AOS STANDARD OPERATING PROCEDURE: DSC – CONFIGURATIONS, SETTINGS, AND COLLECTION METHODS FOR STREAM DISCHARGE MEASUREMENTS USING THE FLOWMETER METHOD

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/14/2024	ECO-07082	Initial release

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1 DESCRIPTION

1.1 Purpose

The Standard Operating Procedure (SOP) described in this document is an extension of the AOS Protocol and Procedure: Stream Discharge (RD[04]). This document outlines the procedures for:

- Flowmeter settings and configuration
- Flowmeter calibration
- Collecting discharge measurements using the Flowmeter Method

1.2 Scope

This document provides a change-controlled version of an Observatory procedure. Documentation of content changes (i.e. changes in particular tasks or safety practices) will occur via this change-controlled document, not through field manuals or training materials.

1.3 Applies To

The procedure described in this document is used in the following protocols:

Doc #	Title
NEON.DOC.001085	AOS Protocol and Procedure: DSC - Stream Discharge

1.4 Acknowledgments

NEON acknowledges the definitive work on this topic, “Discharge Measurements at Gaging Stations, U.S. Geological Survey Techniques and Methods Book 3, Chapter A8” by D. Phil Turnipseed and Vernon B. Sauer (2010).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain higher-level information that is implemented in the current document. Examples include designs, plans, or standards.

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.000724	Domain Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.004104	NEON Science Data Quality Plan

2.2 Reference Documents

Reference documents contain information that supports or complements the current document. Examples include related protocols, datasheets, or general-information references.

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.002652	NEON Data Products Catalog
RD[04]	NEON.DOC.001085	AOS Protocol and Procedure: DSC – Stream Discharge
RD[05]	NEON.DOC.005390	Datasheets for AOS Protocol and Procedure: DSC – Stream Discharge

2.3 Acronyms

Acronym	Definition
LEW	Left edge of water (looking downstream)
REW	Right edge of water (looking downstream)

2.4 Definitions

Area (A): The cross-sectional area of a stream or a subsection of a stream. For a rectangular subsection, it is the width times the depth. For an irregular cross-section, it is the summation of a series of subsection areas, or the width times the average depth.

Control: A specific section of a stream channel, located downstream from the staff gauge that controls the relation between gauge height and discharge at the staff gauge.

Depth (D): The depth of the water column at a particular point, measured from the water surface to the stream bottom.

Discharge (Q): (streamflow) The volume of water flowing through a cross-section during a given period of time, measured in units of volume per unit time, such as cubic feet per second, cubic meters per second, liters per second, gallons per minute, or acre-feet per year. Discharge is computed as velocity x area.

Fulcrum: Software tool used to create NEON electronic data entry applications.

Left edge of water (LEW): The edge of the stream that is on the observer's left when looking downstream.

Right edge of water (REW): The edge of the stream that is on the observer's right when looking downstream.

ServiceNow: Software tool used for problem/incident tracking and resolution.

Stage: (i.e. stream height, water level) Height of a stream or river relative to a fixed point. Stage can be measured at a single point in time by reading the water level on a calibrated staff gauge mounted in the stream channel, or by using a weighted measuring tape to measure down from a fixed point to the water surface. Stage can also be measured continuously with a pressure, optic or acoustic sensor, or a staff gauge.

Station: A location along the stream discharge measurement transect where velocity and depth are measured, and area and streamflow are calculated. Station, or vertical, spacing is dependent on the wetted width of the channel and velocity distribution throughout the transect.

Thalweg: The line that connects the deepest part of the active channel.

Transect: The stream cross-section under the measuring tape stretched across the measuring section, along which velocity measurements are made to compute discharge.

Velocity (V): The speed of water flowing past a point along the transect, measured in units of rate, such as liters/meters per second.

Wetted Width: Width of a stream channel that contains water. As water levels fluctuate in streams, the wetted width may as well, depending on the cross-sectional shape of the channel.

3 SAFETY

This document identifies procedure-specific safety hazards and associated safety requirements. It does not describe general safety practices or site-specific safety practices.

Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD[02]) and EHS Safety Policy and Program Manual (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

While measuring discharge using the Flowmeter Method, adhere to the following safety considerations:

- Activities in streams should only be performed when flow conditions are safe.
- Never enter the channel when it is unsafe to do so.
- Be aware of the potential for downstream debris transport as stage increases.
- Logs, debris, cobble, and boulders can be very slippery and unsafe to walk on. Ensure that all staff have proper PPE to reduce risk and maximize safety.

