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STANDARD OPERATING PROCEDURE
FH950 Portable Velocity Meter

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KEY WORDS

Flowmeter, discharge measurements, electromagnetic sensor, depth

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Environmental Monitoring Branch organization and personnel, such as management, senior scientist, quality assurance officer, project leader, etc., are defined and discussed in SOP ADMN002.

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1.0 INTRODUCTION

1.1 Purpose

The Hach FH950 is a handheld flow meter instrument that collects flow velocity and discharge measurements. This document provides standard operating procedures (SOPs) for calibration, quality control, field use, maintenance, and safety procedures for the Hach FH950.

1.2 Definitions

1.2.1 Cell - The distance between two adjacent stations (i.e., vertical measurements) along the discharge cross section (also referred to as "segments", "sections", or "partial areas" in other sources).

1.2.2 Station - Measurement locations for depth and velocity taken along the discharge cross section (also referred to as "observation points" or "verticals" in other sources).

1.2.3 Vernier Scale - A small, moveable graduated scale that slides along a main scale of a measuring instrument. The small scale is calibrated to indicate fractional divisions of the main scale.

1.2.4 One-point method – A method used to determine cell depth and width along the cross section. For depths measuring 4.50 to 75.0 cm (0.15 to 2.45 ft) one measurement is taken at sixty percent of the depth (0.6 depth) from the water surface.

1.2.5 Two-point method – A method used to determine cross section cell depth and width. For depths greater than or equal to 76.0 cm (2.50 ft) two depth measurements are taken and averaged. Measurements are taken at twenty percent (0.2 depth) and eighty percent of the depth (0.8 depth) from the water surface.

1.2.6 Three-point method – A method used to determine cell depth and width along the cross section if the two-point method produces a non-standard or inverted-velocity profile. An additional velocity measurement at sixty percent of the depth (0.6 depth) from the water surface is taken.

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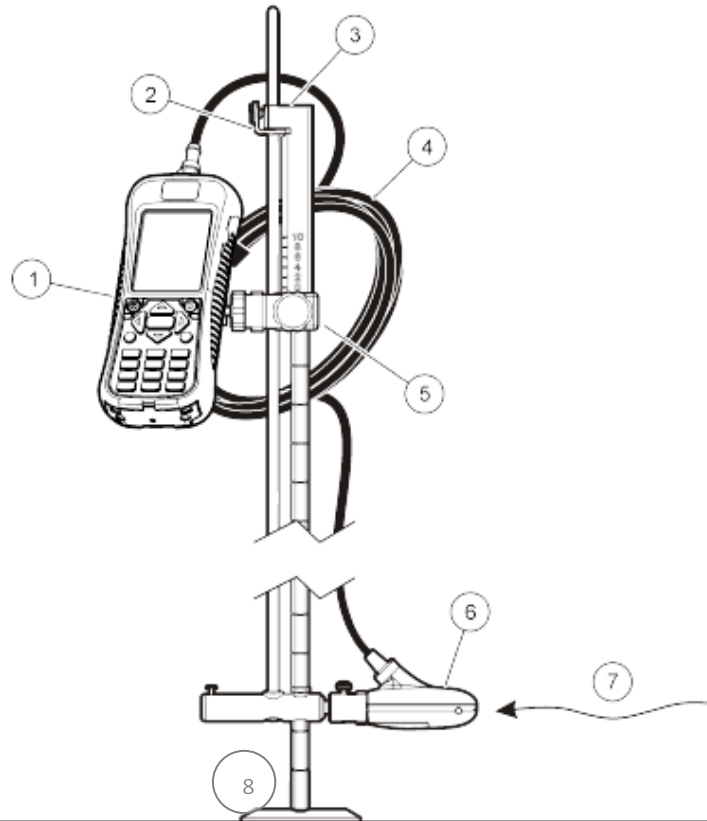

2.0   MATERIALS

2.1   Portable meter (Figure 1: 1; Figure 2: 11; Figure 3).

2.2   Sensor height lock/release device (Figure 1: 2).

2.3   Top setting wading rod (Figure 1: 3).

2.4   Sensor cable (Figure 1: 4; Figure 2: 5; Figure 4).

2.5   Adjustable mount for portable meter (Figure 1: 5; Figure 2: 3).

2.6   Sensor (Figure 1: 6; Figure 2: 5; Figure 4).

2.7   Setting rod (Figure 1: 8).

2.8   Carrying case (with slot for sensor cable) (Figure 2: 1).

2.9   USB cable with mini-USB connector, 1 m (3 ft) (Figure 2: 2).

2.10   Battery charger, 100–240 VAC (Figure 2: 4).

2.11   Extra thumb screws (4x) (Figure 2: 6).

2.12   Cloth to dry the sensor (Figure 2: 7).

2.13   Universal sensor mount (Figure 2: 8).

2.14   Velcro strap (Figure 2: 9).

2.15   Lanyard (Figure 2: 10).

2.16   Lithium battery pack (Figure 2: 12).

2.17   Non-metallic bucket (for flowmeter calibration).

2.18   Clamp (for flowmeter calibration).

2.19   Calculator.

2.20   100 m measuring tape.

