmerged cobbles on left bank. The high flow section control (B) is a small riprap cascade located just downstream of the riffle. Note the lack of vegetation, and how all of the cobbles from the low-flow control are now fully submerged. The drop associated with the cascade is also much steeper than the low-flow riffle control.

• Cleaning the Control

Any clearing of the control (removing sticks, debris, etc.) MUST BE NOTED on the data sheet or field notes collected during a site visit and supported with before & after photos. It is also useful to observe the staff gauge before and after cleaning the control. See Figure 5 below for an example of the effect of debris on the control.

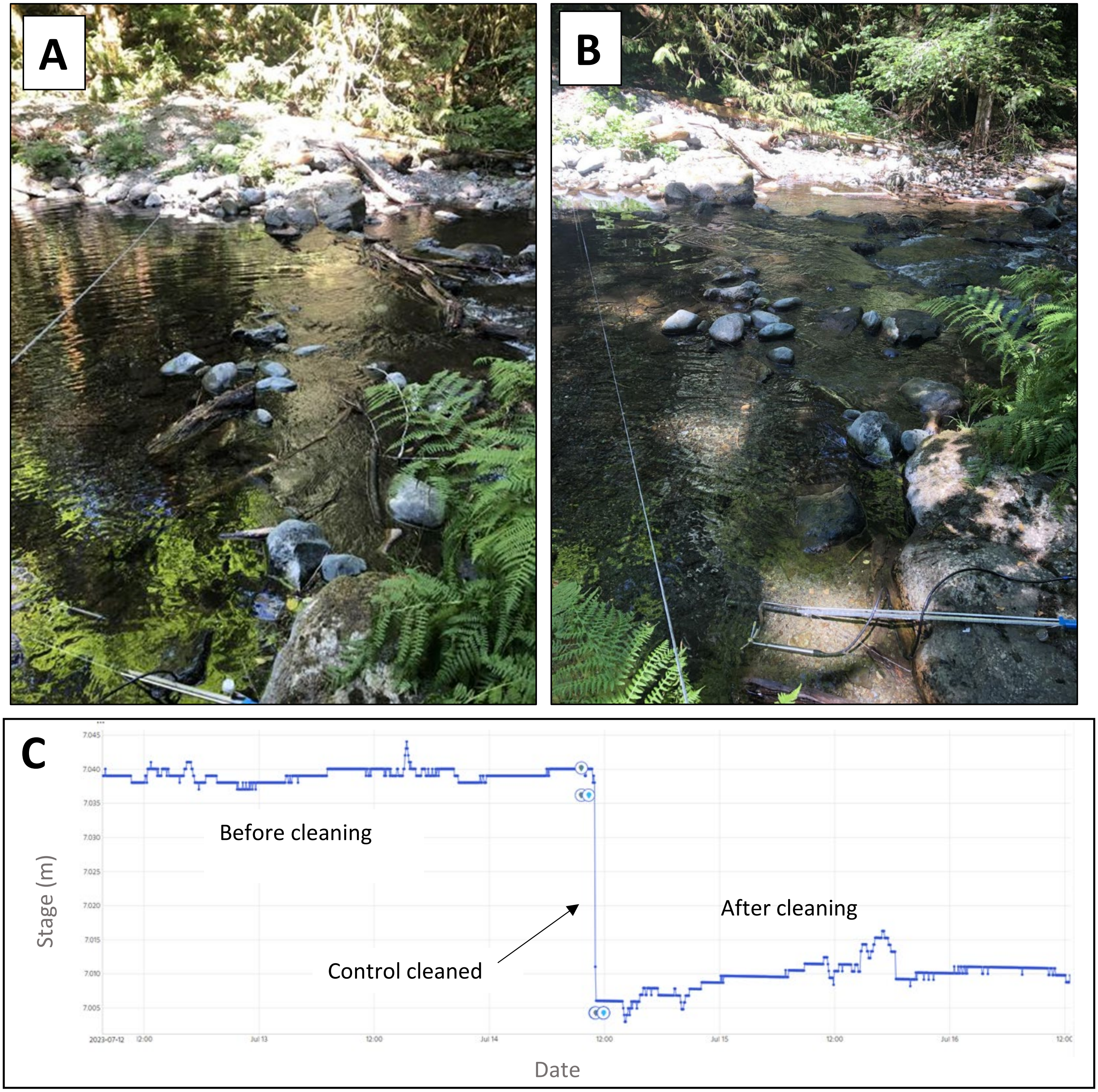


Figure 5. Photos of a control before cleaning (A) and after cleaning (B). Note the backwatering effect of the debris (sticks) trapped among the rocks in the riffle. This effect can greatly impact the water level (stage) measured by the logger in the gauging pool (C).

Appendix 4.7. Manual of BC Hydrometric Standards (RISC Manual) Grading Guidelines

*Goal for Flow Network stations is minimum Grade C

Table 1-1: Standards requirement criteria

Data Quality Indicator	**Standard Grade for Discharge Data**					
	Grade A/RS	**Grade A**	**Grade B**	**Grade C**	**Grade E** (Estimated)	**Grade U** (Unknown data quality)
Instrumentation						
Meter calibration (When applicable)	N/A	Meter calibrated, and the validity of calibration is confirmed	Meter calibrated, and the validity of calibration is confirmed	Meter calibrated, and the validity of calibration is confirmed	Meter previously calibrated but validity of calibration is not confirmed	Undefined
Meter field verification (When applicable)	N/A	At least annually	At least annually	Less often than annually	See Notes below	Undefined
Water level gauge reading/sensor accuracy	Either 3 mm or 0.2% of effective stage, whichever is greater	Either 3 mm or 0.2% of effective stage, whichever is greater	Either 5 mm or 0.2% of effective stage, whichever is greater	1 cm or better	See Notes below	Undefined
