STANDARD OPERATING PROCEDURE FOR STREAM FLOW MEASUREMENT

WATER QUALITY

State of Utah
Department of Environmental Quality
Division of Water Quality

Revision 1.0
Effective July 2021

Foreword

Utah Division of Water Quality (DWQ) Standard Operating Procedures (SOPs) are adapted from published methods or developed by in-house technical experts. This document is intended primarily for internal DWQ use. This SOP should not replace any official published methods.

Any reference within this document to specific equipment, manufacturers, or supplies is only for descriptive purposes and does not constitute an endorsement of a product or service by DWQ. Additionally, any distribution of this SOP does not constitute an endorsement of a procedure or method.

Although DWQ will follow this SOP in most instances, there may be instances in which DWQ will use an alternative methodology, procedure, or process.

The methodology detailed below is the protocol followed by DWQ's monitoring staff and verified by DWQ's Quality Assurance officer.

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REVISION PAGE

Date	Revision #	Summary of Changes	Sections	Other Comments
5/1/14	0	Not applicable	Not Applicable	Put previous procedures into new standardized format, began document control/revision tracking.
5/1/19	1	Updates to use and limitations of flow meters	1	
5/21/21	1.1	Updated language, grammar, and structure	All	Clarified and revised
5/21/21	1.1	Removed Marsh McBirney references	All	No longer use this flow meter at DWQ

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1.0 SCOPE AND APPLICABILITY

This document presents the Utah Division of Water Quality's (DWQ) Standard Operating Procedure (SOP) for performing stream flow measurements. Flow is also referred to as discharge and is measured routinely at each water quality sampling site whenever feasible. Flow measurements are performed for natural (rivers, streams) and engineered (outfalls, ditches, canals, impounded wetland outlets, etc.) surface water bodies. Flow data is used by DWQ scientists and engineers for a variety of purposes including but not limited to:

- understanding the effect of hydrologic condition on aquatic life uses
- determining pollutant loading into receiving waterbodies
- setting permit requirements for discharge of treated wastewater
- understanding groundwater/surface water interactions
- characterizing current water quality conditions and detecting long-term changes

This SOP applies to any DWQ monitor, non-DWQ cooperator, or volunteer performing flow measurements. This SOP covers taking flow measurements at both wadable and non-wadable sites using the following equipment/methods. The difference between non-wadable and wadable sites is subjective and should be determined by personnel based upon access and current conditions.

Generally, if the stream is wadable, use the SonTek/YSI FlowTracker Handheld-ADV® or other handheld flow meters. When the stream is non-wadable, use the StreamPro ADCP (also known as a Q-boat).

Flow can also be determined without a flow meter. Although not discussed in the main body of this SOP, flows can be calculated using the following methods:

- Use of the neutrally buoyant object method combined with an estimate or measure of the channel cross-section (see Appendix 2).
- Location of a waterfall, discharge pipe, or similar pour-over and time filling a bucket of known volume.
- Use of a flume or V-notch weir to create a small spillway and use the timed filling method. Direct calculation of flow can be made with several types of flumes or weirs using a tape or staff gage.

Segment of circles calculation may also be used when there is a known pipe diameter and velocity. Teledyne ISCO FlowCalc is a useful app available for Android and Apple to find flow conversions.

Estimates, when appropriate. Flow meters used by DWQ may not be appropriate to use when the water levels are shallow.

If a stream is too shallow (≤ 4 cm), or the stream has large cobbles, turbulence, heavy vegetation, etc., AND it appears to flow less than 5 cfs, a flow estimate is acceptable. The flow measure is recorded as "Estimated" on the data sheet and in the data file.

Important Considerations:

- A flow should always be measured at a site regardless of the water level, if possible. Even if the flow is <5 cfs crews should attempt to measure flow if conditions permit. Estimates should only occur when conditions are too shallow for the flow meter or other unforeseen circumstances (e.g. equipment malfunction, etc.). If an estimation is inadequate or the flow >5 cfs, crews need to record a comment in the field file explaining why a flow rate could not obtained.
- Flow data is critical for TMDL (total maximum daily load) monitoring. Monitors must make every possible effort to obtain flow measurements for non-gaged TMDL sampling locations, as long as conditions for obtaining the measurement are safe.
- When developing sampling portfolios for a monitoring run, the project field team leader should identify those sampling sites which are gaged by a non-DWQ entity/agency. Before a monitoring run, the project field team leader should check with the managing entity to ensure the gage is still operating and if not, make the necessary changes to the sampling portfolio. Additionally, monitors should perform a flow measurement at a gaged site if, upon arrival to the site, the gage appears to be damaged or non-functioning. Make every effort to determine the sampling sites for which flow data is being monitored by a non-DWQ entity (e.g. wastewater treatment plant outfall or USGS gaging station) prior to beginning a sampling trip. If possible, monitors should record the flow gage reading or obtain a gage height (staff plate or wire weight gage) in the field, contact the wastewater treatment plant operator for discharge data during the time of sampling, or note the USGS (or other entity) gage number in the field notes/field sheet so discharge at the time of sampling may be queried at a future date.
- Some sampling sites are continuously monitored for flow by gaging stations installed and maintained by Utah DWQ (pressure transducers), although the data is not accessible in real-time. At these locations, monitors should perform the flow measurement and gage inspection and then notify the DWQ field monitor responsible for the gaging station that a flow measurement was performed at that site (see DWQ's SOP for Pressure Transducer Installation and Maintenance).
- The information discussed in this SOP is not a substitute for the official flow meter product user manual. Consult the appropriate manual for a complete guide of the proper use, maintenance, and troubleshooting of discharge measuring equipment (see **Section 12.0** - References).

