Streamflow Measurements

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Preface

The Watershed Protection Branch (WPB) of the Georgia Environmental Protection Division (GAEPD) has created a series of standard operating procedures (SOP) establishing uniform methods for the field collection of data, document control, quality assurance, laboratory safety, as well as other activities. These guidance documents were developed to document, and ensure, the validity of measurements, analyses, and the representativeness of samples collected. This is necessary in the event of a dispute with other parties regarding data collection techniques and the resulting quality of field information. Enforcement activities by the Branch require full documentation on particulars of data collection and the equipment used to collect it. All Branch associates who collect samples or field data must be familiar with the procedures outlined in the appropriate SOP's.

Requirements pertaining to specifics of sample collection for certain parameters are specified in federal regulations under the authority of the Clean Water Act (CWA) and the National Pollutant Discharge Elimination System (NPDES) permitting program. The most widely applicable guidance at this level is *Title 40 of the Code of Federal Regulations (40 CFR).* The procedures and techniques given in *40 CFR* are updated periodically by the United States Environmental Protection Agency and field workers are advised to consult the latest revision for proper procedures and new developments. In addition, the SOPs utilized by the Branch should be reviewed annually to certify their concurrence with federal statutes. Other references used in developing each SOP are cited at the conclusion of the individual documents.

The collection protocols in *40 CFR* are in many instances based on the concern for quality assurance. As such, each SOP will contain a section devoted to maintaining and improving the quality of data collected. 'Quality Assurance and Quality Control' sections contained within individual SOPs are not meant to replace the overall Quality Assurance Project Plan documents prepared for the Branch, but rather, are provided as supplemental data for each specific standardized activity.

This document is dynamic and will be continually revised as new developments warrant. As the Branch assumes more responsibilities for studying and sampling in new investigational areas, it is anticipated that additional SOPs will be required.

A. Introduction

The WPB of the GAEPD is responsible for managing the surface waters of the State of Georgia. The WPB works to ensure that Georgia's surface waters are of a quality and quantity sufficient for fulfilling multiple uses within the State by controlling nonpoint sources of pollution, managing storm water discharges, and regulating the amount of discharges to, and withdrawals from, surface waters. These tasks are accomplished through the issuance of NPDES permits to local governments and industry for the discharge of treated wastewater and to local governments, industry, farmers, and subdivisions for surface water withdrawals. However, none of these tasks would be possible without the vital data collected through water quality monitoring.

Streamflow measurements are vital to developing calibrated stream models to determine the assimilative capacity of Georgia's surface waters to enable GAEPD to issue NPDES permits for the discharge of treated wastewater. Streamflow measurements are also vital to quantifying the loading of point sources and non-point sources of pollution in Georgia's streams and lakes. Streamflow measurements are generally conducted during trend monitoring studies, model calibration studies, and other intensive surveys for documenting water quality

B. Purpose and Applicability

The purpose of this SOP is to establish uniform procedures for measuring streamflow and discharge in rivers and streams in the State of Georgia. This protocol is applicable to all Branch associates who measure or assist in the measuring of streamflow for water quality and compliance monitoring.

C. Definitions

1. **Clean Water Act (CWA)** – As amended in 1977, the Act establishes the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the U.S. EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also contains requirements to set water quality standards for all contaminants in surface waters. The Act makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit is obtained under its provisions. It also funds the construction of sewage treatment plants under the construction grants program and recognizes the need for planning to address the critical problems posed by nonpoint source pollution.

2. **Compliance Sampling Inspections (CSI)** – Studies that monitor permitted discharges for compliance with NPDES permits.

3. **Intensive Survey** –A study that incorporates many different fields of research to fully understand the complexity of a water system. In most cases, this includes tributary and lake sampling for water quality characteristics, biotic life, sediment quality, and flow status. These studies tend to be a minimum of a year in duration, but may be also conducted over several days during critical conditions.

4. **National Pollutant Discharge Elimination System (NPDES)** – As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic

system, or do not have a surface discharge do not need an NPDES permit. However, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

5. **Special Response Investigation** – A study conducted in response to a complaint or request submitted by a member of the general public, a water treatment facility operator, a member of a municipal government, a citizen's action group, etc.

6. **Surface water(s) of the State or surface water(s)** – Any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs producing in excess of 100,000 gallons per day, and all other bodies of surface water, natural or artificial, lying within or forming a part of the boundaries of the State that are not entirely confined and retained completely upon the property of a single individual, partnership, or corporation.

7. **SonTek Flowtracker** – A acoustic doppler velocimeter that consists of a handheld unit and velocity sensor. The velocity sensor has an acoustic transmitter with receivers on opposite sides in a v-shaped arrangement that measures velocity at a point 10 cm from the acoustic transmitter.