2.21   Phillips head screwdriver.

2.22   Rebar.

2.23   Zip-ties.

2.24   Hammer.

2.25   Clippers.

2.26   Tap water (to rinse the flowmeter after measurements).

2.27   Handheld GPS.

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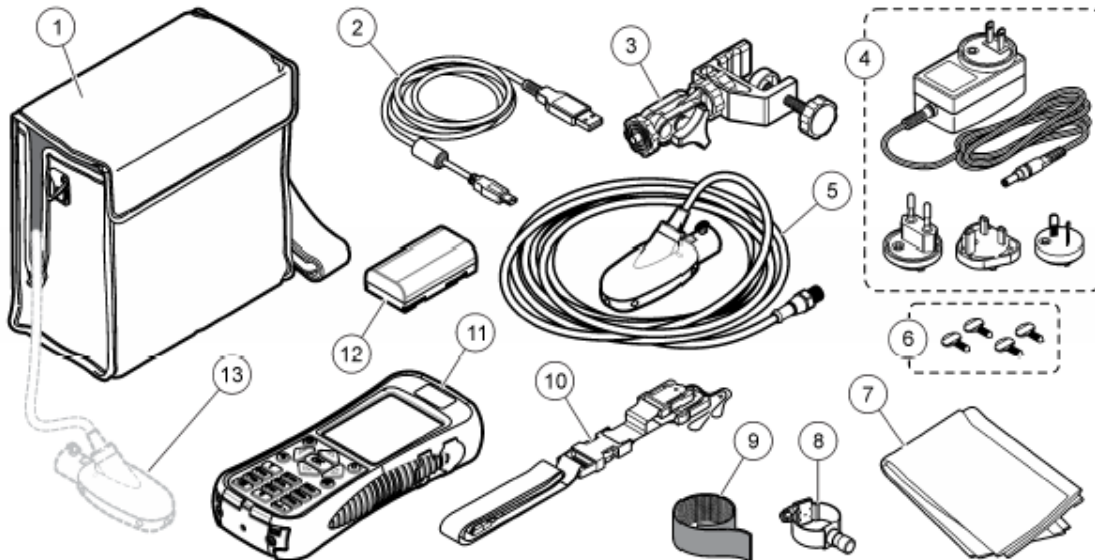
STANDARD OPERATING PROCEDURE
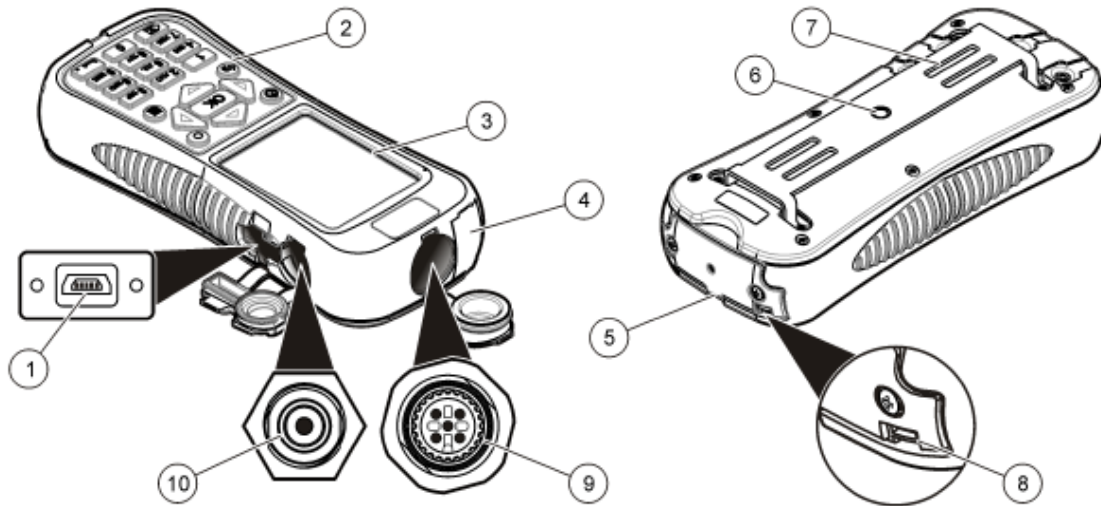*FH950 Portable Velocity Meter*

Figure 1. Assembled components: 1. Portable meter; 2. Sensor height lock/release device; 3. Top setting wading rod (accessory); 4. Sensor cable; 5. Adjustable mount for portable meter; 6. Sensor assembly; 7. Flow direction; 8. Setting rod. Adapted from HACH (2021).

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Figure 2. System components: 1. Carrying case (with slot for sensor cable); 2. USB cable with mini-USB connector, 1m (3 ft); 3. Adjustable portable meter mount; 4. Battery charger, 100-240 VAC; 5. Sensor; 6. Extra thumb screws (4x); 7. Cloth to dry the sensor; 8. Universal sensor mount; 9. Velcro strap; 10. Lanyard; 11. Portable meter; 12. Lithium battery pack; 13. Sensor as connected to meter inside case. Adapted from HACH (2021).

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Figure 3. Meter components: 1. USB connection port; 2. Keypad; 3. Meter display; 4. Expansion port; 5. Battery compartment cover; 6. Threaded hole for adjustable meter mount; 7. Slots for Velcro or strap attachment; 8. Slot for neck strap attachments threads (2x); 9. Sensor connection port; 10. Battery charger connector. Adapted from HACH (2021).
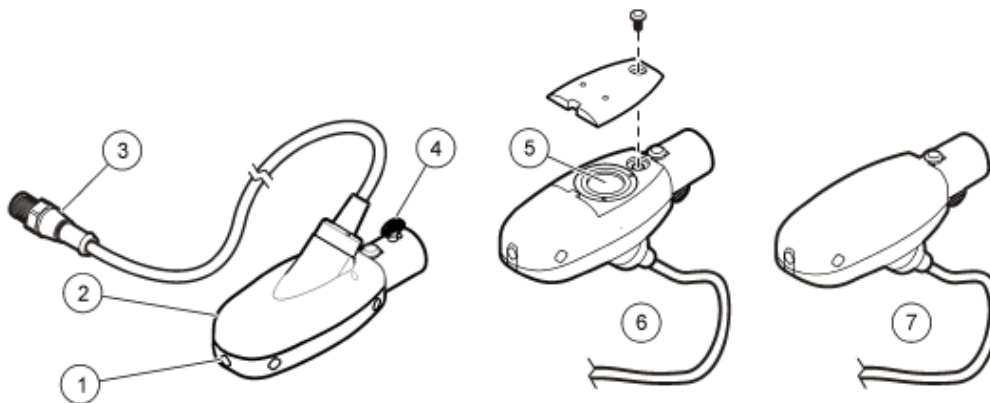
Figure 4. Sensor components: 1. Sensor electrodes; 2. Sensor body; 3. Sensor connection plug; 4. Sensor attachment thumb screw; 5. Pressure cell (sensors with depth option); 6. Sensor with depth option; 7. Sensor without depth option. Adapted from HACH (2021).