2.0 SUMMARY OF METHOD

2.1 Wadable Sites using a Sontek/YSI FlowTracker Handheld-ADV®

A stream cross-section is established and the Flow Tracker is used to determine velocity at each point measured. The meter is attached to a wading rod used to measure depth and keep the meter properly positioned within the current. The monitor faces the meter upstream while standing downstream of the meter and a tagline. The Flow Tracker uses acoustic Doppler technology to measure 2D flow in a small sampling volume located at a fixed distance (10 cm or 3.9 in.) from the probe. Sound generated by the transmitter bounces off suspended particles in the water. This reflected sound returns to the receivers, is averaged together by the processor, and results in water velocity measurements that are recorded at a rate of one per second. At the end of the measurement, the FlowTracker calculates the discharge.

2.2 Non-Wadable Sites using a Teledyne RD Instruments StreamPro Acoustic Doppler Current Profiler (StreamPro ADCP)

A StreamPro (also called a Q-boat) is used when stream depth or velocity is such that a monitor cannot safely enter the water to take a flow measurement. Q-boats allow the measurement of multiple flows at a set location in a short amount of time and therefore allow more accuracy from multiple measurements which is sometimes useful in wadable streams as well. The unit is designed for operation in stream depths ranging from 15 cm to 6 m (0.5 to 20 ft). The instrument is pulled across the stream as the monitor walks across a bridge or the unit can be attached to a tagline or pulley system and operated from the bank if a bridge is not present. The unit uses acoustic Doppler technology and bottom tracking to measure current velocity from the top of the water column to the bottom at the same instant with a 5 cm resolution. Data is collected continuously as the unit is pulled across the stream and is sent wirelessly by Bluetooth to a laptop running WinRiver software.

3.0 DEFINITIONS

ADCP:	acoustic Doppler current profiler
ADV:	acoustic Doppler velocimeter
Discharge:	A term used in this SOP interchangeably with “flow”. This is the volume of water flowing past a fixed point per unit of time. Units are typically cubic feet/second (ft3/s or cfs) or cubic meters/second (m3/s).
EPA:	Environmental Protection Agency
Flow/discharge measurement:	A manual measurement of flow/discharge performed by a DWQ monitor/cooperator/volunteer.

PC:	Personal computer
USGS:	United States Geological Survey
Velocity:	Distance water travels per unit time. Units are typically centimeters or meters/second (cm/s or m/s) or feet/second (ft/s).

4.0 HEALTH AND SAFETY WARNINGS

Hazardous conditions potentially exist at every waterbody. If unfavorable conditions are present at the time of sampling, it is recommended that the sampling be rescheduled. If hazardous conditions arise during sampling, such as lightning, high winds, rising water, or flash flood warning, personnel should cease sampling and move to a safe location.

When working in Utah and other warm climates, precautionary steps should be taken to avoid heat induced illnesses such as heat stroke or heat exhaustion.

Use caution when working in waders as drowning hazards exist.

Take appropriate precautions when operating equipment and working on, in, or around water, as well as possibly steep and unconsolidated banks, bridges, or edges of ponds/lagoons. All field crews should follow DWQ health and safety procedures and be equipped with safety equipment such as proper wading gear, personal flotation devices (PFDs), gloves, first aid kits, cellular phone, etc.

Use caution when sampling from a bridge or boat and take appropriate actions to make the situation as safe as possible; suspend the sampling if conditions are unsafe.

5.0 CAUTIONS

Always be observant of potential debris floating from upstream that could potentially damage equipment and/or cause harm to the operator.

Use caution when handling flow equipment. Flow meters must be placed in a travel case or in a safe place within a vehicle to prevent damage during transport.

Submersion of any of the flow meter's electronic housing is strongly discouraged by the manufacturer.

The flow meter should be kept as level as possible during the measurement.

If the electronics in the StreamPro reach a temperature of 50°C, the Bluetooth connection will likely be lost. When performing discharge measurements on very hot days, be aware of this issue; the instrument may need to cool down.