8. **SonTek RiverSurveyor** – A multiband acoustic meter for discharge and bathymetric measurements. The River Surveyor core system consists of an M9 Acoustic Doppler Profiler (ADP) sensor and *RiverSurveyor Live* software. The software can be installed on a PC, tablet, or smart phone. Optional equipment includes a Power and Communications module (PCM), Real-Time Kinematic (RTK) GPS base station, Differential GPS receiver, Bluetooth, and various float platform models.

9. **AA Current Meter** – A vertical axis current meter that has a rotor 5 inches in diameter and 2 inches in height with 6 cone shaped cups mounted on a stainless-steel shaft. A pivot bearing supports the rotor shaft. The meter has a magnetic contact and makes one contact for each revolution of the rotor. The AA meter has a tailpiece that keeps the meter pointing into the current.

10. **Pygmy Current Meter** –A vertical axis current meter that is scaled two-fifths as large as the AA meter. This meter also has a magnetic head and makes one contact for each revolution of the rotor. The pygmy meter does not have a tailpiece.

11. **Aquacalc 5000** – A streamflow computer used for discharge measurements with the Pygmy and AA Current Meters.

12. **0.6 Depth** – A depth 60% of the vertical distance from the stream surface to the streambed.

13. **0.2 Depth** – A depth 20% of the vertical distance from the stream surface to the streambed.

14. **0.8 Depth** – A depth 80% of the vertical distance from the stream surface to the streambed.

D. Health and Safety Warnings

The Associate should wear appropriate personal protective equipment and appropriate clothing when conducting sampling events. Planning for any type of field sampling should include extensive health and safety considerations including required training (CPR, First Aid, Boating Safety), personal protective equipment, and degree of personal, physical condition in accordance with federal, state, or organizational requirements.

E. Cautions

During extremely hot weather, be sure to pack plenty of fluids and drink often to ward off the risk of heat exhaustion and heat stroke. Associates should also wear sunscreen, especially on sunny days.

*Field sampling should **NEVER** be conducted alone. Sampling teams should always consist of a minimum of two associates.

F. Personnel Qualifications

All Branch associates who collect streamflow data must be familiar with the procedures outlined in this document. In all aspects of water quality planning and field assessment activities, safety is to be addressed and treated as a critical element. The Georgia DNR *Safety Manual* is to be consulted and its policies, protocols, and procedures are to be incorporated and implemented in WPB field activities.

G. Site Selection

The site where the flow measurement will be made is selected using the following criteria:

1. A straight section where the threads of velocity are parallel to each other.
2. Stable streambed free of large rocks, aquatic plants, and woody debris that would create turbulence.
3. A flat streambed profile to eliminate vertical components of velocity.

It is usually not possible to satisfy all these conditions; however, the best possible site is selected based on these criteria. A general reconnaissance of the stream is first made in order that the most suitable site for the flow measurement is selected. This may require walking upstream and downstream a few hundred yards.

When natural conditions for measuring flow are in the range considered undependable, the streambed can be altered to provide acceptable conditions. Often it is possible to build small dikes to cut off dead water and shallow flows at a site. The site can be improved by removing large rocks and woody debris. After modifying a site, allow the flow to stabilize before starting the flow measurement**.**

H. Stage and Tapedown Measurements

To document the stability of flow during streamflow measurement, a stage or tape down measurement should be performed prior to and after taking a streamflow measurement. A relation between stage and flow can be defined after several measurements at a site and a rating curve and rating table developed from this relationship.

1. Stage

The stage of a stream is the height of the water surface above an established datum plane. The datum may be a recognized datum, such as mean sea level, or an arbitrary datum plane chosen for convenience. The datum selected for operating purposes must be below the elevation of zero flow on the control for all conditions. For staff gages the arbitrary datum is generally set at the zero mark on the staff.

Staff gages

Staff gages can be installed in the stream using several techniques. A common technique is to install the staff gage on a post of some type and place the post in the stream. Be sure it is positioned to prevent large objects from washing downstream and damaging it during rain events. Installing staffs on bridge supports and concrete culvert wingwalls are two other common techniques.

2. Tapedowns

A tapedown measurement is the distance from the reference point to the surface of the stream. A 100 feet nylon coated steel measuring tape, calibrated in tenth of feet, with a brass weight attached is the standard equipment used to measure tapedown distance. The total tapedown distance is the distance indicated on the tape at the reference point plus the distance from the zero mark on the tape to the bottom of the brass weight (TD = Tape + WT).

Reference Points

Reference points need to be placed on stable structures that are positioned above the surface of the stream under all flow conditions. For bridge rails or concrete culverts chisel a square on the top edge of the rail or culvert. For metal culverts chisel 2 parallel chisel marks on the top edge of the culvert. For overhanging trees drive a nail into the tree to within one-quarter inch of the nail head.