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3.0　　HACH FH950 OPERATION

3.1　　Site Selection.

A site with the typical profile shape characteristics described below gives the most accurate results. Visual inspection is typically sufficient to identify problem sites. A natural river/stream is neither straight nor uniform and it consists of three basic parts: a riffle, run and a pool (Haucke, 2014).
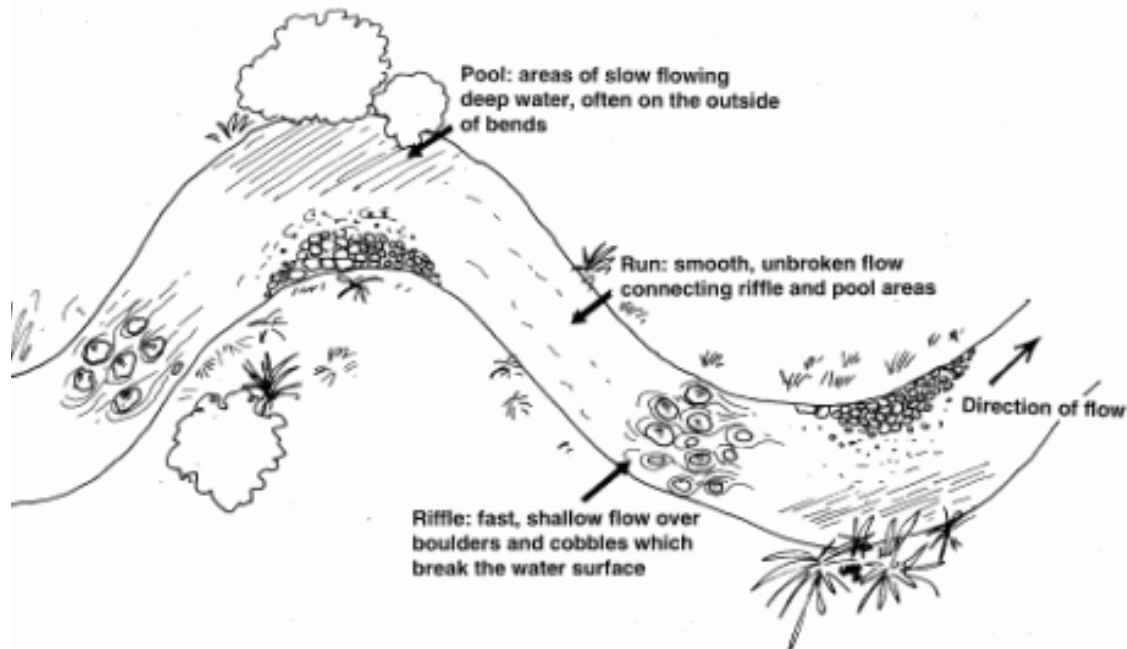
Figure 5. Natural river/stream basic shape: pool, run and riffle (WVDEP, 2022).

　　3.1.1　　The stream should have as much straight run (Figure 5) as possible. If the length of the straight run is limited, the length upstream from the profile should be two times the downstream length.

　　3.1.2　　The stream should be as free of flow disturbances as possible. The site must not have sudden changes in diameter, contributing side-streams, outgoing side-streams, or obstructions.

　　3.1.3　　The flow should not have visible swirls, eddies, vortices, back-flow, or dead zones. Do not select areas immediately downstream from sharp bends or obstructions. Do not select areas with converging or

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diverging flow (approaches to a flume) or vertical drops. Do not select areas immediately downstream from sluice gates or places where the channel spills into a body of stationary water.

3.1.4   Flow is often measured while wading; for safety reasons, water depth should not exceed operator's waist depth. More information on safety procedures is described in Section 7.0.

3.2   Setting Velocity offset (Zero adjustment)

3.2.1   Perform a "zero" adjustment each day before data collection.

3.2.2   Connect the sensor to the portable meter.

3.2.3   Collect a bucket (must be non-metallic) of water from the water in the profile area. The bucket depth must be at least 20.32 cm (8 in.). The water depth must be at least 15.24 cm (6 in.). Suspend the sensor secured to the setting rod in the non-metallic bucket with water.

3.2.3.1   Place sensor (secured to the setting rod) in the bucket with water.

3.2.3.2   Secure the meter cable to the setting rod with a clamp.

3.2.3.3   To avoid touching the electrodes on the sensor leave at least 7.6 cm (3 in). between the sensor and the bucket.

3.2.4   Power on the FH950.

3.2.4.1   Click **Setup** on the Main Menu screen.

3.2.4.2   Select **Velocity Calibration**.

3.2.5   Select **OK**, when the meter reads 0.00 m/s (0.00 ft/s).

3.2.5.1   The cycle reads every 10 seconds.

3.2.5.2   If the meter does NOT read 0.00 m/s (0.00 ft/s), wait for the reading to stabilize, and select **Zero Velocity**.

3.2.5.3   The zero stability of the instrument is +/- 0.01 m/s (0.05 ft/s).

3.2.5.4   If reading is greater than +/- 0.01 m/s (0.05 ft/s), repeat the zero adjust process and consider cleaning the sensor

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electrodes or ensure the water in the bucket is completely still.

3.2.6   After setting Velocity offset is complete continue onto FH950 use.

3.3   Setup the portable handheld

3.3.1   Connect the sensor to the portable meter.

3.3.2   Power on the FH950 portable handheld.

3.3.3   Check the system settings to ensure that the proper measurement time interval, station entry method, discharge computation method, units of measurement, and measurement resolution are selected.

   3.3.3.1   From the Main Menu select **Setup**.

   3.3.3.2   Select **Filter Parameters**.

   3.3.3.3   Select **Main Filter**.

   3.3.3.4   Select **Fixed-Period Avg. (FPA)** and ensure the time is between 10 and 20 seconds.

   3.3.3.5   Select **OK**.

3.3.4   Set the distance between stations by fixed (automatic) or non-fixed (manual) methods.

   3.3.4.1   From the Main Menu select **Setup**.

   3.3.4.2   Select **More** (bottom of the screen).

   3.3.4.3   Select **Station Entry**.

   3.3.4.4   Select **Non-fixed**.

   3.3.4.5   Select **Top**.

   3.3.4.6   Select **OK**.

3.3.5   Set flow calculation method.

   The user can select the Mean-section or the Mid-section method for flow calculations. The Mid-section method divides the cross-section into individual flow segments (Wahl et al., 1995). The first and last verticals should be as near to the stream edges as possible. Experience shows that the Mid-section method gives more exact results compared to the Mean-section method, so it is the default

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setting (HACH, 2021; Young, 1950). Mid-section and Mean-section methodologies are presented in the Appendix.

    3.3.5.1   From the Main Menu select **Setup**.

    3.3.5.2   Select **More** (at the bottom of the screen).

    3.3.5.3   Select **Flow Calculation**.

    3.3.5.4   Select **Mid-section**.

    3.3.5.5   Select **OK**.

  3.3.6   Set or check the units of measurements.

The rod graduation marks are set in metric units. To facilitate measurement dynamics, set the units to the metric system.

    3.3.6.1   From the Main Menu select **Setup**.

    3.3.6.2   Select **More**.

    3.3.6.3   Select **Units**.

    3.3.6.4   Select **Metric**.

    3.3.6.5   Select the corresponding boxes.

    3.3.6.6   Set the units for velocity: meters per second (m/s).

    3.3.6.7   Set the units for flow: cubic meters per second (m^3/s).

    3.3.6.8   Set the depth: centimeters (cm). The rod graduation marks are set in centimeters.

    3.3.6.9   Set the area: square meters (m^2).

    3.3.6.10 Select **OK**.

  3.3.7   Set the velocity measurement resolution.

    3.3.7.1   From the Main Menu select **Setup**.

    3.3.7.2   Select **More**.

    3.3.7.3   Select **Measurement Resolution**.

    3.3.7.4   Select **0.01**.

    3.3.7.5   Select **OK**.

3.4   Connect the FH950 to the Top-Setting Wading Rod.

  3.4.1   Place the mounting hole of the FH950 sensor over the mounting shaft on the bottom end of the wading rod.

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3.4.2   Hand tighten the thumb screw clockwise to secure the sensor onto the mounting shaft. Do not overtighten the thumb screw.