6.0 INTERFERENCES

The physical makeup of a stream may prevent an accurate flow measurement. If the stream is shallow and has a substrate dominated by cobble, a FlowTracker will have difficulty reading the speed of particles. When establishing the cross section, look for an area of laminar, smooth flow with minimal obstructions. Obstructions, including large rocks, can be moved out of the way of the cross section, but only before flow measurements begin, never during the measurement. The StreamPro works best with uniform straight stream reaches, stream bottoms made up of smaller substrate material with little or no aquatic vegetation or debris, little turbulence, no standing waves or "boils", depths between 15 - 600 cm (.5 - 20 feet), and velocities <6-7 ft/s.

An equipment test must be performed each day prior to taking a flow measurement with the FlowTracker or StreamPro to ensure the equipment is operating properly.

For wadable sites, be sure to place the flow meter downstream of the tape measure and be sure to stand downstream of the flow meter.

Discharge measurements performed on low-velocity streams with the StreamPro can be highly variable. Research has shown dramatic increase in variability when flow velocities are < 0.8 ft/s (Blanchard 2005). The manufacturer recommends that if water velocity is <20 cm/s (0.66 ft/s) and the depth is <1.0 m (3.3 ft), the operator should use the StreamPro software's "Low Noise Profiling Mode, or Mode 13" to reduce variability. For all other conditions, use the standard profiling mode.

7.0 PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

DWQ personnel performing water sampling must be familiar with sampling techniques, safety procedures, proper handling, and record keeping. Samplers are responsible for attending refresher meetings held each spring/summer to review procedures and techniques. New staff will be trained in the field by DWQ trained personnel.

Cooperators are required to read this SOP annually and acknowledge they have done so via a signature page that will be kept on-file at DWQ along with the official hard copy of this SOP (see **Appendix 1**).

Monitors must read through the product manuals for the discharge equipment described in this SOP (see Section 12.0 – References) prior to their training session as well as keep these manuals on-hand in the field, as this SOP does not cover all details regarding equipment setup and use, troubleshooting, precautions, software setup and use, and downloading/reviewing of data.

Monitors have the responsibility of maintaining flow meters and flagging the equipment if it is in need of repair.

8.0 EQUIPMENT AND SUPPLIES

FlowTracker:

- ❑ Meter and rod with case
- ❑ Copy of this SOP
- ❑ User manuals
- ❑ Tape Measure (10ths of ft)
- ❑ Tool box for repairs/replacement
- ❑ Field sheet or notebook
- ❑ Extra Batteries (8 AA)
- ❑ Phillips Screwdriver
- ❑ Waders and boots

StreamPro:

- ❑ Meter with case
- ❑ User manuals
- ❑ Tagline, tow ropes
- ❑ Tool box for repairs/replacement
- ❑ Field sheet or notebook
- ❑ Laptop and charging cables
- ❑ Extra Batteries (8 AA)

9.0 PROCEDURE

9.1 Measurement of Wadable Sites

Use the same procedure when using either the FlowTracker or other flow meters. Establish a stream cross section for flow measurement to occur. Desirable characteristics for the site location include:

- A straight section of stream, away from stream bends
- A stream flow parallel to stream banks
- A constant stream gradient

Note: When the flow is too low to measure with the flowmeter (<5 cfs) estimate the flow and record flow as "E" for estimate on the Trip Sheet.

9.1.1 Procedure for measuring flow in Wadable streams

Attach a tape measure (marked in 10ths of feet) to one stream bank and string it across the stream securing onto the opposite bank. The tape should create a line perpendicular to the flow of the stream. Make sure the tape is tightly stretched across the stream.

Sontek/YSI FlowTracker Handheld-ADV®

Flow Tracker Assembly: See Section 13, **Figure 1**

1. Assemble the wading rod by matching up the two sections of the graduated rod. Raise the adjustable rod up so that it is easier to tighten the graduated rod. Once the graduated rod is assembled and secure, lower the adjustable rod to match up with the threaded section. Twist the top of the adjustable rod to tighten.
2. Attach the SonTek handheld display to the top of the wading rod and tighten using the attached wing nut.
3. Secure the Doppler probe to the appropriate outlet and secure using a Phillips screwdriver or by tightening the wing nut (if available).
4. Determine Measurement Interval
5. If stream width is < 10 feet, collect data every 0.5 feet; and take first reading at 0.25 feet (half of interval) from edge.
6. If stream width is > 10 feet, collect 20 evenly divided measurements across the entire stream; take the first reading at half of the determined interval from edge.

Data Collection

Be sure to position the sensors perpendicular to the tape measure and stand on the downstream side of the tape measure and flow meter when taking measurements. See Section 13, **Figure 2.**

See FlowTracker Manual for detailed instructions and troubleshooting issues.

1. On the FlowTracker handheld, hold on/off button down for one second.
2. Select Main Menu. Setup Parameters and System Functions will be set, refer to FlowTracker manual for details.
3. Press #3 Start Data Run. Follow on screen instructions (use the last four digits of the site code as site name).