Field Procedure						
Minimum number of benchmarks	3	3	3	3	See Notes below	Undefined
Number of verticals in manual flow measurements when current meter is used	N/A	20 or more (if sufficient channel width to meet minimum flow meter panel widths) and not more than 10% of total flow in each panel	20 or more (if sufficient channel width to meet minimum flow meter panel widths) and not more than 10% of total flow in each panel	10 or more (if sufficient channel width to meet minimum flow meter panel widths) and not more than 20% of total flow in each panel	See Notes below	Undefined
Number of manual flow measurements per year	Minimum of one field measurement for rating verification	5 or more over adequate range of streamflows	3 or more over adequate range of streamflows	2 or more over adequate range of streamflows	See Notes below	Undefined

Table 1-1: Standards requirement criteria (Contd.)

Data Quality Indicator	**Standard Grade for Discharge Data**					
	Grade A/RS	**Grade A**	**Grade B**	**Grade C**	**Grade E** (Estimated)	**Grade U** (Unknown data quality)
Number of benchmark elevation and ref. gauge elevation level checks per year	2 or more, or at least once when ref. gauge and the benchmarks have been documented to be stable	2 or more, or at least once when ref. gauge and the benchmarks have been documented to be stable	2 or more, or at least once when ref. gauge and the benchmarks have been documented to be stable	1 or more	See Notes below	Undefined
Data Calculation and Assessment						
Discharge rating accuracy /Rating curve shift deviation threshold	<5%	<7%	<15%	<25%	See Notes below	Undefined
Data and calculation reviewed for anomalies	Yes	Yes	Yes	Yes	See Notes below	Undefined
Results are compared with other stations and/or other years for consistency	Yes	Yes	No	No	See Notes below	Undefined

Table 1-1: Standards requirement criteria (Contd.)