3.5   Discharge cross section setup.

3.5.1   Mark the discharge cross section with a rebar headpin (HP) on the left bank (looking upstream) and a tailpin (TP) on the right bank. Install the HP and TP rebar into the streambank beyond the wetted edge of the water.
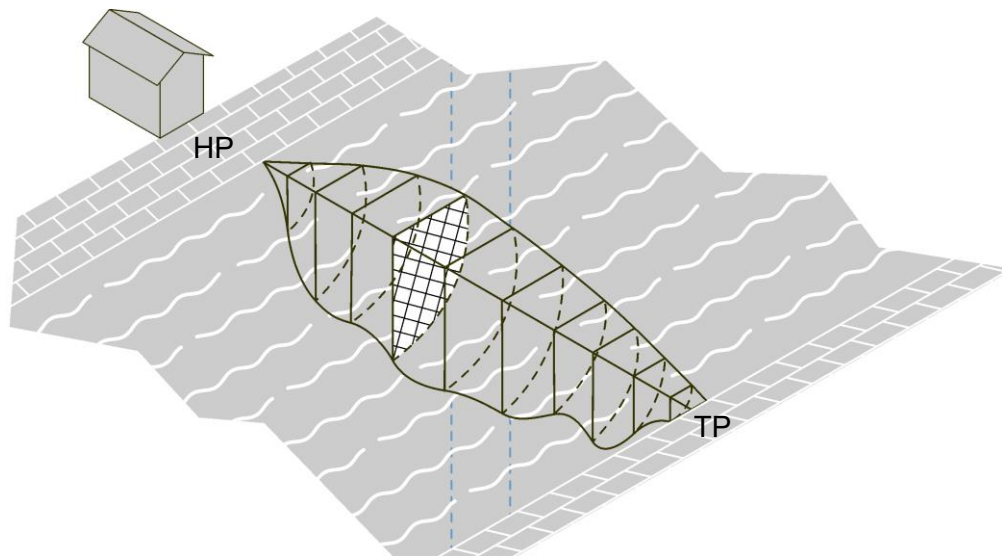
Figure 6. Example of a typical cross section indicating headpin (HP) on the left bank (looking upstream) and a tailpin (TP) on the right bank. Adapted from HACH (2021).

3.5.2   If permitted, flag the cross section with site information above the high-water mark on vegetation, and on the HP and TP if the cross section will be measured at different flows.

3.5.3   Take a GPS waypoint at the HP for reference and to ensure future repeatability, if needed.

3.5.4   Once the HP and TP are installed on the streambank, stretch a measuring tape from HP to TP and ensure that the tape is taut. Secure the measuring tape on both ends with zip-ties.

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Figure 7. Stream cross section demarcation in Concord, CA.

3.5.5   If the cross section has been modified in any way (i.e., removal of large rocks) to provide more reliable velocity measurements, allow the flow conditions to stabilize before beginning. Once velocity measurements have begun, do not alter the cross section.

3.5.6   After the measuring tape is installed, photograph the cross section.

　　3.5.6.1   Photograph the cross section while standing upstream on the **left bank** above the HP, aiming the camera across the stream towards the TP. Include the survey measuring tape in the image.

　　3.5.6.2   Photograph the cross section while standing upstream on the **right bank** above the TP, aiming the camera across the stream towards the HP. Include the survey measuring tape in the image.

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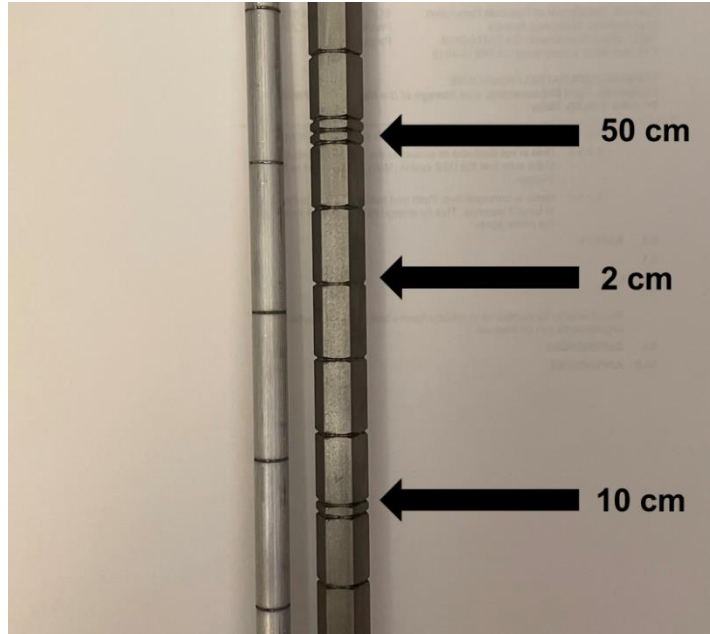*FH950 Portable Velocity Meter*

3.5.6.3   Photograph the entire longitudinal profile of the cross section from HP to TP (while standing both downstream and upstream of the cross section). Record the photo numbers in the appropriate field on the datasheet.

3.5.6.4   Photographs are helpful for documenting and comparing wetted cross section widths and channel conditions between measurements.

3.6   Determine cell depth and width for collection of velocity measurements along the cross section

The FH950 is used in conjunction with the top-setting wading rod to estimate site-specific discharge measurements. The depth that the FH950 sensor is set at for each individual measurement along the cross section is based upon the depth of the water column at that station. The fixed, hexagonal portion of the top-setting wading rod measures depth and has graduations of 2.0 cm. Double graduation marks represent increments of 10.0 cm, and triple graduation marks represent increments of 50.0 cm. The hexagonal rod scale is read to the nearest 1.0 cm by visually estimating between the 2.0 cm graduation increments. This is particularly important when measuring shallow depths. The minimum operable water depth for the FH950 sensor is 4.50 cm (0.15 ft).

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Figure 8. Rod graduation marks.