The following are common reference points and the correct method used to measure the tapedown distance from the reference point:

1. Chiseled square on beveled surface – Read from the top edge of the bevel.
2. Chiseled square on flat surface – Read from the top edge of the surface.
3. Two parallel chisel marks on top edge of metal culvert – Read from top edge of culvert between parallel marks.
4. Nail in overhanging tree – Read from bottom of nail head.

I. Streamflow Measurement Methods

Streamflow is expressed as the volume of water passing a given point within a unit time period. Usually expressed in cubic feet per second (ft^3/sec). In the making of a streamflow measurement the cross-section is divided into 20-30 partial sections with width (ft), depth (ft), and velocity (ft^2/sec) of each partial section measured separately.

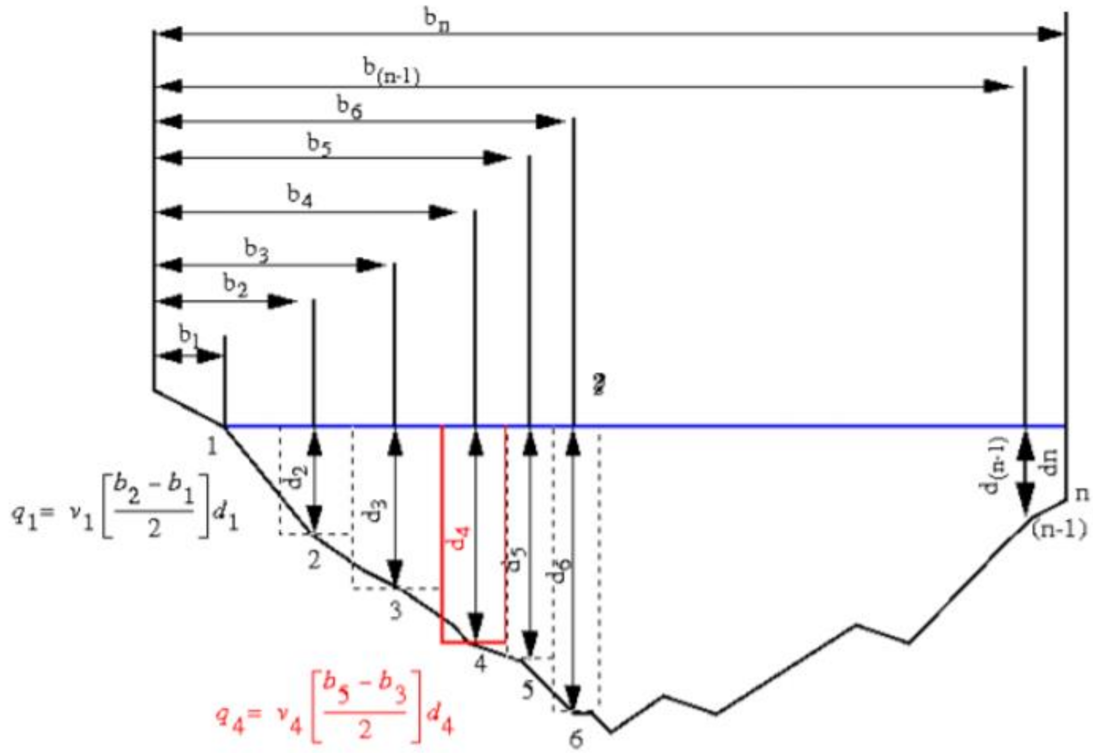
1. Midsection Method

A streamflow measurement is the summation of the products of the partial areas of the stream cross-section and their respective average velocities. The formula representing the computation is:

$$Q = \Sigma(a*v)$$

Where: Q is total flow,
a is an individual partial cross-section area, and
v is the corresponding mean velocity of the flow normal to the partial area.

In the midsection method of making a streamflow measurement, it is assumed that the velocity at each location represents the mean velocity in a partial rectangular area. The area extends laterally from half the distance from the preceding location to half the distance to the next and vertically, from the water surface to the streambed (see Figure 1).



Explanation

1,2,3 ....n --Observation verticals

$b_1, b_2, b_3, ...b_n$ --Distance from initial point to observation vertical

$d_1, d_2, d_3, ...d_n$ --Depth of water at observation vertical

Dashed lines --Boundaries of subsections

$$Q = q_1 + q_2 + ... q_n$$

Figure 1. Sketch of midsection method for computing discharge

Partial Section Spacing

After the cross-section has been selected, determine the width of the stream. String a tag line or measuring tape across the stream. String the tape at right angles to the direction of flow to avoid horizontal angles in the cross-section.