Data Quality Indicator	Standard Grade for Stage/Water Level Data Only				
	Grade A	**Grade B**	**Grade C**	**Grade E** (Estimated)	**Grade U** (Unknown data quality)
Instrumentation					
Water level gauge reading/sensor accuracy	Either 3 mm or 0.2% of effective stage, whichever is greater	Either 5 mm or 0.2% of effective stage, whichever is greater	1 cm or better	See Notes below	Undefined
Field Procedure					
Minimum number of benchmarks	3	3	3	See Notes below	Undefined
Number of benchmark elevation and ref. gauge elevation level checks per year	2 or more, or at least once when ref. gauge and the benchmarks have been documented to be stable	2 or more, or at least once when ref. gauge and the benchmarks have been documented to be stable	1 or more	1 or more	See Notes below
Data Calculation and Assessment					
Data and calculation reviewed for anomalies	Yes	Yes	Yes	See Notes below	Undefined
Results are compared with other stations and/or other years for consistency	Yes	No	No	See Notes below	Undefined

[Notes: Hydrometric data should be graded as “E” (i.e., Estimated) when stations are operated using RISC Standards (i.e., water level or discharge data could be either Grade A/RS, A, B, or C) but data were estimated because of instrument anomalies, shift correction, missing data, or rating-curve extrapolation beyond maximum or minimum measured discharge level. Hydrometric data should be graded as “U” (i.e., Unknown data quality) when RISC hydrometric standards are not followed for data collection and/or data quality is unknown]

Appendix 4.7.1 Setting up the Flow Tracker2

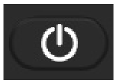
Refer to the FT2 User's Manual for more detailed set up instructions.
https://www.geotechenv.com/Manuals/SonTek_Manuals/sontek_flowtracker2_manual.pdf

Figure 1. FT2 components

Wading rod attachment:

1. Assemble metric wading rod and attach the FT2 probe end to the wading rod base tightly, using the screw provided. Ensure probe end does not wiggle when gentle pressure is applied.
2. Remove the yellow head unit from case, attach the probe cable to the base of the head unit (if not already attached) and ensure pins are lined up and cables fit snugly together.
3. Mount the head unit to the top of the wading rod using the black plastic attachment.
4. Install battery pack into head unit (if not already attached) and power the unit on.

Turning on/off:

The On/Off power button for the FlowTracker2 can be accessed on the right side of the keypad, 3rd row from the top. 

To start system, hold the power button until the LCD screen turns on.
To shutdown system, hold the power button until a message is displayed to shut down the handheld. To activate sleep mode, press the power button once shutdown. To wakeup system, press any button on keypad.

It's good practice to remove the battery cartridge at the end of each workday for inspection and charging/replacement.
If the system is not used or stored for long periods, remove the batteries to prevent unnecessary draining and potential battery leakage.

Navigation Keys:

Left Soft Key – The text directly above the soft key is associated with the key operations and allows the user to perform the following actions:

- return to previous menu,
- select action based on text displayed
- restart or cancel current operation

Right Soft Key - The text directly above the soft key is associated with the key operations and allows the user to perform the following actions:

- start a new measurement
- accept data entry or operation
- create new template
- access the quality control menu

Enter Key – The enter key (square) is situated between the four arrow keys

- Select the menu item in the menus
- Activate or deactivate running average during the beam-check data collection. This information is only displayed graphically and will not be stored in the data files.

Figure 2. FT2 keypad layout

Left & Right arrow:

- select different options under each parameter in configuration
- select station type or velocity method in measurement
- select station in data collection

Top & Bottom arrow:

- scroll through the menu options
- select files or templates
- display graphics during data collection
- scroll through the measurement, station and discharge summary reports

Numbers (0-9) – Numbers will default to the first option on the key if only numerical values are required in the entry field.

- Menu shortcut (number next to text) associated with each menu item.
- Configuration of instrument such, data collection settings, quality control parameters and discharge settings
- Enter measurement data such, station location, depth and other information

Letters (A-Z) – Letters will default to the first option on the key if letters are required in the entry field.

- Create file and template names
- Enter comments at a station, supplement data or overall measurement

Backspace – The key allows the user to perform the following delete actions:

- Text or values in user entry fields
- Data file folder with all content or individual data files

Customize settings and confirm FT2 operation:

Before beginning a measurement, confirm that the date and time on the instrument are correct.