3.6.1   The vernier setting scale on the handle of the top-setting wading rod is used in conjunction with the sliding setting rod to position the sensor at the correct depth to measure velocity. When the foot scale on the setting rod and vernier scale are aligned to match the water depth observed on the hexagonal rod, the sensor is automatically set to six-tenths depth (0.6 depth) from the water surface. The **vernier scale will be used to set the unit**, while the graduation marks on the **setting rod will represent the tens** (i.e., **1**0, **2**7). Squeeze the lateral button to move the wading rod up and down. For example, Figure 9 indicates a water depth of 62 cm. Set the scale to 62 cm by aligning the "6" on the setting rod foot scale with the "2" on the vernier scale of the wading rod handle. This will

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automatically set the sensor to measure velocity at 0.6 depths of 62 cm (24.8 cm).
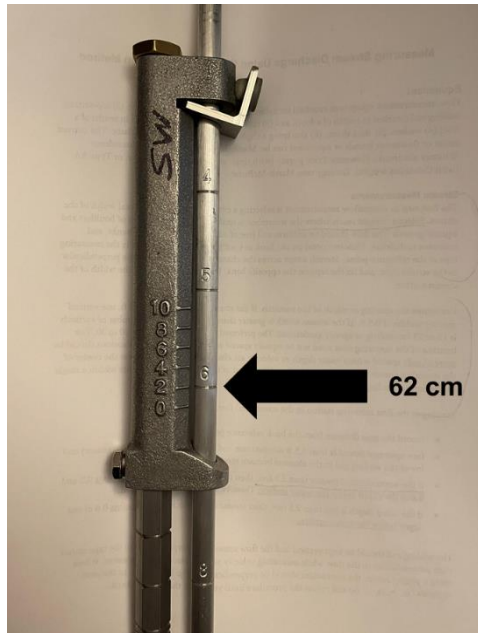
Figure 9. Vernier setting scale marks on Top-setting wading rod. Water depth set at 62 cm.

3.6.2 For depths measuring 4.50 to 75.0 cm (0.15 to 2.45 ft): **One measurement is taken at 0.6 depth from the water's surface**. This is referred to as the **one-point method** (Rantz, 1982). Set the sensor at 0.6 depth by lining up the foot scale on the setting rod with the vernier scale on the wading rod handle. For example, if the depth is 60 cm, line up the "6" on the setting rod foot scale with the "0" on the wading rod handle's vernier scale. In this example, the sensor will automatically be set to measure velocity at a depth of 24 cm (0.6 depths of 60 cm).

3.6.3 For depths greater than or equal to 76.0 cm (2.50 ft): Two depth measurements are taken and averaged. **If wading, water depth should not exceed the operator's waist depth. Measurements are taken at two-tenths depth (0.2 depth) and eight-tenths depth (0.8 depth) from the water's surface.** This is referred to as

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the **two-point method** (Rantz, 1982). For example, if the depth is 100 cm, set the wading rod as follows:

3.6.3.1 To measure at 0.2 depth from the water surface, double the depth observed on the hexagonal rod (i.e., 100 cm x 2 = 200 cm) and set the scale to 200 cm by aligning the "20" on the setting rod foot scale with the "0" on the vernier scale of the wading rod handle. This will automatically set the sensor to measure velocity at a depth of 80 cm. Photographs are helpful for documenting and comparing wetted cross section widths and channel conditions between measurements.

3.6.3.2 To measure at 0.8 depth, divide the depth by two (i.e., 100 cm / 2 = 50 cm) and set the scale to 50 cm by aligning the "5" on the setting rod foot scale with the "0" on the vernier scale of the wading rod handle. This will automatically set the sensor to measure velocity at a depth of 20 cm.

3.6.4 If the two-point method produces a non-standard or inverted-velocity profile, take an additional velocity measurement at 0.6 depth. This is referred to as the **three-point method**. A non-standard velocity profile is one in which the velocity at the 0.8 depth is greater than that at the 0.2 depth, or in which the velocity at the 0.2 depth is greater than twice that of the 0.8 depth. The velocity at the 0.6 depth is then averaged along with the average velocities of the 0.2 and 0.8 depths to determine the velocity at that station along the cross section.

3.6.5 Determine the spacing or width of the verticals. As a rough guide, the distance between each station can be determined by the length of the cross section.

3.6.5.1 If the stream width is less than 150 cm (5 ft), use vertical spacing widths of 15 cm (0.5 ft).

3.6.5.2 If the stream width is greater than 150 cm (5 ft), the minimum number of verticals is 10 or 25 (ISO, 2008; Wahl et al., 1995).

3.6.5.3 The cross section must have no more than 10% (ideally less than 5%) of the total discharge occurring in any one cell or between any two stations along the cross section. The location of the metering sites need not be equally spaced across the stream. **The locations should be more closely**

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spaced where water depth or velocity are changing most rapidly.

### 3.7   Data Collection Using the FH950

3.7.1   In the Main Menu, select **Profiler**.

3.7.2   Enter the operator's name. Make operator names alpha-numeric with a maximum of 23 characters. Push **OK** to save the operator's name.

3.7.3   Select **Setup**.

3.7.4   Select **Maximum Depth**.

3.7.5   Select **Automatic**. In this mode, the instrument uses the pressure transducer to measure the maximum depth at each vertical.

3.7.6   Align the foot scale on the setting rod and vernier scale to match the water depth observed on the hexagonal rod. The sensor is automatically set to six-tenths depth (0.6 depth) from the water surface.

3.7.7   Enter the distance (D) from the bottom of the channel to the bottom of the sensor mount (Offset). The Offset distance value can be

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different based on the water depth, wading rod used, and the properties of the bottom.
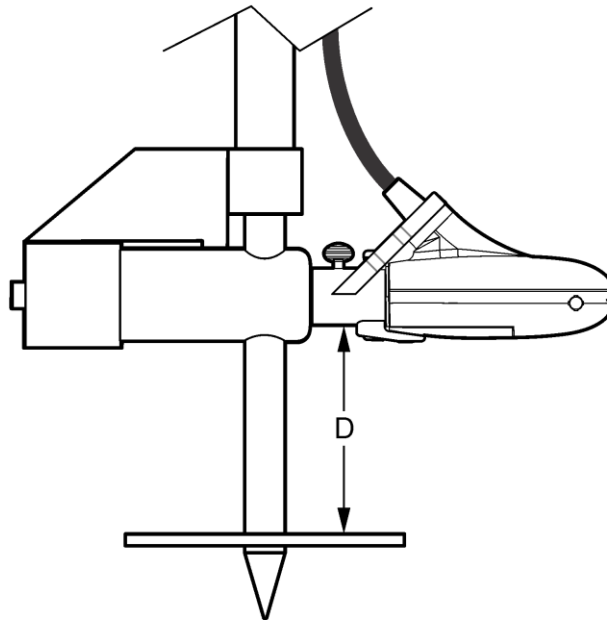
Figure 10. Offset distance (D). Adapted from HACH (2021).

3.7.8   Select **Stream.**

3.7.9   Enter the name of the new stream profile. Make profile names alpha-numeric with a maximum of 23 characters. Push **OK** to save the profile name or select Clear to delete all current stream data.