4 PERSONNEL

4.1 Training Requirements

All technicians must complete protocol-specific training as required in the Field Operations Job Instruction Training Plan (AD[04]). Additional protocol-specific required skills and safety training are described here.

Personnel should be:

- Trained in Water Safety Awareness.
- Trained in collecting wading discharge measurements.
- Adept at wading in streams.

4.2 Specialized Skills

The following expertise is required to collect discharge measurements using the Flowmeter method:

- Experience assessing velocity distribution across the cross-section of a stream.
- Experience using a top-setting wading rod for flowmeter positioning and depth measurement.
- Experience using a flowmeter to measure stream velocity.
- Experience reading a staff gauge for water level measurement.
- Experience using the mobile application for data entry.

5 STANDARD OPERATING PROCEDURES

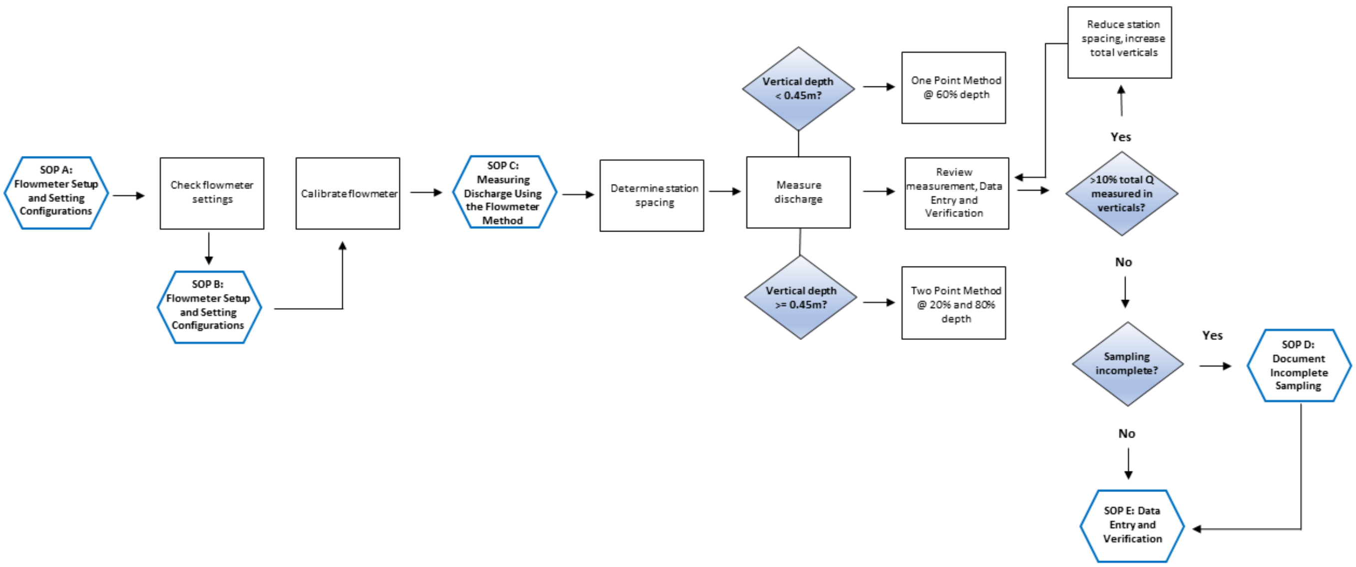

Figure 1. A high level workflow diagram that visually shows how the separate SOP sections are sequentially connected.

SOP A Flowmeter Setup and Setting Configurations

It is critical that the flowmeter settings are configured correctly in the handheld unit as incorrect settings will negatively affect data quality. Follow the steps below to setup the flowmeter and ensure that flowmeter settings are correct prior to measuring discharge.

Two interchangeable handheld flowmeter models are currently at use at NEON, the HACH FH-950 and the Ott MF-Pro. The following steps detail the required settings for these models.

1. Ensure that the latest firmware version is installed on the flowmeter.
    a. Version v2.05 and later are required to perform the NEON discharge protocol.
    b. Turn the flowmeter on by pressing and holding the "ON/OFF" button on the outside of the handheld instrument. Note that the meter may first run a diagnostic check to ensure it is connected to the sensor. Once complete, the Start Menu will appear on the screen (**Figure 2**).