Note: If data storage is full, erase the previous data after ensuring the previous data was downloaded to a PC. To do this, return to the "Main Menu" screen. Press #2 "System Functions", then press #3 "Format Recorder". The system will prompt you to press 123 to confirm your decision to erase all previously recorded data.

4. Select the option to run the "QC test" once at the beginning of the day (press "skip test" the rest of the day) to ensure the meter is working properly. Instructions for

performing the QC test will automatically appear on the display: go through the entire QC test. (If the test fails, check the manual and send for repairs as needed).

5. You will be taken to the "Starting Edge" screen. Move to the water's edge of one stream bank and place the wading rod into the water to measure depth.
6. Press the "Set Location" button and enter the distance value (what the tape measure reads at the water's edge).
7. Press the "Set Depth" button and enter the depth of the water level at your starting location (measuring with graduated wading rod). If the bank is sloping, this depth will likely be zero but there will be a depth measurement if the bank is undercut.
8. Press "Next Station" to continue to the next measurement interval.
9. Move FlowTracker to the first measurement location. This location should be at ½ the determined measurement interval. Press "Set location".
10. For example, if the stream is <10 feet wide, intervals will be 0.5 feet. If the edge of water is at 0.0 feet on the tape, the first interval will be at 0.25 feet. The next measurement should be at 0.5 feet beyond the first location, 0.25 feet + 0.5 feet = 0.75 feet.
11. Enter in the actual depth on the handheld and move the adjustable rod to the corresponding measurement depth (60% of depth of water).
12. Press "Measure" to record the flow at that interval. Use the bubble level on the wading rod to keep the FlowTracker parallel to the stream flow. After 20 seconds of recording, the handheld will give the velocity of the interval in feet/second.

Note: If something has caused the accuracy of the flow data to be degraded, error warnings will be displayed. Some common errors include: High Angle, Low SRM, and QC out of bounds. Table 1 includes a summary of common errors and the corresponding solutions.

Table 1. Common error messages and solutions for the SonTek/YSI FlowTracker.

Error Message	**Potential Problem**	**Solution**
Low SNR	Lack of suspended material/high water clarity	Introduce seeding material/accept error
Boundary QC Error	Interference from submerged object	Move objects or relocate transect to clear channel
Spikes	Large Particles or bubbles	Move transect to location with less or no whitewater
High Angle	Improper alignment of probe to flow/ probe not level	Re-align probe directly into flow and level

13. Move to the next location and be sure the handheld shows the correct location. If not, "Set Location".
14. Continue to enter in the depth, move the adjustable rod, and measure the flow for each interval until you reach the last measurable interval. This may be at the opposite

bank or at a point where water is no longer flowing or is flowing backward or in an eddy.

15. At the final location, press "End Section." The FlowTracker will ask for confirmation of the ending section and go through all the errors found for the entire reach.
16. After going through the errors, the main screen will pop up again where the depth of the last interval can be entered. Press the "Set Depth" button to enter in the correct depth for the opposite edge of water and "Set Location" button if location needs to be entered (i.e. last measurement was not performed at the bank).
17. Press "Calculate Discharge" to get the flow in cubic feet per second (ft3/s) for the measured reach. The FlowTracker will ask for confirmation of calculation and then will give the flow (discharge) reading. Verify that the flow value is reasonable before recording.
18. Record flow value on the trip sheet.

9.2 Measurement of Non-wadable Sites

Typically, the StreamPro, will be towed across a transect from a bridge crossing the river/stream. If a bridge is not available, a tagline twice as long as the water body is wide can be stretched from bank to bank, with the StreamPro in the middle. As one person feeds out the tagline, another will pull the StreamPro across the water body. Although the StreamPro measures distance across the transect, initial measurements of the stream edge must be manually entered to define starting and ending points of the transect (edge of water).

StreamPro ADCP

General directions are given here but the operator should follow along with the StreamPro Quick Start Guide for detailed directions incorporating easy-to-follow software screenshots.

Preparation for Deployment

The Q-boat should be assembled according to the StreamPro user manual. See Section 13, **Figure 3**. Visually inspect all components for damage. Check that the transducer beams are aligned correctly and that the transducer head is set to the correct depth (3-6 cm or 1.2-2.4 in. below the water surface) (see manual). A laptop is used along with the Q-boat. Before deploying the Q-boat, it must be powered on and synchronized with the Bluetooth on the laptop; a successful link is indicated by the blue light on the StreamPro electronics housing. When the StreamPro is turned on, the amber light on the electronics housing should not be blinking; if it blinks, the batteries (8 AA) should be replaced. Follow the steps in the user manual to load the default configuration file. Before the StreamPro is put into the water, run the Self-Test (see manual) to verify that the StreamPro's electronics and transducers are functioning. The test can be run with the StreamPro out of the water.