Determine the spacing of the verticals (velocity observation points), generally using about 25-30 partial sections. With a smooth cross-section and good velocity distribution, fewer sections may be used. Space the partial sections so that no partial section has more than 10 percent of the total flow in it and preferably no more than 5 percent of the total flow in it.

Equal widths of partial sections across the entire cross-section are not recommended unless the flow is well distributed. Make the width of the partial sections less as depth and velocities become greater.

1-Point or 2-Point Velocity Measurements

The method selected is determined by the stream depth: The 1-point method is used if the depth at a vertical is less than or equal to 2.5 feet and the 2-point method is used if the depth at a vertical is greater than 2.5 feet.

With the 1-point method, the current meter is positioned at the 0.6 depth from the surface. The velocity measured with the 1-point method is the mean velocity of the section.

With the 2-point method, the velocity is measured at the 0.2 depth and at the 0.8 depth, then the two velocities are averaged together to obtain the mean velocity for the section.

Wading Rod

The wading rods used by the Division are top-setting wading rods. The top-setting wading rod has a one-half inch hexagonal main rod for measuring depth and a three eights inch diameter round rod for setting the position of the current meter. The rod is designed to easily set the position of the current meter at either the 0.6, 0.2, or 0.8 depths. If the actual depth is entered with the round rod, then the meter is placed at the 0.6 depth. If the actual depth is doubled and then entered with the round rod, then the meter is placed at the 0.2 depth. If the actual depth is halved and then entered with the round rod, then the meter is placed at the 0.8 depth. For example, if the 0.6 depth setting is 0.7 feet then the wading rod needs to be placed on the 0.35 foot mark to take the 0.8 depth reading and at the 1.4 foot mark to take the 0.2 depth reading.

Current Meter Selection

The standard current meter used by the Division in wadeable streams is the SonTek Flowtracker. The Flowtracker can utilize a variety of velocity measurement methods, including either the 1-point (0.6) method or the 2-point (0.2/0.8) method. A second option that can be used in wadeable streams is with a pygmy or AA current meters in combination with the Aquacalc 5000 stream flow computer. Meter selection depends on the average depth of the stream. If the depth is less than or equal to 1.5 feet, then use the pygmy current meter. If the average depth is greater than 1.5 feet, then use the AA current meter. Continue with the same current meter for the entire cross-section. Velocity is measured with the pygmy current meter by the 1-point (.6) method. Velocity is normally measured with the AA current meter by either the 1-point method or the 2-point (0.2/0.8) method.

SonTek Flowtracker Setup and Operation

1. Open and close the small metal cap covering the data port on the handheld to vent the unit to equalize pressure. Make sure this cap is closed before entering the stream.

2. Hold down the ON/OFF button to turn the unit on.

3. Perform Pre-Deployment Diagnostics at each sampling site.
   - Open System Functions Menu (#2 in Main Menu).
     i. Check recorder status/memory (#2 in Sys. Functions Menu).
     ii. Check water temperature (#4 in Sys. Functions Menu).
     iii. Check battery (#5 in Sys. Functions Menu).
     iv. Check raw data (#6 in Sys. Functions menu).
        Ideally, SNR values should be >10dB but 4 dB is acceptable.
     v. Verify time and change if needed (#8 in Sys. Functions Menu).

4. Set System Parameters to be performed at each sampling site.
   - Check Setup Parameters Menu:
     Only change the items in this part if needed (#1 in Main Menu).
     i. Chose measurement units: should be "Standard" (#1 in Setup Para. Menu).
     ii. Select averaging time: should be 40 seconds (#2 in Setup Para. Menu).
     iii. Select data collection mode: should be "Discharge" (#3 in Setup Para. Menu).
     iv. Enter salinity from an *in situ* reading (#4 in Setup Para. Menu).

5. Start Data Collection.
   - Return to main menu, press 3 to start data run.
   - In file name menu, select 1 to enter file name (max 8 char.).
     i. Press enter when file name is complete.
     ii. Press 2 if a file extension is needed (max 3 char.).
   - When ready to start data collection, press 9.
     - Staff, Gauge and rated discharge data can be entered, if needed or avail.
     - Press "Next Station" when ready.
     - Be sure to enter data onto paper log sheet at every station.

6. Enter starting-edge info.
   - Press "Set Location" (blue button on the right) to set starting-edge location (loc).
   - Press "Set Depth" (blue button on the right) to set starting-edge water depth (Dep)
     - Zero depth.
   - Press "Corr. Factor" to set correction factor, if needed (not normally needed).
     - Press "LEW/REW" to toggle starting edge of water. Determine left and right by looking downstream.
   - When complete, press "Next Station" to continue.