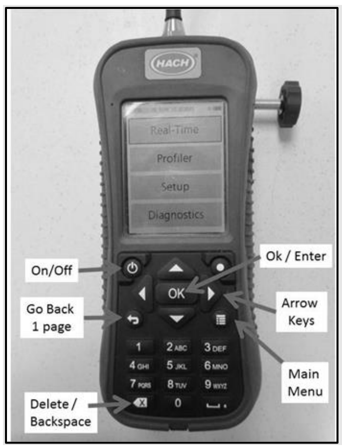

Figure 2. The HACH FH950 flowmeter with displayed Start menu.

    c. To check which firmware version is currently installed on the flowmeter, from the Start menu, select "Diagnostics" > "About" (**Figure 3**).

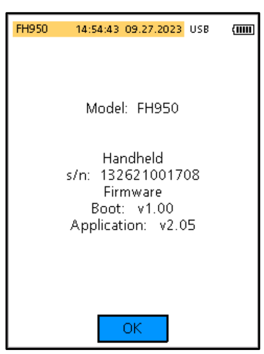

Figure 3. Diagnostics screen on the HACH FH950 flowmeter indicating the firmware version (v2.05).

   d. Reference the manufacturer website for specific instructions on firmware availability and upgrades.

   e. Ensure that all saved data have been downloaded off the flowmeter prior to a firmware update as this will delete all files that were stored on the unit.

2. Attach the flowmeter to the wading rod.

   a. Ensure the hexagonal wading rod is attached properly to the rod base. The base and the rod screw together; see that the connection is tight if the parts appear loose.

3. Attach the sensor bulb of the flowmeter to the mounting shaft of the wading rod using the thumbscrew (**Figure 4**).

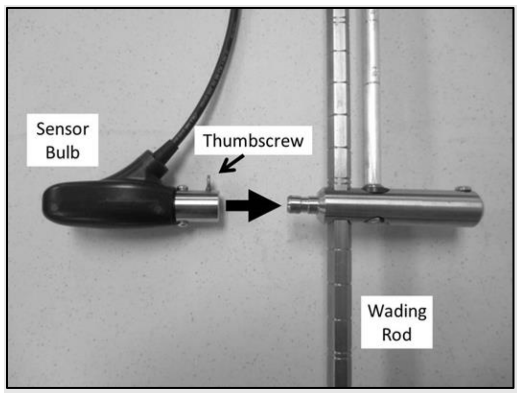

Figure 4. The sensor bulb of the flowmeter is attached to the wading rod by tightening the thumbscrew.

4. Review the flowmeter settings.

   a. Reference **Table 1** for required parameter settings. The discharge measurement will contain critical errors if flowmeter settings are not correctly configured.

   b. For the Wet/Dry Threshold setting, “20” is the default setting. If the specific conductivity of the water is very low (i.e. < 15 us/cm) the flowmeter may not function properly, and this value will need to be adjusted. An indication of the threshold value being too high is when the flowmeter measures 0.000 m/s velocity rates in flowing water.

      i. To troubleshoot:

         1) Record a “dry conductivity reading” with the flowmeter out of the water.

         2) Record a “wet conductivity reading” with the flowmeter submerged in a bucket of water from the stream.

         3) Set the Wet/Dry threshold value to the average of the “dry” and “wet” conductivity reading values recorded.

4) Note that specific conductivity fluctuates with stream stage. If the threshold value is adjusted be sure to update it again during the next discharge measurement bout based on current stream conditions.

5) If problems persist and velocity cannot be measured using any threshold value, create a sampling impractical record in the Fulcrum app and submit a ServiceNow ticket to Science.

Table 1. Measurement parameter settings for the flowmeter. *The "Measurement Reference" parameter may not be available for MF Pro flowmeter models; **See information in the steps above regarding troubleshooting "Wet/Dry Threshold" values.

Measurement Parameter	Measurement Unit
Units: Velocity	m/s
Units: Flow	Liters/s
Units: Depth	m
Units: Area	m^2
Filter Parameters: Fixed Period Averaging Time	40 seconds
Filter Parameters: Pre-filter Rank	5
Flow Calculation Method	Mid-section
Measurement Reference*	Top
Measurement Resolution	0.001
Auto Zero Mode: Auto Zero Depth	ON
EMI	60 Hz
Wet/Dry Threshold	20**
Clock	Local date/time

SOP B Flowmeter Calibration

Prior to each discharge measurement, the flowmeter must be "zero-calibrated" using the following steps:

1. Fill a 5-gallon bucket with water from the stream where you will be measuring discharge. Using the local water will ensure that the ionic strength of the "zeroing water" is the same as the water being measured.
2. Place the sensor bulb of the flowmeter in the water. Keep the sensor bulb positioned in the center of the bucket (or as close to it as possible). The sensor bulb must be kept a minimum of 3-inches from the sides and bottom of the bucket as well as the surface of the water.
3. Allow water to settle for 1-2 minutes to stabilize. Water in the bucket must remain still throughout the calibration process.
4. Turn on the flowmeter and select "Setup" from the Start menu.
5. Select "Velocity Calibration" > "Zero Calibration".
6. Allow the flowmeter to cycle through a calibration reading and, once complete, verify that the unit reads a velocity of 0.00 m/s. Note that -0.00 m/s is acceptable.
7. If the calibration velocity is 0.00 m/s, return to the Start menu.
8. If the final calibration velocity does not equal 0.00 or -0.00 m/s at the end of the calibration cycle (100%), repeat previous calibration steps.
    a. Reasons for calibration errors may include:
        i. The sensor bulb tip was touched or is dirty and needs to be wiped off with a dry cloth.
        ii. Flowmeter batteries are low.
        iii. The water in the 5-gallon bucket was shifted during the calibration procedures.
        iv. The sensor bulb tip was too close to the bucket edges or the water surface during calibration procedures.
9. If, after five attempts, the flowmeter cannot be zero-calibrated, the flowmeter should not be used, and discharge should not be measured. If possible, use another flowmeter that can be zero-calibrated to measure discharge. If discharge cannot be measured, create a sampling impractical record in the app and submit a ServiceNow incident ticket to Science.

SOP C Measuring Discharge Using the Flowmeter Method

C.1 Setting up the Discharge Transect and Delineating Station Spacing for Depth and Velocity Measurements

Discharge surveys at NEON wadeable stream sites are to be measured from the right to left bank, looking downstream. Velocity measurement stations are to begin at the right edge of water (REW) and extend to the left edge of water (LEW).

To ensure high data quality is collected, velocity measurement stations must be spaced correctly across the stream discharge transect. To determine proper station spacing across a transect, first assess the relevant hydrologic conditions present at the time of the discharge measurement, specifically streamflow magnitude, water surface elevation, and wetted width. The overall goal is to establish as many velocity measurement stations as possible to obtain a complete and well-distributed velocity profile throughout the cross-section. However, stations must not be set so close so that subsequent stations measure the same velocity profile. The location of velocity measurement stations do not need to be equally spaced across the transect. Rather, the locations should be more closely spaced where water velocity and depth are changing most rapidly (this is often at the center of the channel and/or near the banks) to ensure that no more than 10% of the total discharge occurs within a single velocity measurement station. Use the following steps to determine station spacing across the discharge transect.

1. Attach the measuring tape to the permanent stake on the right bank and extend it across the stream so that is perpendicular to the flow. Attach the opposite end to the permanent stake on the left bank.
2. Assess whether streamflow appears to be relatively uniform across the channel. Note the location of any non-laminar streamflow conditions (e.g. water that is flowing in non-parallel vertical layers).
    a. Note the presence of any non-ideal streamflow conditions in the Fulcrum app. If conditions are so egregious as to significantly affect measurement quality, consider re-locating the discharge transect and note this occurrence in the app.
3. Measure the wetted width within the transect (the distance between the REW and the LEW) and enter this value into the Discharge Fulcrum app. The app will calculate the distance between the edge of water locations and provide *suggested* distances between stations. Station spacing should be modified based on flow conditions (**Table 2**) using the following steps:
    a. If the wetted width is >2.00m:
        i. Divide the transect into roughly 20-25 sampling stations.

ii. Space stations evenly and at wider intervals where flow conditions are homogenous and more closely together where flow conditions are non-laminar (**Figure 5**).

iii. Maintain a minimum 0.05m station spacing to avoid duplicate measurements between stations.

b. If the wetted width is ≤ 2.00m:

i. Divide the transect into as many stations as possible without duplicating measurements between stations.

1) Maintain a minimum 0.05m station spacing.

2) Obtaining 20-25 stations may not be possible in very narrow streams, so less sampling stations are permitted. The goal is to obtain a well-distributed velocity profile while avoiding duplicate measurements between stations.

4. All attempts should be made that discharge measured at a single station does not exceed 10% of the total measured discharge across the transect.

a. If non-uniform flow conditions are present (more concentrated areas of high flow within the transect), increase the number of sampling stations so that a higher number of stations are concentrated along the part of the transect with the greatest flow (**Figure 6**). Achieving this standard may be impossible during periods of non-uniform flow conditions and/or during the low-flow regime.

Table 2. Station spacing within the discharge cross-section relative to the wetted width using the Flowmeter Method.