Set up the Configuration File

Once the Self-Test has been passed, the StreamPro will be used to calculate the maximum depth and maximum velocity of the cross section to be measured. Following the detailed instructions in the manual, move the StreamPro across the stream and note the maximum depth and velocity that comes up on the laptop screen. Record these on the field sheet. Edit the configuration file according to the maximum depth and velocity. If the max depth is <1.0 m (3.3 ft) and the max velocity is < 0.25 m/s (0.8 ft/s), select the "Low Noise Mode". If using Low Noise Mode, tow velocity should be half the current velocity. Once the configuration is set, save the configuration file.

Determining Edge Distances

Before collecting data, you must determine the edge locations. Edge measurements are taken as close to the bank as possible where the StreamPro can still read valid data – defined as a minimum of two good depth cells (a cell is a portion of the vertical velocity profile measured by the StreamPro – max depth cells per profile is 20).

1. Attach a line to the StreamPro and lower it into the water.
2. With the StreamPro is close to the bank, select "Start Pinging."
3. Move the StreamPro far enough from the bank to produce a solid two-depth cell measurement (indicated by "Number of Good Bins" = 2 on the display).
4. Mark this location and line the mark up with the center of the StreamPro transducer head. This is the starting point for the transect.
5. Measure the distance between the edge location and the physical edge of the stream; record these distances in the laptop as right and left bank distances. For measuring these distances, use a metered tape lined along the bridge.
6. Repeat finding the edge of the transect (actual physical edge) for the opposite bank along the transect.

Data Collection

Data collection should be performed by 2 people – one to maneuver the StreamPro and the other to operate the laptop. The StreamPro can be towed from a bridge or from shore. Either method is acceptable as long as slow, steady control of the raft is maintained. In a bridge situation, make sure the transect is downstream of the bridge so that the StreamPro is visible to the operator at all times. Make sure to keep an eye out for debris floating from upstream.

1. Move the StreamPro to the starting point and press "Transect Start" to initiate data recording. The StreamPro will start the measurement by confirming the edge of the transect. Once the edge measurements have been taken, the StreamPro will prompt the user to proceed with the transect.

2. Slowly tow the StreamPro across the channel in a straight line perpendicular to the flow. Tow speed should be less than the water velocity for the most accurate and precise measurements. During the measurement, keep an eye on the Good Bins Indicator on the laptop screen. If the indicator is green, three or more cells in the profile are good. Use the indicator to help determine when you need to slow down the StreamPro at the opposite bank, trying not to overshoot the predetermined transect edge. Once again, the StreamPro will confirm the edge of the transect and then stop recording.
3. Repeat the transect measuring process in the opposite direction. Continue until three transects have been recorded.

Data Review

Use the "History" tab to compare the measured transects. If the "Delta Q" value (the difference (expressed as a percentage) between the measured discharge of a particular transect and the mean of all the measured transects) for any measurement file is >5%, that particular file should not be used for calculating the discharge measurement. If at least three good transects are not available, the procedure should be performed for additional transects. If Delta Q is still > 5% after eight transects use best professional judgment to determine if more transects are necessary. A new cross-sectional location may be needed. In this case, repeat the procedure for measuring transects. The software allows the user to deselect transects with high error which can lower the overall error among the selected transects.

10.0 DATA AND RECORDS MANAGEMENT

Flow measurements are recorded and stored on the FlowTracker handheld or laptop from the StreamPro data. Readings are recorded immediately on the Trip Sheet and transferred to the hydrofile and filed in the appropriate DWQ monitoring section shared folder. If data is pre-requested, save the file from the laptop or FlowTracker in the Monitors folder in the DWQ drive. Additional comments should be noted in the Trip Sheet when flow is not collected (i.e. gage or too swift).

FlowTracker: All flow readings are stored in the hand-held unit of the FlowTracker until they are deleted by the user. See the FlowTracker manual for instructions on how to recover stored flow readings. Once flow has been calculated by the FlowTracker, the user should record the reading on the trip sheet and lab sheet associated with the sample trip. Trip sheets containing flow measurements will be scanned in at the end of the sample trip and stored electronically.

StreamPro: Measurement files should be stored on the laptop SD card. After collecting four transects, review the files in the field to ensure that each file (transect) is within 5% of the mean discharge for the set of transects. If any of the transects is outside of the tolerance, additional

transects should be measured. All flow readings are stored in the laptop until they are deleted by the user. Transfer the flow reading onto the trip sheet associated with the sample trip.

Flow measurement data and associated comments should be added to the downloaded electronic hydrofile (field water quality readings) stored in the appropriate Monitoring Section shared folder.

Any flow data measured using the FlowTracker or StreamPro is labeled as "M" for measurement. When an estimate is made on flows below 5 cfs, record the flow as "E" for estimate.

If a flow measurement was not performed by DWQ monitors, the flow field in the hydrofile should be left blank but the "comments" field should be filled in. The comment section of the should be used to annotate when flow data is missing (such as no gage and Q-boat malfunctioning, or no gage and stream was too deep or swift to perform flow measurement, etc.).