3.7.10 Enter the **Stage Reference**. The stage reference is usually an elevation value from an object that cannot be moved (e.g., a survey marker, staff gauge, bridge).

3.7.11 If Edge/Obstruction present, in the Station menu, select **Edge/Obstruction**. **Select one of the options: Left, Right, Open Water.**

3.7.12 Select **Distance to Vertical** and enter the information.

3.7.13 Select **Set Depth** and enter the information. If at an edge, the meter automatically sets this value to 0.00. If Automatic mode was selected in the Profiler setup, put the probe at the bottom and push

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OK to set the maximum flow depth at the value shown. Then, adjust the sensor offset.

3.7.14 If Left or Right was selected in Step 3.7.11, enter an edge factor for the vertical. Select a factor from the list or **User-defined**. For User-defined values, enter a roughness factor between 0.50 (very rough) and 1.00 (smooth). The roughness factor is relevant only for right angled cross sections. It is used as a factor in the calculation of the discharge proportion of edge areas. For example:

• Smooth edge with no vegetation (e.g., concrete, steel, cement) — 0.8 to 0.9.

• Brick sides with vegetation — 0.7.

• Rough walls with heavy vegetation — 0.6 to 0.5.

3.7.15 Select **Next** to move to the next station. Note: Velocity is zero at the edge.

3.7.16 Select **Distance to Vertical**.

3.7.17 Enter the distance of the vertical to the reference point at the bank (e.g., tagline zero).

3.7.18 Select **Set Depth**.

3.7.19 Measure the maximum depth (automatic mode).

3.7.20 Enter the stage reference.

3.7.21 Select **Measure Velocity**. Select an applicable velocity measurement method (e.g., Mid-Section).

3.7.22 Select a measurement point from the list. Follow the instrument prompts and adjust the sensor to the correct depth. Adjust the sensor depth until the depth box is green. This means the sensor is

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in at the correct position. Note: Red indicates more adjustment is necessary. Yellow indicates the depth is close to the correct depth.

3.7.23 For accurate measurement results, stand to the side of the instrument.
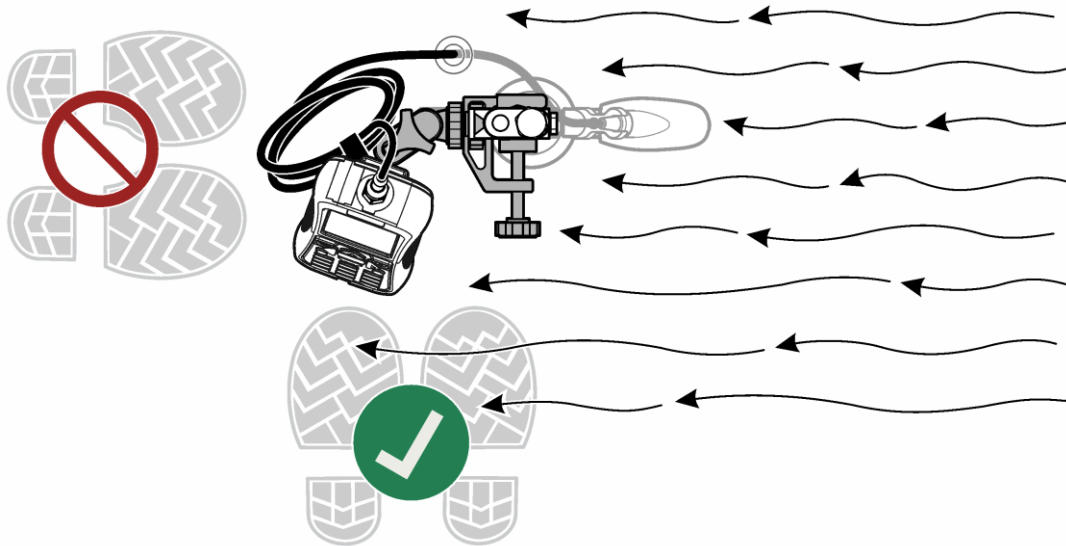
Figure 11. Position of user in the flow. Adapted from HACH (2021).

3.7.24 Select **Capture** to start the measurement process.

    3.7.24.1 If necessary, the setup can be changed, and the measurement can be repeated.

    3.7.24.2 It is <u>highly</u> recommended to collect data through field notes due to the flowmeter's low data storage capacity.

3.7.25 When the measurement is complete, push **OK** to store the data.

3.7.26 Repeat steps 3.7.22–25 for the other measurement points on the vertical.

3.7.27 When all measurements for the station are complete, select **Main** or **Verify Results**. Push **OK** to return to the list of measurement points.

3.7.28 Select **Next** to go to the next station.

3.7.29 Repeat steps 3.7.16–28 for all the remaining stations selected for velocity measurements.

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3.7.29.1 If the stop bank shows, select **Edge/Obstruction**. Repeat steps 3.7.11–14. To examine the measurement before exiting, select **Channel Summary**.

3.7.30 Select **Save Data and Exit**. Enter a name for the file and push **OK**. A warning flag will show if the discharge in one or more segments is more than 5% of the total discharge.

3.7.31 Insert or delete a station.

3.7.31.1 **Prev**, **Next**, **Ins** and **Del** options show at the bottom of the display in the Station screen. **Prev** and **Next** are used to navigate to a previous or subsequent station. **Ins** and **Del** are used to insert or delete a station.

3.7.31.2 For example, after measurements have been taken at 10 stations, a user may wish to insert a new station between

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stations 3 and 4. These steps can be applied in similar situations.

1. Select **Prev** and push **OK** until the display shows the information for Station 3.

2. Select **Ins** and push **OK**. The instrument adds a new station named Station 4. Subsequent stations are automatically given new sequential numbers.

3. To delete the current station (when in non-fixed mode), select **Del** and push **OK**.

4.0   DATA MANAGEMENT

4.1   Data download

4.1.1   Power on the FH950.

4.1.2   Set the FH950 to USB mass storage mode.

    4.1.2.1   From the Main Menu select **Setup**.

    4.1.2.2   Select **USB**.

    4.1.2.3   Select **Mass Storage**.

4.1.3   Connect the FH950 to the computer.

    4.1.3.1   Connect the USB cable to the handheld and computer.

4.1.4   Click **Setup** on the Main Menu.

4.1.5   Navigate to a drive labeled "PVM" on the computer.

    4.1.5.1   Data files are stored in tab separated variable (.TSV) format in a directory labeled "P."

4.1.6   Right-click or double-click to export the desired files to Microsoft Excel.

4.1.7   Delete old files.

    4.1.7.1   From the Main menu select **Diagnostics**.

    4.1.7.2   Select **Delete Files**.

4.1.8   Note: if the computer displays a warning message indicating that the device needs to be formatted before use, ignore the warning and **do not** format the device. In most instances, unplugging the

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USB cable from the computer and reconnecting with the FH950 power turned on will solve the issue.