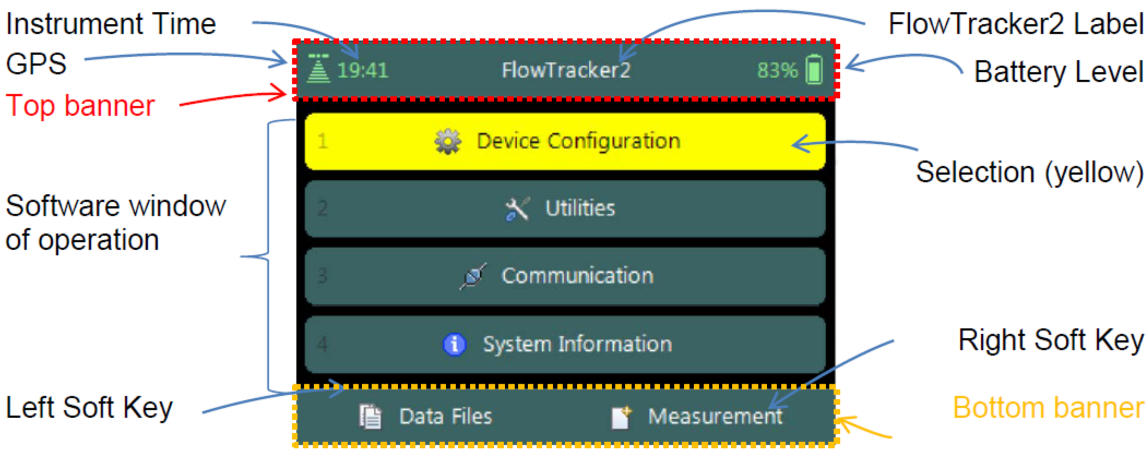


Figure 3. FT2 main menu screen layout

"Device Configuration" menu:

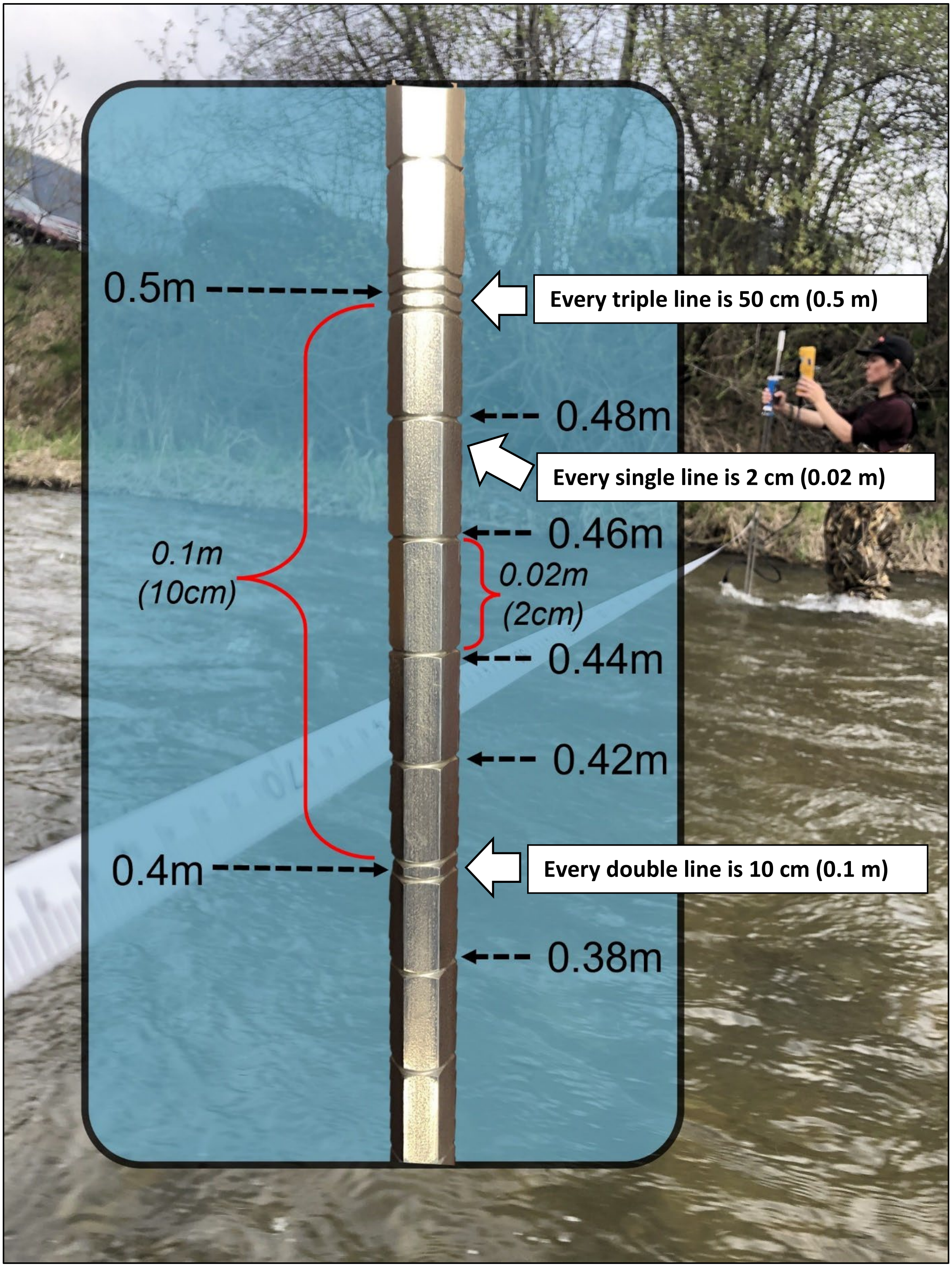
- Under the "User Interface" menu, you can change the font size (requires restart)
- Under the "Application Settings" menu, you can change units, naming conventions, etc.
- Under "***Disharge*** Templates" menu, you can save desired settings for a particular project to
- use quickly again next time (this can also be done in the office)

"Utilities" menu:

- If needed: under "1. System clock", update the time/date.
- If needed: under "2. Recorder", check remaining memory.
- If needed: under "3. Battery Data", check battery status.

Press the right soft key ("Measurement") to navigate to the measurement set up menu.