7. Station info for next station will be displayed.

- Press “Set Location” to set station location, this is the location on the tape tag line.
- Press “Set Depth” to set water depth. (if the depth is >2.5 feet see #12 below)
  i. The following choices are optional.
    - If the water depth is greater than 2.5 feet, then see 12. Press “Corr. Factor” to set correction factor, if needed.
    - Press “Set Ice Depth” if ice is present (must have determined ice depth).

8. When all values are correctly set press “Measure” to start data collection.
   i. If the reading is valid after completion press 1 to accept the reading.
   ii. Press “Abort” to terminate measurement, if needed. Press 2 to repeat measurement.
     - If there is more than one depth measurement to be taken at each station (e.g. 0.2 & 0.8) the system will proceed to the next measurement in the series.
     - When the measurement is complete the Flowtracker displays the next station.
   i. Location, Depth and method data for new stations are predicted based on previous stations.
   ii. If a multiple measurement method was used, the next station will use the same method in the opposite order.

9. Until you reach the other bank edge repeat steps 7 and 8 to add each additional station.
   - If a station needs to be repeated, it can be deleted and repeated before the ending-edge measurement (see below for method).

10. When all stations are completed press “End Section” key.
    - Enter ending-edge info, this works just like starting edge (step 6).

11. When all values are set correctly press “Calc. Disch.” to complete discharge calculations.
    - After final discharge calculations are complete, five data screens are available. Move through these and enter this data on the data sheet.
    - When data has been logged onto the sheet press 9 to exit and return to main menu. The data will be saved and can be downloaded onto a computer.

12. If depth is greater than 2.5 feet: Change the measurement method to 0.2/0.8 using “Toggle Method+” and/or “Toggle Method-”. Remember to raise/lower the wading rod after each measurement and that the 0.2 setting will be double the 0.6 setting and the 0.8 setting will be half the 0.6 setting (for example, if the 0.6 depth setting is 0.7 feet then the wading rod needs to be placed on the 0.35 foot mark to take the 0.8 depth reading and at the 1.4 foot mark to take the .2 depth reading).

13. Always return to the main menu before turning the unit off.

Additional Information:

Deleting and repeating a station:

All measurements at the selected station will be deleted.

To delete an existing station:

- Use "Next Station" or "Prev. Station" to scroll to the desired station.
- Press "Delete", enter 123 to confirm.
- Station is deleted, display will return to current station.

To repeat a station:

- Delete desired station (as above)
- At the current station, enter the location, depth and measurement method of the station to be repeated. Move to the spot to be measured and follow standard measurement procedures.
- The new station data will automatically be sorted into the correct position so that the discharge calculations will be accurate.

Aquacalc 5000 Streamflow Computer Setup and Operation

1. Set up transect information.
   - Enter 4-digit user ID number
   - Enter site ID number
   - Enter stage
   - Enter meter ID number
   - Enter current meter type used
   - Enter measurement time of 40 seconds

2. Set up system information.
   - Check date and time setting
   - Enter flow computer ID number
   - Indicate 1-point (0.6) or 2-point (0.2/0.8) measurement
   - Select English language
   - Select baud rate of 48

3. Start Data Collection.
   - Measure and enter the distance and depth for the starting edge of the water.
   - Position the current meter at the proper location on the top setting rod.
   - Check the method of velocity setting on the flow computer. The velocity method can be toggled between 0.6, 0.2, and 0.8.
   - After the meter is placed at the proper depth, permit it to become adjusted to the current before starting the velocity measurement.
   - Select measure on the flow computer to begin the measurement.
   - Keep the wading rod in a vertical position and the meter parallel to the direction of flow while measuring the velocity. If the flow is not at right angles to the tape, measure the angle coefficient carefully and enter into the flow computer.
   - Move to each of the verticals and repeat the procedure.
   - Enter the distance and depth at the final edge of water.

- Select calculate discharge button for the flow computer to compute the total flow.
- The flow measurement can be downloaded onto a computer and the data can be copied into a spreadsheet to verify the accuracy of the data.

2. Single Moving Boat Discharge Measurement Method

The Single Moving Boat Discharge Measurement Method is the procedure used to calculate total discharge with the RiverSurveyor system. The SonTek RiverSurveyor is the system used for discharge and bathymetric measurements in nonwadeable water bodies. The RiverSurveyor system consists of the M9 ADP sensor, *RiverSurveyor Live* software installed on a PC, tablet, or smart phone, Power and Communications module (PCM), Differential GPS receiver (provides sub-meter accuracy), Bluetooth (either the internal Bluetooth radio of the device or an external Bluetooth dongle), and a trimaran float platform. Optionally, a Real-Time Kinematic (RTK) GPS base station can be utilized to provide ±3 cm accuracy.

Th Single Moving Boat Discharge Measurement Method consists of three components:

- Starting Edge,
- Transect, and
- Ending Edge.