11.0 QUALITY ASSURANCE AND QUALITY CONTROL

Most of the quality control for flow measurements involves reviewing data in the field. Resolution of data collection and data quality problems may include selecting a different cross section, measuring additional transects (StreamPro), troubleshooting equipment issues, adjusting settings/configurations, etc.

If variation between measurements (transects) by the StreamPro is greater than 5%, try repeating the measurement by moving the boat more slowly across the stream (typically needs to be done for slow-moving shallow streams). Ideally measurements should take at least 3 minutes but if the velocity is <30 cm/s (about 1 ft/s) or the depth is <1 m (about 3.3 ft), measurements should take longer to increase measurement precision.

Duplicates are not performed for quality control since stream conditions can change rapidly. When a sample site requires duplicate samples, one flow reading will be used for both the original and duplicate samples.

In addition, monitors should consult the United States Geological Survey's quality assurance guidance for the use of ADCPs (Oberg et al. 2005) that includes deployment and use guidance as well as guidelines for data review and rating the quality of discharge measurements.

12.0 REFERENCES

BLANCHARD, STEPHEN F. 2005. GUIDANCE ON THE USE OF RD INSTRUMENTS STREAMPRO ACOUSTIC DOPPLER PROFILER. OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2005.05. U.S. GEOLOGICAL SURVEY.

OBERG, K.A., MORLOCK, S.E. AND W.S. CALDWELL. 2005. QUALITY-ASSURANCE PLAN FOR DISCHARGE MEASUREMENTS USING ACOUSTIC DOPPLER CURRENT PROFILERS - SCIENTIFIC INVESTIGATIONS REPORT 2005-5183. U.S. GEOLOGICAL SURVEY.

Shedd, J., Springer, C., and Clishe, C. 2008. Standard operating procedure for operation of the Teledyne RD Instruments Stream-Pro Acoustic Doppler Current Profiler. Washington State Department of Ecology Environmental Assessment Program. EAP055.

USEPA. 2007. National Rivers and Streams Assessment: Field Operations Manual. EPA-841-B-07-009. U.S. Environmental Protection Agency, Washington, DC. (Section 6.2.6.3 Stream Discharge)

FlowTracker User Manual:
https://www.uvm.edu/bwrl/lab_docs/manuals/Flow_Tracker_Manual.pdf

StreamPro User Documents:
http://www.rdinstruments.com/support/documentation/cc_documents.aspx#spro

StreamPro ADCP Operational Manual:
http://www.otronix.com/kr/data/p03/StreamPro_ADCP_Operationa_Manual.pdf

StreamPro Quick Start Guide:
http://www.teledynemarine.com/Documents/Brand%20Support/RD%20INSTRUMENTS/Technical%20Resources/Manuals%20and%20Guides/StreamPro/StreamPro%20ADCP%20Guide_Jul19.pdf

StreamPro Software User Guide:
http://www.teledynemarine.com/Documents/Brand%20Support/RD%20INSTRUMENTS/Technical%20Resources/Manuals%20and%20Guides/Workhorse/WinRiver%20II%20User%20Guide_Mar20.pdf

Missouri Stream Teams' Volunteer Water Quality Monitoring Notebook (Chapter 2 on Stream Discharge):

http://www.mostreamteam.org/Documents/VWQM/Intro_Notebook/Chapter%2003%20Intro%20Stream%20Discharge.pdf

Related DWQ SOPs:

Standard Operating Procedure for Pressure Transducer Installation and Maintenance