Appendix 4.5. Interpreting metal wading rod depths

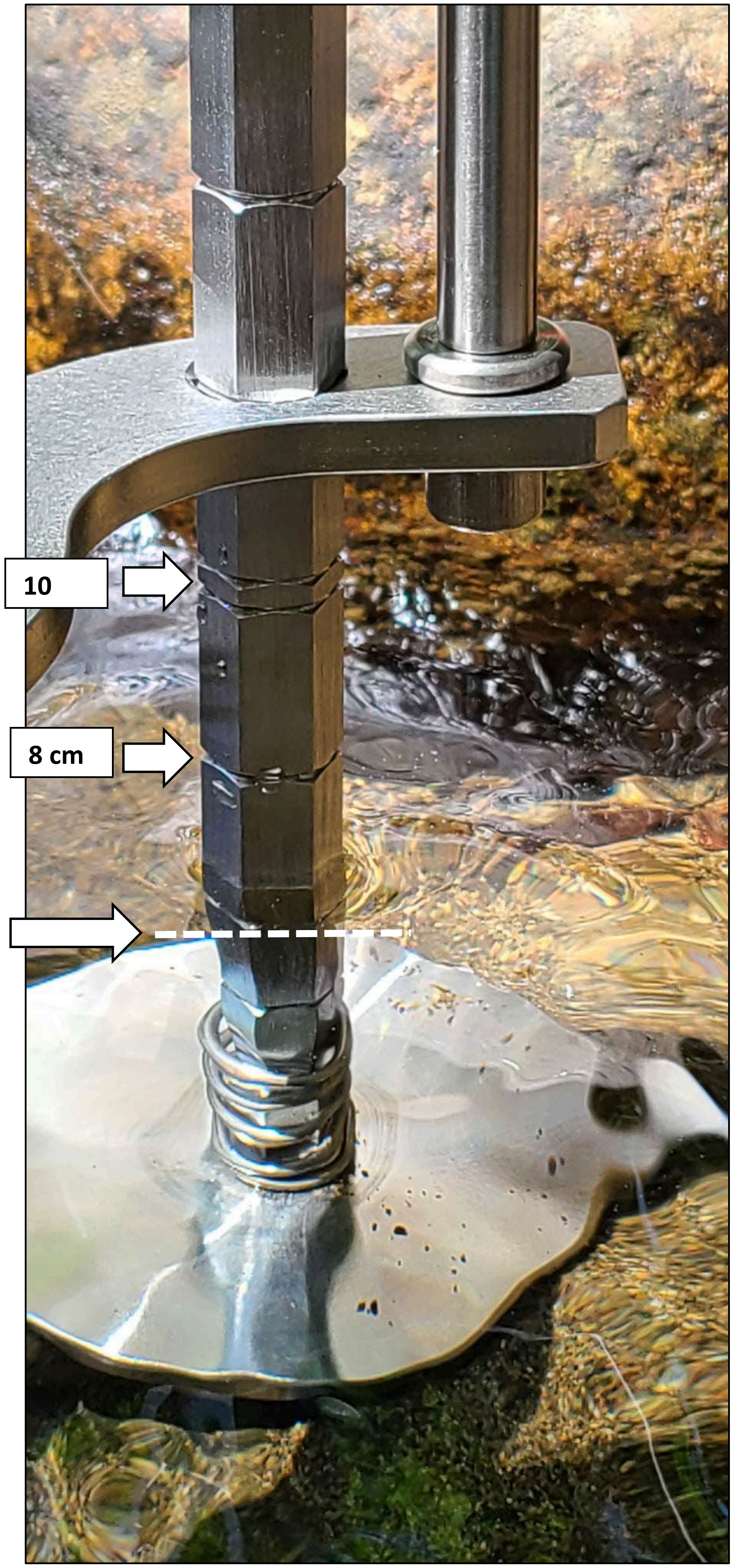


It is easiest to start at the top and work your way down

E.g., find the closest triple line (50cm) to your depth and count down by double lines (10cm) or single lines (2cm) until you reach the water level

In this photo, the depth is very shallow, so we'll start at the closest double line which is equal to 10 cm

The water level is in between lines (8 cm and 6 cm) so we can measure it at 7 cm or 0.07 m



Appendix 4.7.1 SNR, Tilt, Velocity Angle Interpretations

Many of the contents of this document are derived from the Flow Tracker2 User Manual: https://www.geotechenv.com/Manuals/SonTek_Manuals/sontek_flowtracker2_manual.pdf

Refer to this manual for more detailed information on SNR, tilt, velocity angle, and other Quality Control Parameters.

2 Signal to Noise Ratio (SNR)

SNR is the most important Quality Control parameter. It measures the strength of the acoustic reflection from particles in the water. Without sufficient SNR, the FlowTracker2 cannot measure velocity. SNR is reported in units of dB (decibels). The FlowTracker2 can operate reliably with SNR **as low as 4 dB**, although the noise in individual measurements will increase. For the best operating conditions, SNR should be **greater than 10 dB**.

Low SNR indicates a lack of suspended material in the water. For clear water, seeding material can be introduced to increase SNR (e.g. walking upstream of your measurement location to stir up sediment *before* a measurement is completed).