Additionally, the Transect can be further broken down into the:

- Top Estimate,
- Measured Area, and
- Bottom Estimate.

Total discharge is calculated by summing the Start Edge, Top Estimate, Measured Area, Bottom Estimate, and Ending Edge. The Measured Area is the only component directly measured the by ADP sensor. The other components are estimated for the following reasons:

- The ADP sensor has a minimum operating depth. The starting and ending edges typically have depths below the minimum operating depth and the discharge must be estimated.
- The mounting depth of the ADP sensor leaves a small section of water at the surface that is unmeasured. This unmeasured area is referred to as the Top Estimate.
- Potential data contamination in the last cell or side-lobe interference when near the end of the profile leaves a section of water near the bottom unmeasured. This unmeasured area is referred to as the Bottom Estimate.

The unmeasured areas at the top and bottom are estimated using a technique known as Velocity Profile Extrapolation. The Velocity Profile Extrapolation technique uses a power law velocity profile (proposed by Chen 1991 and Simpson and Oltmann 1990) to calculate velocities within the unmeasured areas at the top and bottom. The velocity profile power law is expressed using the equation:

$$\frac{u}{u^*} = 9.5 \cdot \left(\frac{z}{z_0}\right)^b$$

Where: u is the velocity at height
z measured from the stream bottom,
$u^*$is the bottom shear velocity,
z_0 is the bottom roughness height, and
b is a constant (equal to 1/6 according to Chen 1991).

The Starting Edge and Ending Edge discharge are calculated by selecting the bank profile in the RiverSurveyor software (constant sloped bank or vertical wall) and maintaining a fixed position while taking at least 10 velocity and depth measurements. The velocity and depth measurements will be combined to form a single average velocity and depth profile. Discharge in the Transect is calculated based on the depth, distance travelled, and mean water velocity. The RiverSurveyor system automatically compensates for changes in speed and course.

RiverSurveyor Setup and Operation

1. Assemble Components
   - Insert battery pack into the PCM and mount PCM to float platform.
     - Insert ADP (transducers looking down) into the cutout on float platform. To properly align the transducers, line up the female plug-in of the ADP and PCM.
   - Mount the GPS receiver onto the top of the ADP sensor.
   - Connect data cables for PCM, ADP transducer, and GPS.
   - Measure submersed depth of ADP sensor.

2. Connect computer, tablet, or smartphone to RiverSurveyor using Bluetooth.

3. Once the connection is established, select “Change Site Information” to enter data such as site name and station ID.

4. Open “Change System Settings” and complete the following data fields:
   - “Transducer Depth”. This setting is the submerged depth of the mounted ADP sensor.
   - “Screening distance”. Leave this value at the default setting of 0.00. This setting is primarily intended to compensate for wake disturbance when the ADP sensor is directly mounted to a boat.
   - “Salinity”. Enter the salinity value of the stream.
   - “Magnetic Declination”. The magnetic declination angle can be found on a map or online resources.

- The "GPS Compass Heading Alignment", "GPS Antennae X Offset", and "GPS Antennae Y Offset" fields should be left at the default settings of 0.00 since the GPS sensor is directly mounted to the ADP sensor.
- "Track Reference". For a stationary riverbed, choose the "Bottom-track" option. For a moving riverbed (this can occur in streams with swift current and fine substrates, such as sand) select the "GGA GPS" option. The "GGA GPS" option must be used with the Differential GPS sensor or RTK base station.
- "Depth Reference". The two available options are "Vertical Beam" and "Bottom-Track". "Vertical Beam" uses echo sounder data to determine the depth and "Bottom-Track" determines depth by averaging readings from 4 angled beams.
- "Coordinate System". Select the ENU option.
- "SmartPulseHD". This option is enabled by default, so no changes are necessary.

5. Perform System Test. The System Test is a 60 second verification process to ensure the battery voltage, compass, SD memory card, and temperature sensor are functioning properly.

6. Calibrate Compass
   - Remove all sources of magnetic interference from the immediate vicinity such as cell phones/mobile electronic devices, hand tools, keys, wristwatches, etc.
   - Open the "Compass Calibration" window in the *RiverSurveyor Live* software. Click "Start" to begin calibration procedure.
   - Rotate the fully assembled RiverSurveyor (ADP transducer, PCM, GPS, and float platform) through 2 complete circles taking approximately 60 seconds for each rotation (120 seconds is the maximum time for the calibration routine allowed by the software).
   - Vary the pitch and roll angles while rotating the RiverSurveyor. Ideally, the pitch and roll angles will be similar to the conditions experienced during the transect measurement.
   - Click "Stop" on the "Compass Calibration" window upon completion of calibration procedure.
   - Review the results and feedback in "Compass Calibration" window to ensure the compass was properly calibrated. A good compass calibration will have an "Error From Calibration" value <0.5 deg and will cover the range of pitch and roll expected during the measurement.