Wetted Width (m)	Station Spacing
≤ 2.00	• Divide the transect into as many stations as possible without measuring duplicate velocity profiles between stations. • Maintain a minimum 0.05m station spacing. • Obtaining 20-25 stations may not be possible in very narrow streams. • Ideally, a single station does not account for >10% of the overall total measured discharge, though this can be challenging under certain flow conditions.
> 2.00	• Divide the transect into roughly 20-25 sampling stations. • Space stations evenly and at wider intervals where flow conditions are homogenous and more closely together where flow conditions are non-laminar. • Maintain a minimum 0.05m station spacing to avoid duplicate velocity measurements between stations. • Ideally, a single station does not account for >10% of the overall total measured discharge, though this can be challenging under certain flow conditions.

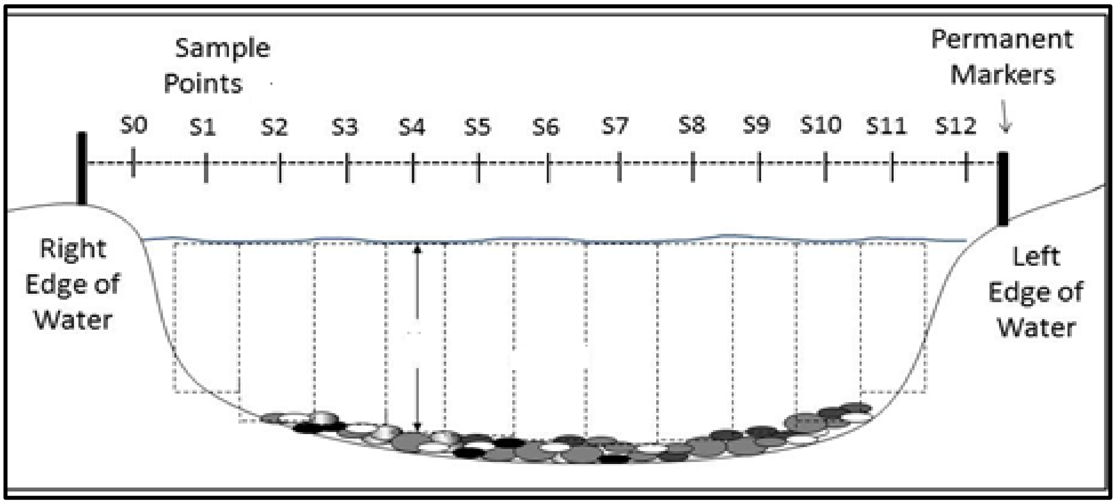

Figure 5. Example of well-distributed stations across the discharge cross-section using the Flowmeter Method. S0-S12 represent stations and dashed rectangles represent sub-sections. Note that laminar flow is assumed in this example.

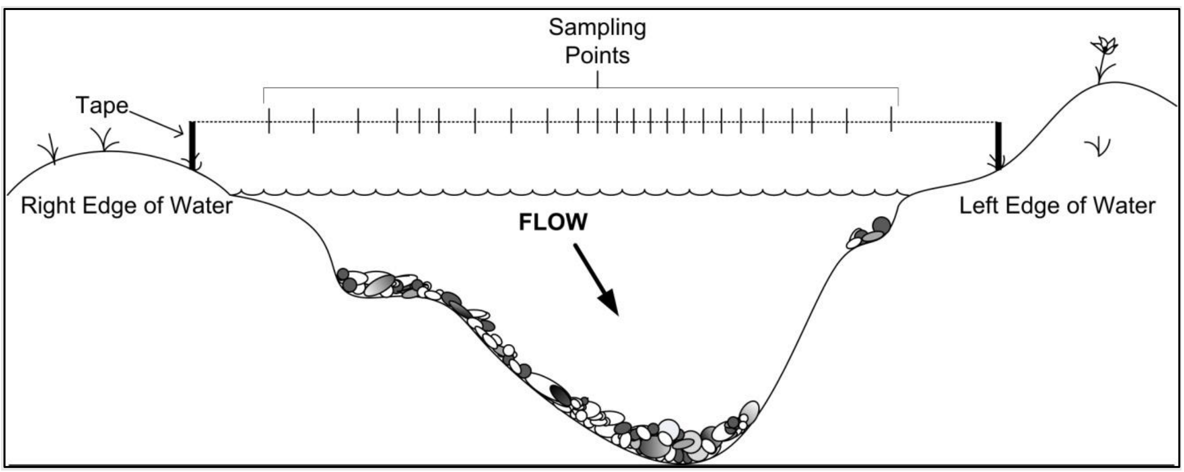

Figure 6. Example of uneven station spacing across a discharge transect at a wadable stream site using the Flowmeter Method. Note that non-laminar flow is assumed in this example.