13.0 FIGURES

Figure 1. SonTek FlowTracker Setup

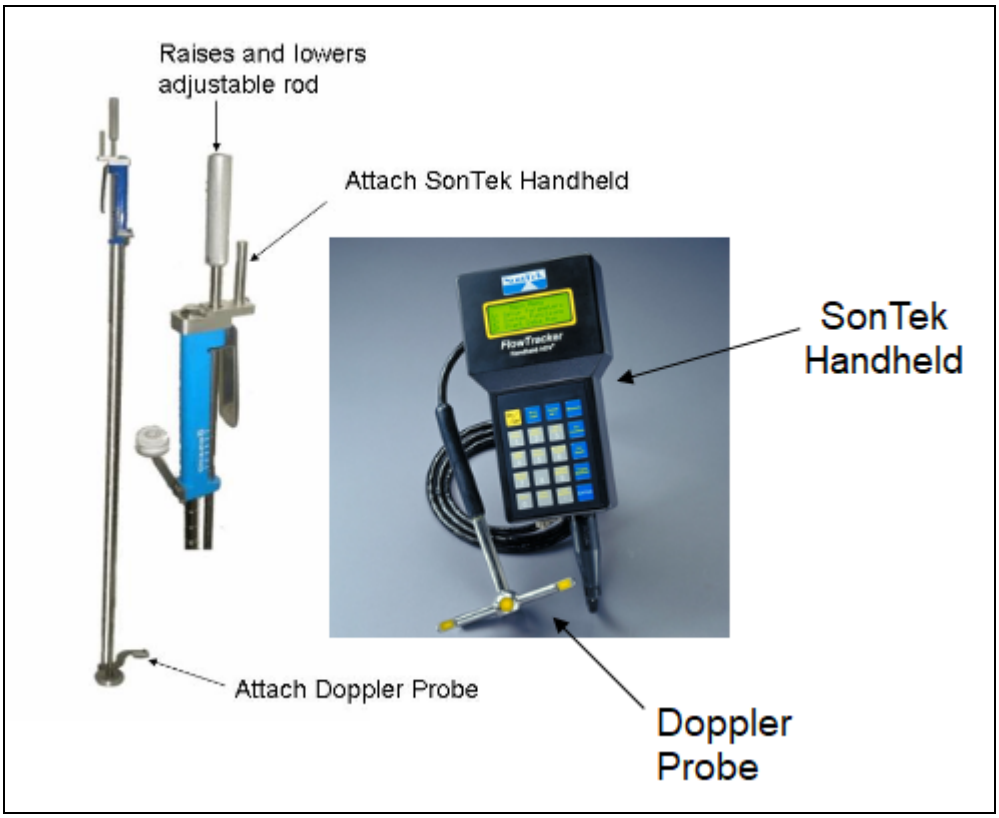


Figure 2. FlowTracker orientation in stream (image from user manual).

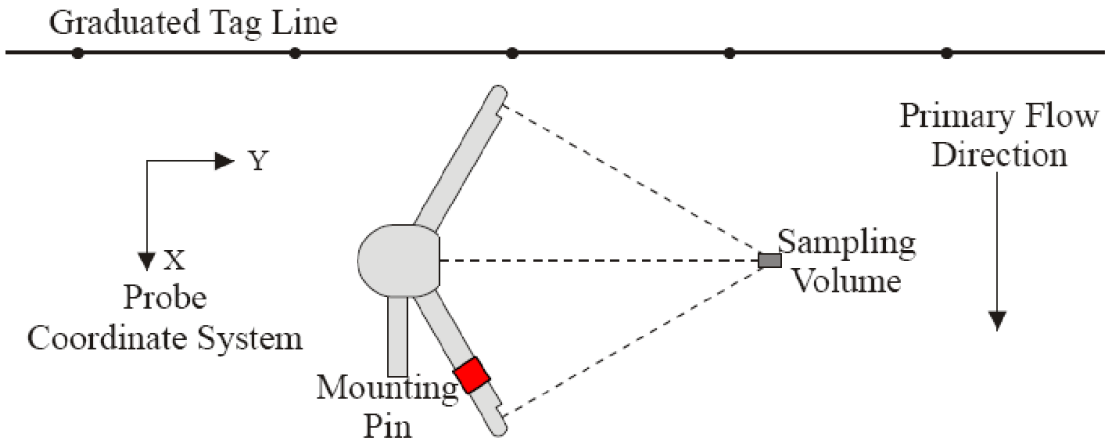
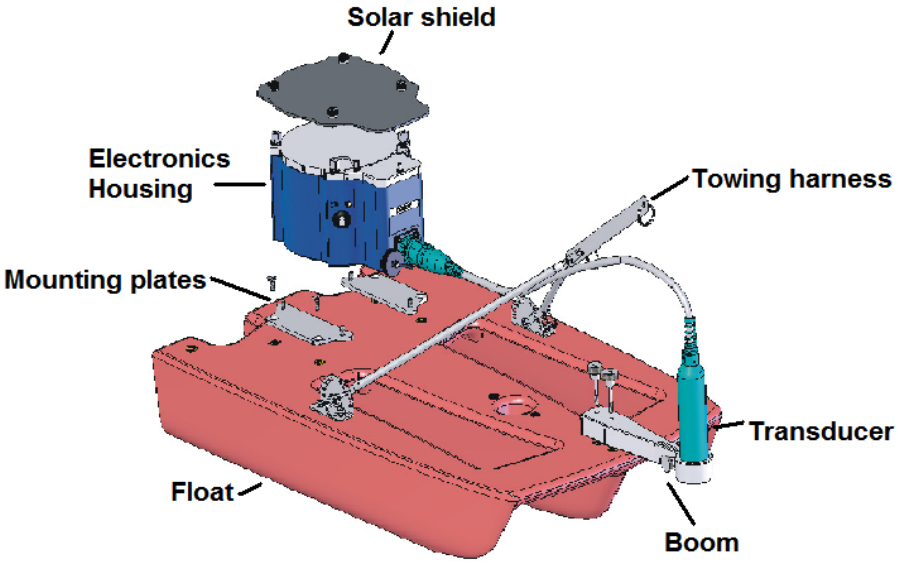


Figure 3. StreamPro assembly.



14.0 APPENDICES

APPENDIX 1 - SOP ACKNOWLEDGMENT AND TRAINING FORM

SOP Acknowledgement Form

This SOP must be read and acknowledged annually, and this form must be kept on file at DWQ.