7. Open "Edge Settings" and complete the following fields:
   - "Start Edge". Select either "Left Bank" or "Right Bank".
   - "Left/Right Method". Select the bank type, either "Sloped Bank" or "Vertical Wall" for the left and right banks.
   - "Left/Right Distance". Enter the distance from the bank for the beginning and ending measurement.
   - "Start/End Gauge Height". Enter the gauge height or tapedown measurement at the start and end of the discharge measurement.

- "Start/End GH Observation Time". Enter the time for the start and end of the discharge measurement.
- "Auto-Edge Profiles". Selecting this option enables automatic switching from collecting edge data to the transect measurement after a specified number of edge samples. By default, the number of edge samples is 10.
- "Show Edge Dialog". When checked, the edge dialog box is shown, and it is possible to change edge settings after clicking the "Start/End Edge" buttons. If unchecked, the dialog box does not pop up after clicking "Start/End Edge".

8. Place float platform at water's edge and start data collection.
   - Click the "Start a Measurement" button to begin data collection.
   - Click the "Start Edge" button to collect the starting edge samples. Keep the float platform as stationary as possible.
   - Once the starting edge samples are collected, click the "Start Moving" button.
   - Move the float platform across the channel, keeping the direction and speed constant. There are three methods to move the float platform across the channel:
     i. Connect the float platform to a tag line and tow across the channel. Typically, this method will produce the best results.
     ii. Connect a rope or cable to the float platform and walk across from the bridge. This method requires enough current to keep the float platform straight.
     iii. Connect a rope or cable to the float platform and tow across the channel with a boat or canoe. This method is a good option for large streams or locations where the previous two methods prove impractical.

9. Click the "End Edge" button when the float platform reaches the edge of the opposite bank. Keep the float platform as stationary as possible while collecting ending edge samples.

10. Click the "End Transect" button once the ending edge data collection is completed.

11. Follow the previously outlined procedures and tow the float platform back across the channel to repeat the discharge measurement.

12. Calculate discharge using the *RiverSurveyor Live* software.

J. Flow Measurements Procedures

Wadeable Streams

- Identify cross-section location and remove debris, obstructions, and make any necessary channel modifications.
- Stretch tagline or tape measure across width of stream.

- Record GPS coordinates for the center of the cross-section and use a compass to determine bearing of tagline and two benchmarks.
- Establish benchmarks should be stable objects that are easy to identify.
- Take photographs from the center of the cross-section of the left bank, right bank, upstream, and downstream. Photographs of benchmarks should also be collected. For sites that will be revisited, mark tagline location with stakes, flagging tape, or spray paint.
- Determine the average stream depth if the Aquacalc 5000 and Pygmy or AA current meters are selected for use. All cross-section and location information will be recorded on the discharge/cross-section field sheet. Once the equipment has been readied, begin the flow measurement.
- Follow the setup, QC, and operating procedures for the selected current meter.
- Stand in a position that least affects the velocity of the water passing the current meter. This position is usually obtained by facing the bank, with the water flowing against the side of the leg. Holding the wading rod at the tape, stand from 1 to 3 inches downstream from the tape and 18 inches or more from the wading rod. Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross-section of a narrow stream.
- After the meter is placed at the proper depth, permit it to become adjusted to the current before starting the velocity measurement. In slow moving streams, allow time for current to stabilize and ripples to subside after moving location to avoid backflow.
- Select measure to begin the measurement. Keep the wading rod in a vertical position and the meter parallel to the direction of flow while measuring the velocity. In streams with sand or other soft substrates, make sure that the wading rod base does not sink into the substrate.
    - For Pygmy or AA current meters only: If the flow is not at right angles to the tape, measure the angle coefficient carefully and enter into the flow computer**.**
    - For Flowtracker only: Review for QC warning messages and verify depth, location, and velocity method are correct before accepting the velocity reading.
- Record depth, velocity, and location information on the discharge/cross-section field sheet.
- Move to each of the verticals and repeat the procedure.
- Enter the distance and depth at the final edge of water.
- Select calculate discharge and record total discharge, mean velocity, total width, and total area on the discharge/cross-section field sheet.

2. Non-Wadeable Streams

- Identify a cross-section location that is free of obstructions and is deep enough to meet the minimum depth requirements for the RiverSurveyor ADP sensor. Avoid cross-section locations that have shallow bars.
- Record GPS coordinates for cross-section location and use a compass to determine bearing of cross-section and two benchmarks.
- Establish benchmarks, which should be stable objects that are easy to identify.
- Take photographs of the left bank, right bank, upstream, and downstream. Photographs of benchmarks should also be collected. For sites that will be revisited, mark cross-section location with stakes, flagging tape, or spray paint.
- Once the cross-section location has been selected, determine the method that will be used to tow the float platform across the channel.
- Assemble the RiverSurveyor system
- Follow the setup, QC, calibration, and operating procedures.