C.2 Collecting Velocity, Depth, and Distance Measurements

All data and metadata relevant to the discharge survey are entered in the Discharge Fulcrum app. See the Manual for Fulcrum Application (AOS): Stream Discharge for details on how to use the app and its functionality.

At each measurement station along the discharge transect the handheld flowmeter is used to measure velocity, the wading rod is used to measure depth, and the meter tape is used to measure distance. The app then calculates discharge at each station based on these measurements and calculates total discharge as a summation of all station discharge values.

Once station spacing along the discharge transect has been determined and all metadata have been entered into the app, complete the following steps to perform the discharge measurement.

1. Navigate to the first station along the meter tape at the right edge of water (REW) and click the "Add Station Information" button on the app to begin auto-populating records for data entry.
2. At the REW Station:
    a. The "Edge/Obstruction" value will auto-populate to "Right" for Station 1 as each discharge measurement must begin at the REW.
    b. Enter the "Distance to Vertical (m)" value in the app by reading the number on the meter tape (to the nearest 0.01m) that is above the REW.
    c. The "Station Depth" value will auto-populate to "0" for the REW station as this is the point where the water surface hits the bank and depth is zero.
    d. The "Stream Profiling Method" field will auto-populate based on the "Station Depth" value.
        i. The 1 and 2 point methods are not relevant to the REW station because velocity is not measured at this location.
    e. The "Velocity at Vertical" value will auto-populate to "0" for the REW station as Depth = 0.
    f. Note that the Stage value entered in the parent record will auto-populate for each child record. Update this value accordingly if stage levels are changing during the discharge measurement. The app will average all stage child records and update the parent record following the completion of the measurement.
3. At all stations between the REW and LEW (left edge of water):
    a. Navigate to the next station along the meter tape.
        i. Maintain a minimum of 0.05m between stations to ensure that unique velocity profiles are measured.
    b. The "Edge/Obstruction" value will auto-populate to "Open Water" for stations between the REW and LEW.
    c. Enter the "Distance to Vertical (m)" value by recording where the station location falls along the meter tape (to the nearest 0.01m).
    d. Enter the "Station Depth" value by measuring the depth at the station using the wading rod (round to the nearest 1 cm).
        i. Position the base of the flowmeter rod flat on the bottom of the streambed and note where the water surface meets the graduated marks etched into the flowmeter rod.

1) The depth at each station must be ≥ 0.06m to allow for full submersion of the sensor bulb.
2) Graduated marks are etched into the flowmeter hexagonal rod to allow for water depth measurement.
3) The marks are delineated into 2 cm (one band mark), 10 cm (two band marks – the bottom double band), and 50 cm (three band marks).
4) The “Stream Profiling Method” field will auto-populate based on the “Station Depth” value.

ii. Set the flowmeter based on the Depth value at the station.

1) The 1-point method is used for Depths between 0.06m and 0.45m.
   1) If the 1-point method is required, a single velocity measurement must be taken at 60% depth (relative to the water surface equaling 0m).
2) The 2-point method is used for Depths ≥ 0.45m.
   1) If the 2-point method is required, two velocity measurements must be taken at 80% and 20% depths. The Fulcrum app will indicate the 80% and 20% flowmeter settings.

iii. See boxed text in **Figure 7** for examples on how to set the flowmeter using the 1-point and 2-point methods.

e. Enter the “Velocity at Vertical” value by recording the 40 second average velocity calculated by the handheld flowmeter.

i. ‘Real-Time’ mode is used to collect velocity measurements on the handheld flowmeter. This function allows the user to prompt the flowmeter to begin taking continuous measurements of velocity which are averaged over 40 seconds to produce the “Velocity at Vertical” value at each station.

ii. Turn on the flowmeter by pressing the ON/OFF button on the device.

iii. On the main screen choose “Real-Time” (**Figure 8**).

iv. Select “Fixed Period Avg” as the desired setting (**Figure 8**).

v. Enter “40” as the Fixed Period Averaging time (**Figure 8**).

1) Press “OK” for the instrument to begin taking velocity measurements.

vi. A new screen will appear which indicates that the flowmeter is now taking velocity measurements (**Figure 8**).

1) Note in **Figure 8** the black line moving across the time vs. velocity graph that represents velocity over time as well as that the Velocity (m/s) value in the lower window = 0.000 (this indicates that the duration of the measurement is < 40 seconds and average velocity has not yet been calculated).
2) Hold the rod steady and in the correct position for 40 seconds.

vii. Once 40 seconds have elapsed, a red vertical line will appear moving across the graph along with a velocity value in the "Velocity (m/s)" window (**Figure 8**).