Document Title:	
Document Revision Number:	
Document Revision Date:	

Please sign below in accordance with the following statement:

"I have read and understood the above referenced document. I agree to perform the procedures described in this SOP in accordance with the document until such time that it is superseded by a more recent approved revision."

Date	Printed Name	Signature

SOP Training Form

Training is required for all new samplers and Refreshers are required annually.

Trainee: Sign below to acknowledge that training on this SOP was received, understood, and all questions/concerns were addressed by the trainer.

Trainer: Sign below to acknowledge that training on this SOP was completed for the individual listed and that trainee is competent to perform the procedures described within.

Date	Trainee Printed Name	Trainee Signature	Trainer Printed Name	Trainer Signature
Management Approval				
Printed Name:				
Signature:				
Date:				

Appendix 2 - DWQ's Standard Operating Procedure for Estimating Stream Flow Using a Simple Float (non-formal SOP quick reference)

1. Scope and application

1.1. Stream flow, or discharge, is the volume of water moving past a cross-section of a stream over a set period of time. Stream flow affects the biology of a stream system, and coupled with the concentration of water chemistry parameters can estimate the load of substances in a stream.

2. Summary of Procedure

2.1. Stream flow is calculated by determining the average cross-sectional area (ft2) and multiplying the area by the corrected velocity determined over an established stream segment (ft/sec). The velocity is corrected due to varying velocities in a stream throughout the water column, depending on stream substrate.

3. Definitions

3.1. Float – A neutrally buoyant object that will be mostly submerged in the stream water.

3.2. Stream segment – A section of a stream measured and marked off to determine velocity with the float.

4. Health and Safety Warnings

4.1. You will need to enter the stream channel to make measurements and calculate velocity. Be aware of stream velocity, water depth and streambed conditions at the prospective stream segment. Do not attempt to measure stream flow if conditions could knock you down or if you could become stuck in the stream substrate. Proceed with caution moving across the stream, or choose an alternate, safer point from which to measure stream flow.

5. Interferences

5.1. Choose a relatively straight, uniform stream segment where the float will not hang up on the streambed or obstructions, or enter slack-water.

6. Equipment and Supplies

6.1. Tape measure
6.2. Yardstick
6.3. Surveying flags/flagging
6.4. Float (An orange works best)
6.5. Net, if necessary, to catch the float
6.6. Stopwatch
6.7. Calculator
6.8. Data form
6.9. Waders

7. Quality Control and Quality Assurance

7.1. Average the cross-sectional area from the starting and ending points of the segment.

7.2. Measure the velocity three times and average the readings

8. Procedure

8.1. Select a stream segment that is deep enough to float the object freely, is free of obstructions, and is long enough that it will take between 10 and 30 seconds for the object to travel. Mark off the start and end and measure this distance, (L in the formula). Note: a round number for the length, i.e. 50 ft., is helpful for the calculations.

8.2. Determine the width of both the starting and ending transects by measuring the distance from shoreline to shoreline by stretching a tape measure (leave the tape in place for the next measure), and enter this value as total width.

8.3. Determine the average depth along the transect by marking off equal intervals along the tape. The intervals should be one-fourth, one-half, and three-fourths of the distance across the stream. Measure the water's depth at each interval point (Fig. 8.1), and enter into the data form. Average these four values to determine average depth.

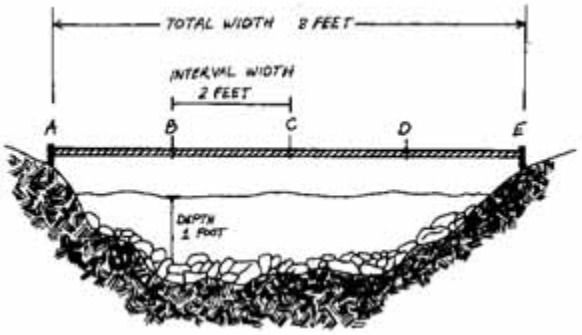


Figure 8.1 A cross-section view to measure width and depth

8.4. Calculate the cross-sectional area of each transect by multiplying width times average depth.

8.5. To determine the average cross-sectional area of the entire stream reach (A in the formula), add together the average cross-sectional area of each transect and then divide by 2.

8.6. Measuring velocity is easiest done with two people, but one person can measure if the current is not too swift.

8.6.1. Gently release the float a few feet upstream of the starting transect so that it may get up to current speed when it passes the start.

8.6.2. Start the timer as soon as it passes the start.

8.6.3. Stop the timer and retrieve the float when it passes the ending transect. Enter the travel time on the data form as trial #1.

8.6.4. If the float gets hung up on a log, rock or other obstruction, repeat that measurement.

8.6.5. Repeat two more times and average the three travel times, giving T.

8.7. Determine the correct coefficient or correction factor based on the streambed (0.8 for rocky-bottom streams or 0.9 for muddy-bottom streams).

9. Data Analysis and Calculations

9.1. Complete the formula: Flow = ALC/T, to determine ft3/sec.