5.0   MAINTENANCE

5.1   Download the PVM utility

The PVM Utility is used to update firmware in the portable meter.

5.1.1   Go to http://www.hach.com

5.1.2   Search for **FH950**.

5.1.3   Select FH950 in the search results.

5.1.4   Click the **Downloads tab**.

5.1.5   Scroll down to **Software/Firmware**.

5.1.6   Click **FH950 PVM Setup**.

5.1.7   Select **Save**.

5.1.8   Open the zip file.

5.1.9   Double-click the **PVMSetup** file.

5.2   Update the firmware

This is the general procedure to update firmware for the meter and sensor. To update the sensor firmware, the sensor must be

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connected to the meter. The PVM Utility (6.1) is necessary for this procedure.

5.2.1 Double-click the **PVM Utility desktop icon** on the PC.

5.2.2 Push the power button on the meter. When the meter self-test is complete, push **OK**.

5.2.3 In the Main Menu, select **Setup**, then push **OK**.

5.2.4 Select **USB>CDC**, then push **OK**.

5.2.5 Connect the USB cable to the portable meter and the PC.

5.2.6 In the PVM Utility window, select **Connect**.

5.2.7 In the drop-down menu, select the **PVM (COM X) port**, where COM X is the virtual port number assigned to the PVM by Windows. Push **OK**.

5.2.8 In the left-side panel, select **Firmware Update**, then select the **Meter or Sensor** tab.

5.2.9 Select the correct firmware version, then click **Start**. The firmware download starts. A "Firmware update successful" message shows when the download is complete. For meter updates, the instrument display turns off until the instrument completes the update. Then, the instrument automatically resets and powers up again after a few

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minutes. Do not try to make the instrument power on or off before the update process is complete.

5.2.10 In the Main Menu, select **Diagnostics > About**. Make sure that the firmware versions for both the Handheld Boot and the Handheld Application are correct.

5.3 Clean the sensor

Clean the sensor when unexpected increases or decreases in flow or level trends occur and after use in sandy or muddy waterways.

5.3.1 For heavy contamination, soak the sensor in clear tap water for a few minutes to help make the contamination easy to remove.

5.3.2 Disconnect the sensor from the meter before it is cleaned.

5.3.3 Acceptable solutions to clean the sensor are **dish detergent and water, window cleaner, and isopropyl alcohol.**

5.3.4 Make sure the holes for the pressure cell chambers are washed out and clear of contamination.

5.3.5 Rinse the sensor with clean water before re-attaching the sensor to the assembly.

5.4 Clean the meter

5.4.1 Push the power button to de-energize the meter.

5.4.2 Use a clean, moist cloth to clean the meter exterior. Mix the water with a mild detergent if necessary.

5.4.3 Dry the meter exterior with a clean cloth. Let the meter air-dry completely before it is energized again.

6.0 TROUBLESHOOTING

6.1 Diagnostics

6.1.1 In the Main Menu, select **Diagnostics** to see information about the meter and to perform diagnostic tests.

6.1.1.1 About: Shows information about the meter and the sensor. Includes the serial number and the firmware version.

6.1.1.2 Delete files: Deletes all files from memory to make space for new measurements. Make sure that the data is downloaded

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to a PC before this option is selected. The system automatically reformats the memory after file deletion.

6.1.1.3   Sensor: Shows diagnostic information about the sensor.

6.1.1.4   Self-test: Makes the meter perform a diagnostic self-test.

6.1.1.5   Keypad test: Does a test of any button to make sure that the button is functional.

6.1.1.6   Display test: Does a test on the display to make sure that the display is functional.

6.1.1.7   Event log: Lets the user view, delete or export the event log. Export the event log to make the contents available as an

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accessible file through USB mass storage. This option is used primarily by factory service.

6.2   Troubleshoot errors

6.2.1   The meter and sensor contain no user-serviceable parts. If the problem does not go away or a problem occurs that is not in the list, contact the manufacturer.

6.2.1.1   Sensor is not connected: Connect a sensor and try the action again.

6.2.1.2   Value is out of range: Change the measurement parameters or put in a different value, then try the action again.

6.2.1.3   Sensor data is known to be not correct or not accurate: Clean the sensor and test.

6.2.1.4   Sensor is not recognized: Check the sensor connection. Make sure that the lock nut on the connection port is tight (finger-tighten only).

6.2.1.5   Display is dim or is not visible: Push a key on the keypad.

6.2.1.6   Data is not available or access to the data is not possible: Make sure that the USB option (Main Menu) is set to Mass Storage.

6.2.1.7   Meter is unresponsive: Push and hold the power button for at least 3 seconds. This de-energizes the meter. Energize the meter again.

7.0   SAFETY

7.1   Field Procedures

The wide range of environmental conditions on a stream combined with the relatively large number of measurements creates a higher potential situation for accidents (Yobbi et al., 1996). Listed below are some safety guidelines that need to be observed according to Yobbi et al. (1996):

7.1.1   If taking measurements at a known location, review the field notation to determine the best section for taking measurements. Also determine if any potential risks are apparent and the maximum velocity and depths that may be encountered.

7.1.2   Determine whether the river stage is rising or falling. Beware of rapid rises in river stage when wading and anticipate and allow for changes in flow conditions at the end of the measurement. It is a

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good idea to select an object (rock, stump, mark along bank, etc.) that is just above water surface and keep watching it to determine if the river stage is rising or falling.

7.1.3   Always probe the stream bed ahead with a rod when moving from bank to bank. Keep your feet spread apart and alignment of legs parallel to the flow for better stability.

7.1.4   If the velocity becomes too dangerous for safe wading do not turn around. When the greater area of the front or back of the body is exposed to the current, you may be swept downstream. Back out carefully, bracing yourself with the wading rod.

7.1.5   If necessary, wear a PFD (Personal Flotation Device) when wading and conducting discharge measurements. Tie the tagline securely so that you may pull yourself out, if necessary.

7.1.6   Do not wear boots or waders that are too tight or too loose.

7.1.7   Beware of sand channels and dense muds where potholes, quicksand, and scour can be hazardous.

7.1.8   Beware of slick, steep banks, and swampy areas.

7.1.9   Watch for debris and ice drifting.

7.1.10 Beware of streams with partial or thin ice cover and especially of ice-covered streams at the time of incipient breakup. To venture out on such ice, tie yourself to some stable object ashore or overhead, if available. Otherwise, stay off and return on another day.