1) Enter this value in the "Velocity at Vertical" field of the app (or in the "Two-point method, 0.2/0.8 velocity" field if the 2-point method is used).

viii. Once the velocity value(s) has been entered into the app, immediately select the "Done" button on the lower left screen (**Figure 8**).

1) Note that if you wait >40 seconds to click "Done", the flowmeter will populate another 40-second averaged velocity value as it is measuring velocity in continuous mode.

ix. Once "Done" is selected you will be returned to the main screen and these steps can be repeated to measure velocity at the next station (or at the next two-point method depth if the 2-point method is used) .

f. Repeat Step 3 at each subsequent station until the LEW is reached.

g. See **Figure 9** for best practices while collecting velocity measurements at each station along the discharge cross-section.

4. At the LEW Station:

a. In the "Edge/Obstruction" field, enter "Left".

b. Enter the "Distance to Vertical (m)" value in the app by reading the number on the meter tape that is above the LEW.

c. The "Station Depth" value will auto-populate to "0" for the LEW station as this is the point where the water surface hits the bank and depth is zero.

d. The "Stream Profiling Method" field will auto-populate based on the "Station Depth" value.

i. The 1-point method is used for Depths between 0.06 and 0.45m.

ii. The 2-point method is used for Depths ≥ 0.45m.

1) These methods are not relevant to the LEW station as no velocity is measured here.

e. The "Velocity at Vertical" value will auto-populate to "0" for the LEW station as Depth = 0.

5. Once LEW data has been entered, select "Yes" in the "Calculate Final Discharge?" field of the app.
   a. The app will display the total measured discharge calculated from all stations and discharge calculated at each station for review.
   b. The app will also show stations with discharge values that contained >10% of the total measured discharge for the bout.
      i. If possible, return to the station that contains >10% discharge and insert an additional station nearby so that the total discharge per vertical is reduced.
         1) Concentrate additional stations in areas with more concentrated flow (maintain a minimum station spacing of 0.05m).
         2) This requirement may be very difficult to achieve in shallow, narrow, and/or irregularly shaped stream channels.

One-Point Velocity Method Example:

- Station Depth = 0.25m
- The one-point velocity method requires no calculations by the user.
- Line up the 2 on the sliding rod (represents 0.20m total station depth) with the 5 on the handle of the fixed hexagonal rod (represents 0.05m total station depth).
- The flowmeter is now set at 60% of station depth 0.25m and a velocity measurement can be made.

Two-Point Velocity Method Example:

- Station Depth = 0.74m
- The Fulcrum app will provide the 80% depth measurement by dividing the station depth by two (0.74 / 2 = 0.37m) and rounding to the nearest centimeter (0.37m).
- Line up the 3 on the sliding rod (represents .30m of the total station depth) with the 7 on the handle of the fixed hexagonal rod (represents 0.07 m of the total station depth).
- The flowmeter is now set at 80% of station depth 0.74m and a velocity measurement can be made.
- The Fulcrum app will provide the 20% depth measurement by multiplying the station depth by two (0.74 * 2 = 1.48m) and rounding to the nearest centimeter (1.48m).
- Line up the 14 on the sliding rod (represents 1.40m of the total station depth) with the 8 on the handle of the fixed hexagonal rod (represents 0.08m of total station depth).
- The flowmeter is now set at 20% of the station depth at 0.74 m and a velocity measurement can be made.

Figure 7. Examples of how to set the wading rod using the One-Point and Two-Point Velocity Methods.