Equipment and Supplies

- SonTek Flowtracker (handheld display unit and sensor package)
  or Aquacalc 5000 stream flow computer and current meter heads (Pygmy and AA)
  or RiverSurveyor system
- Top setting wading rod (not necessary if using the RiverSurveyor system).
- 100 feet nylon coated steel measuring tape graduated in tenth of feet
- 300 feet tag line
- Measuring tape anchors (2)
- Tapedown weight
- Utility bag
- Daypack
- Meter oil (only needed if using Pygmy and AA current meter heads)
- Nails, various sizes
- Cold chisel
- Wood chisel
- Hammer
- Large flat head screwdriver
- Small flat head screwdriver
- Jewelers screwdriver
- Flagging tape (high visibility color such as orange or pink)
- Spray paint (high visibility color such as orange or pink)
- Field book
- Clipboard
- Discharge/cross-section field sheets
- Pencils and Sharpies

- Spare screws—machine screws for Flowtracker battery case, thumb screws for mounting handheld display to wading rod, and extra screw for mounting current meter head to wading rod.
- Spare AA batteries
- Spare RiverSurveyor battery pack
- GPS unit
- Compass
- Camera
- Chest waders
- Hip boots

K. Quality Assurance and Quality Control

For Pygmy or AA current meters

Before and after each flow measurement, examine the meter cups, pivot, and shaft for damage, wear, or faulty alignment. Clean and oil meters daily when in use. If measurements are made in water carrying noticeable suspended sediment, clean the meter immediately after each site. Parts to be oiled on the magnetic head meter are the pivot and the rotor bearing.

After oiling, spin the rotor to make certain it operates freely. If the rotor stops abruptly, find the cause and correct the trouble before using the meter. The pygmy meter should spin for a minimum of 30 seconds while the AA meter should spin for a minimum of 90 seconds.

The pivot needs replacement more often than other meter parts. Examine the pivot after each measurement. Replace a fractured, rough, or worn pivot. Keep the pivot and pivot bearing separated when not in use. The AA meter has a raising nut to separate the pivot and bearing. The pygmy meter has a brass plug that replaces the pivot.

For Flowtracker

Perform pre-deployment diagnostics and record information on discharge/cross section field sheet. Check battery level before usage and replace batteries if needed. Remove batteries if the unit will be stored for an extended period (this is to prevent battery leakage and damage to the unit).

For RiverSurveyor

Perform pre-deployment diagnostics and follow proper compass calibration procedures. Ensure batteries are fully charged before beginning the flow measurement. Inspect cables and connectors for damage regularly and replace if necessary. When changing batteries, ensure battery compartment o-rings are clean and undamaged. Periodically clean the ADP transducer face with a brush or sponge and soapy water.

L. Data Management

Discharge/cross-section field sheets should be scanned, and the data entered into the discharge/cross-section template. After the data has been entered and the QC process has been completed, the discharge/cross-section template should be uploaded into the GOMAS database.

Discharge data download instructions

For Flowtracker

1. Have a .PDF writer downloaded and installed.
2. Install and open Flowtracker software.
3. Connect Flowtracker to computer and click “connect to a Flowtracker” on center left of screen and select comm port that is lit and select connect.
4. Select “recorder”, select files you wish to download, designate destination folder, click download.
5. Click “open Flowtracker file”, have “show discharge summary report” and “export ASCII discharge file (.DIS)” selected.
6. When report opens select print and choose the .PDF writer as the printer then select the folder you want the PDF stored in.
7. The discharge summary report and .DIS files will uploaded as attachments once the discharge/cross-section template is entered into the GOMAS database.

For Aquacalc 5000

1. Download and install Tera Term.
2. Connect Aquacalc to computer and use Tera Term to download gauging files.
3. Convert gauging files to Excel format and save.
4. The gauging files will be uploaded as attachments once the discharge/cross-section template is entered into the GOMAS database.

For RiverSurveyor

1. Install *RiverSurveyor Live for PC* software on computer.
2. Have a .PDF writer downloaded and installed.
3. Connect RiverSurveyor to computer and click “connect to a RiverSurveyor system (Ctrl+N)”.
4. There are 3 options to open data files: click the “Open File” icon on the toolbar (the folder icon), click the “Open file (Ctrl+O)” link, or select a recently viewed file.
5. Click the “Discharge Summary” icon to open the discharge summary window.
6. Click on the “Discharge Summary Report” icon and select print, using the .PDF writer as the printer.
7. Click on the “Export Discharge Summary to ASCII” icon to export the .DIS file.

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