Common SNR Alerts:

1. **Low SNR** - If the SNR of any beam is below 4.0 dB
    - Improve SNR
2. **Approach Low SNR** - If the SNR is between 4 and 7 dB
    - Improve SNR
3. **Beam SNRs Not Similar** - When the difference between any two beams is greater than SNR Threshold
    - This may indicate interference from an underwater obstacle or a potential problem with the probe
    - At the first alert, repeat the measurement (perhaps after moving probe location)
    - If the problem persists, run Beam Check to evaluate FlowTracker2 operation in more detail.
4. **Large SNR Variation** - When the standard deviation of the SNR of each beam during the measurement is greater than a fixed threshold of 5 dB
    - This may indicate interference from an underwater obstacle, a highly turbulent environment, or highly aerated water
    - At the first alert, repeat the measurement (perhaps after moving probe location)

- If the problem persists, evaluate the measurement environment. In some cases, large variations may be unavoidable and may not impact the quality of velocity data

5. **SNR Threshold Variation** - When SNR for a new measurement differs from the mean of three or more completed stations in this measurement by more than SNR Threshold
    - This may indicate interference from an underwater obstacle or some other dramatic change in stream conditions
    - At the first alert, repeat the measurement (perhaps after moving probe location)
    - If the problem persists, evaluate the measurement environment to look for any potential cause for the change in SNR

3 Tilt

Tilt angle is defined as the angle of the wading rod relative to the vertical. The tilt angle is only an indicator and not used in any calculations.

A tilt angle of 0° means that the wading rod is vertical. A good measurement will typically show variations in wading rod angle, but with **all angles less than about 5°.** If the wading rod angle exceeds **Max Wading Rod Angle**, a warning is issued and you are prompted to realign the wading rod.

4 Velocity Angle

Velocity angle is defined as the direction of flow relative to the X direction. The FlowTracker's X-axis is always held perpendicular to the tag line (Figure 1).

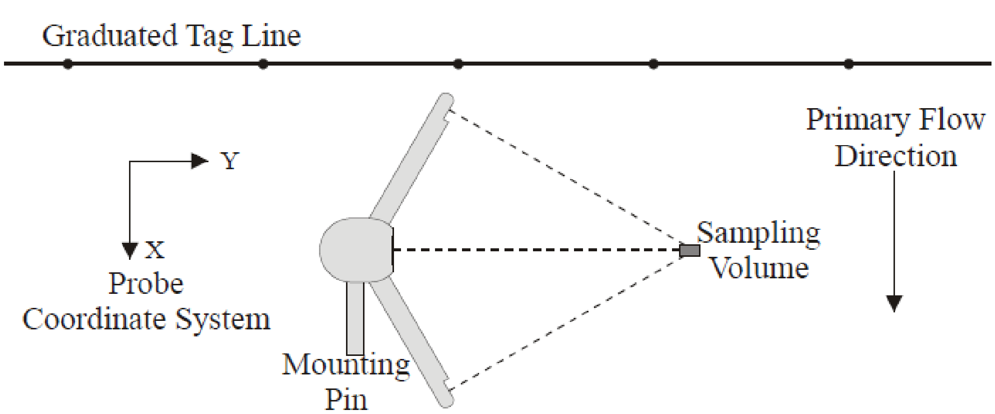


Figure 1. Flowtracker2 probe orientation relative to stream flow.

For an ideal discharge measurement site, flow should be perpendicular to the tag line used to define the cross section. A good measurement site will typically show some flow variations, but with **all angles less than about 20°.** Only the X component of velocity (Vx) is used for discharge calculations. This ensures proper discharge measurements regardless of the flow direction.

Velocity Angle > QC Alert - the Velocity Angle is larger than Max Velocity Angle

- Evaluate the measurement site to verify the measured angle is realistic.
- Consider repeating the measurement if the angle does not appear reasonable (perhaps after moving probe location).
- For large velocity angles, consider moving the measurement site. May indicate a non-ideal measurement environment

FlowTracker2 QC Warnings Field Guide

Warnings in **RED** should be fixed before continuing with the measurement. If these cannot be fixed, abort the measurement. Warnings in **GREEN** should be examined – if all solutions are attempted or the warning is realistic, then proceed with the measurement.