7.1.11 At controlled or regulated streams, consult dam, reservoir or gate operators before entering stream.

7.2   Laboratory Procedures

Follow Environmental Monitoring's Chemical Hygiene Plan when working in the laboratory. General safety includes wearing gloves, safety glasses, and closed-toed shoes. When using bleach and HCl, other protection (such as a lab coat or rubber apron) may be required. Dispose of any solutions according to the Chemical Hygiene Plan.

8.0   REFERENCES

HACH. (2021). *FH950 User Manual* (7 ed.).

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9.0   APPENDICES

9.1   Appendix 1. Mid-Section and Mean-Section methods.

To determine flow in a stream the user must know the stream's average velocity and the cross-sectional area. The user can select the Mid-section or the Mean-section method for flow calculations. The Mid-section method divides the cross-section into individual flow segments. With the Mid-section method, the segments are defined by half of the distance to neighbor verticals in each case. For this reason, the first and last verticals should be as near to the edges as possible (i.e., left edge of water (LEW) and right edge of water (REW)). Boundary conditions dictate the proximity of the first and last vertical to the edge of water. Figure 12 shows the definitions and equation for the Mid-section method.

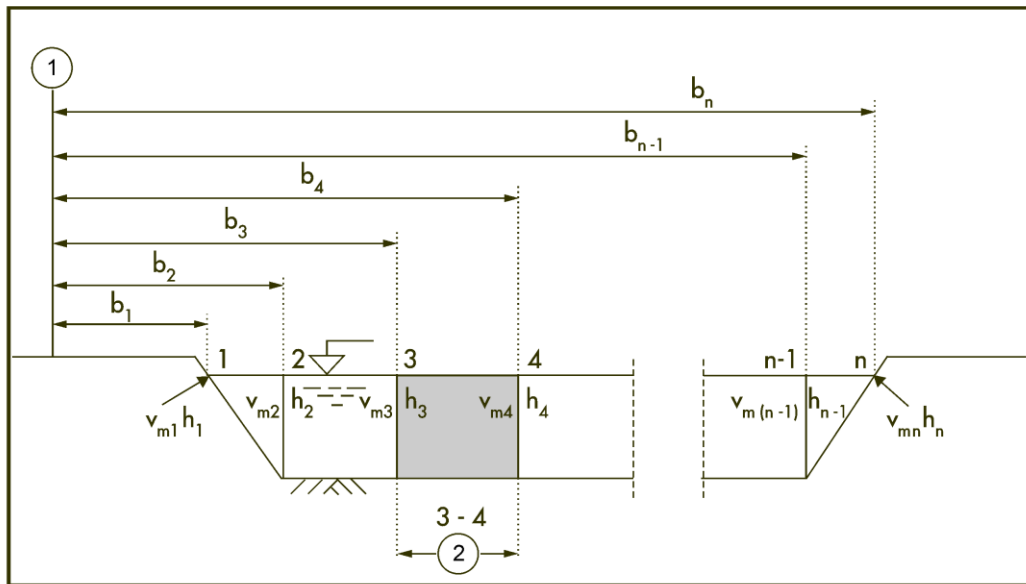$$q_3 = V_{m3} \times \left(\frac{(b_3 - b_2) + (b_4 - b_3)}{2} \right) \times h_3$$
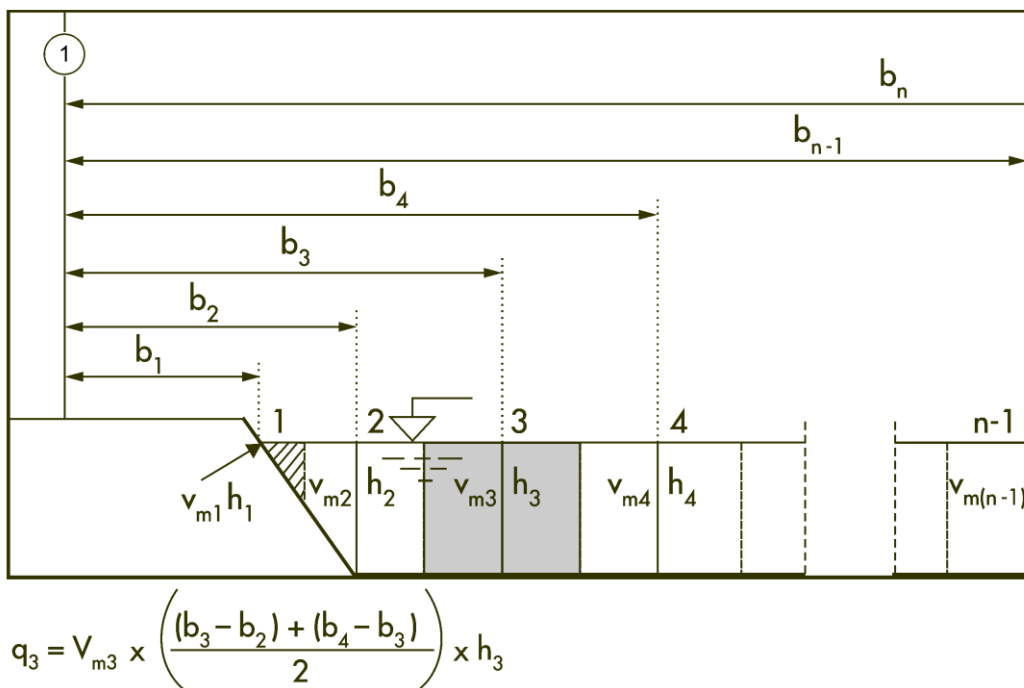
Figure 12. Mid-section method. Adapted from HACH (2021).

Where: m = station number; n = total number of stations; V = velocity at vertical; b = distance to vertical from bank; h = depth at vertical; q = flow at vertical.

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The Mean-section method also divides the cross-section into individual flow segments. Pairs of adjacent verticals are the limits of the segments. The two edges of the cross-section are given values of 0 for the velocity and depth. The total flow is the sum of the partial flows of all segments. Figure 13 shows the definitions and the equation for the Mean-section method.

$$q_{3-4} = \left(\frac{V_{m3} + V_{m4}}{2} \right) \times \left(\frac{h_3 + h_4}{2} \right) \times (b_4 - b_3)$$

Figure 13. Mean-section method. Adapted from HACH (2021).

Where: m = station number; n = total number of stations; V = velocity at vertical; b = distance to vertical from bank; h = depth at vertical; q = flow at vertical.

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Appendix 2. Stream-Discharge Data log sheet.

Stream I.D.:			Date:		Time:	
Weather Conditions:						
Users:						
Stage Reference:						

#	Distance from the Edge (m)	Sensor Depth (cm)	Velocity (m/s)	Observations
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				