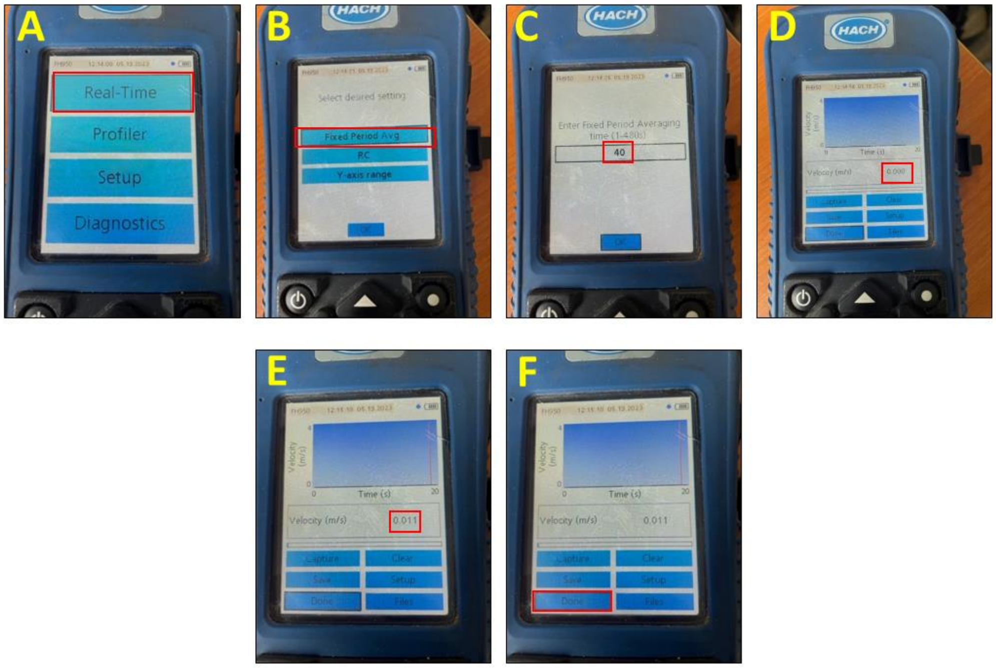

Figure 8. Screenshots showing the steps to measure velocity in Real-time mode. Step D shows the flowmeter while velocity is being averaged (Velocity = 0.00); Step E shows the flowmeter once velocity has been averaged after 40 seconds (Velocity = 0.011); Step F shows the "Done" button, which must be selected within 40 seconds of Step E or else the flowmeter will produce a new velocity value. Once Step F is complete, the screenshot in Step A will appear and the user can conduct another velocity measurement.

<u>Best practices while collecting velocity measurements at each station along the cross-section:</u>

- The wading rod is set to the correct depth and is in the correct position for measurement prior to the instrument beginning velocity measurement collection.
- The wading rod is held directly in front of the operator (at arm's length).
- The sensor bulb on the flowmeter is pointed directly upstream into the flow and perpendicular to meter tape.
- The operator is standing to the side of the velocity sensor (not upstream or downstream). Standing directly in front of or behind the flowmeter creates conditions that bias velocity measurement.
- Minimum station spacing = 0.05m
- Minimum depth at each station between the REW and LEW = 0.06m.

Figure 9. Best practices for collecting velocity measurements at each station.

C.3 Evaluating the Discharge Measurement in the Field

Following the discharge survey, the measurement record must be evaluated in the field prior to leaving the site. Review all fields in the app to ensure that no data transcriptions errors occurred. Ensure that all metadata was entered correctly and any additional information relevant to the discharge measurement is contained in the Remarks field. In particular, ensure that:

- If possible, no station contains >10% of the total measured discharge.
- All depth and velocity values are correct.
- The total measured discharge value makes intuitive sense given the stage and background knowledge of the site.
- All metadata is entered correctly, particularly the staff gauge height.

SOP D Document Incomplete Sampling Within a Site

Incomplete sampling documentation for the Configurations, Settings, and Collections Methods for Stream Discharge Measurements Using the Flowmeter Method SOP is identical to that described in RD(04). Consult this protocol for incomplete sampling procedures.

SOP E Data Entry and Verification

Data Entry and Verification for the Configurations, Settings, and Collections Methods for Stream Discharge Measurements Using the Flowmeter Method SOP is identical to that described in RD(04). Consult this protocol for data entry and verification procedures.

6 REFERENCES

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APPENDIX A EQUIPMENT

The following equipment is needed to implement the procedures in this document. Equipment lists are organized by task. They do not include standard field and laboratory supplies such as charging stations, first aid kits, drying ovens, ultra-low refrigerators, etc.

Table 3. Equipment list – Discharge Using the Flowmeter Method.

Supplier/Item No.	Exact Brand	Description	Purpose	Quan-tity
Hach	Y	Velocity flow meter	Measures stream velocity	1
Fondriest Environmental, Inc.	Y	Top setting wading rod	Houses flowmeter and measures depth	1
	N	Meter tape (minimum length must be greater than the wetted width of the channel)	Delineates the discharge transect	1
	N	Stakes	Anchoring survey tape	2
	N	Clamps	Attaches and secures meter tape to stakes	2
	N	5 Gallon Bucket	Flowmeter calibration	1
	N	Waders (per person)	Safe wading	1
	N	Personal Flotation Device (at sites where required)	Safe wading	1
	NA	Discharge protocol and SOP	Used as a reference during discharge measurement	
	NA	Tablet with Discharge Fulcrum application	Data collection	1
	N	Hand tools (flathead screwdriver, etc.)	Assist in attaching the flowmeter to the wading rod	1