Warning	Description	Why?	What To Do?
Approach Low SNR	SNR is 4 to 7 dB	Clear water, very sediment-rich or poor water conditions	• Repeat or move to a different location
Beam SNRs Not Similar	Difference in SNR between two beams is greater than SNR Threshold	Beams are not seeing similar water quality. Can be caused by obstacles (plants, rocks) or malfunction in probe	• Check for obstacles (plants, rocks, etc.) • Repeat or move to a different location • Perform AutoQC or Beamcheck to ensure proper probe function
Boundary Interference	Indicates quality of measurement (Poor, Fair, Good, or Best)	Poor or Fair quality usually indicates obstacles at or near measurement location	• Check for obstacles • Repeat or move to a different location
Fractional Depth > 1	The ratio between the measurement and total depth is greater than one.	The entered measurement depth is deeper than the water depth. This error will not appear for a standard discharge (0.2/0.6/0.8) measurement.	• Check that measurement depth was entered correctly
High % Spikes	Percent of spikes exceeds Spike Threshold	Highly variable flow, obstacles upstream or at the station, vibrations or moving the probe during data collection	• Check for obstacles upstream or at station • Make sure probe isn't moving during measurement • Repeat or move to different location
High Stn % Discharge	The percent discharge at this station is larger than the Max Station Discharge	High velocity at station, or too much spacing between stations	• Add an additional station in between current and last station
Large SNR Variation	SNR varies more than expected during a measurement	Unusually high or low sediment load at station, or obstacles interfering with probe	• Check for obstacles • Check for changes in sediment load (is the warning realistic?)
Location Outside Edge	Station location is outside edge location	The entered station location is outside of the edge location	• Check that station location was entered correctly
Low SNR	SNR is below 4 dB	Clear water, very sediment-rich or poor water conditions	• Repeat or move to a different location • Perform AutoQC or Beamcheck to ensure proper probe function
Rod Angle > QC	Rod angle is greater than Max Wading Rod Angle	Rod is not vertical during measurement	• Repeat measurement, ensuring rod is vertical (pay attention to indicator during measurement)

FlowTracker2 QC Warnings Field Guide

Warning	Description	Why?	What To Do?
SNR Threshold Variation	Difference in SNR between this station and previous station is greater than SNR Threshold	Sudden changing of water conditions, or obstacles interfering with probe	• Check for obstacles • Repeat or move to a different location • Check for sudden changes in water conditions and sediment load (is the warning realistic?)
Standard Error > QC	Calculated standard error (σV) for this station is greater than the σV Threshold	Velocity variability is greater than 0.010 m/s.	• Check for obstacles • Make sure probe isn't moving during measurement • Repeat or move to a different location
Station Order	Station location out of sequential order	Stations are usually measured in sequential order	• Make sure you meant to measure the station out of order, otherwise correct the station location
Stn Spacing > QC	Spacing between this and previous station exceeds Max Depth Change %	Distance between this station and last station is too large	• Check that station location was entered correctly • Add an additional station in between current and last station, if necessary
Velocity Angle > QC	Flow angle is greater than Max Velocity Angle	The angle of flow at this station is not perpendicular to tag line	• Check that the flow angle is not perpendicular (is this warning realistic?) • Repeat or move to a different location • DO NOT turn wading rod to align probe with flow. Proceed with measurement despite a high flow angle warning if moving to a new location is not possible
Water Depth > QC	Depth at this station differs by more than Max Depth Change % from previous station.	The entered water depth at this station is very different from the previous station	• Check that water depth was entered correctly

Fields in BLUE represent values that can be set by the user during the measurement by going to Menu > Settings > Quality Control Settings or Discharge Settings.

Note: If you notice any of these warnings appearing frequently using one FlowTracker2 system at different sites, please contact Technical Support (858-546-8327 or support@sontek.com) as your instrument may have an issue.