DEPARTMENT OF ECOLOGY
State of Washington

Standard Operating Procedure EAP109, Version 1.1

Watershed Health Monitoring: Standard Operating Procedures for Estimating Stream Discharge (Narrow Protocol)

December 2019
Publication 19-03-226
[Recertified 2019]

Purpose of this Document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication Information

This SOP is available on the Department of Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1903226.html.

Ecology's Activity Tracker Code for this SOP is 18-037.

***Recommended citation*:**
Wolfe, J. 2019. Standard Operating Procedure EAP109, Version 1.1: Estimating Stream Discharge (Narrow Protocol). Publication No. 19-03-226. Washington State Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/SummaryPages/1903226.html. [Recertified 2019.]

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EAP109
APPROVED 2/16/2017
RECERTIFIED 12/11/2019

SIGNATURES AVAILABLE UPON REQUEST

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which the Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Revision History	Summary of changes	Sections	Reviser(s)
1/4/17	1.1	Changed title, added footers, general updates	All	Meghan Rosewood-Thurman
1/20/17	1.1	Glossary updates, formatting, references	All	Meghan Rosewood-Thurman
1/26/17	1.1	General Formatting, References	All	Meghan Rosewood-Thurman
2/8/17	1.1	2.1 Removed italics 4.3 Removed italics 4.6 (2016) 5.1.3 Depth increments in tenths of ft 5.4 (2016) 6.1.2 Cited SOP EAP106 6.3.4.1 lower case: “navigate” 10.5 Edited meter manual citation 10.6 Reordered alphabetically 10.7 Added SOP EAP106 10.9 Version 2.1 (2016)	2.0 4.0 5.0 6.0 10.0	Glenn Merritt
2/13/17	1.1	Added Reviewers	Signature Page	Meghan Rosewood-Thurman
2/16/17	1.1	Removed drafted dates	Signature Page	Meghan Rosewood-Thurman
8/5/19	1.1	5.1 Formatting 6.0 Spelling correction Added Alt text to pictures	5.0 6.0 6.0	Jenny Wolfe
12/11/19	1.1	Recertified	All	Arati Kaza

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program's (EAP) Standard Operating Procedure (SOP) for estimating stream discharge in rivers and streams for the Watershed Health Monitoring (WHM) program. This SOP is also used in the Ambient Biological Monitoring Program.

2.0 Applicability

2.1 This SOP is applied only at data collection events (DCE) that follow the Narrow Protocol. Discharge is not required for the Wide Protocol.

2.2 This SOP is used in conjunction with several others to complete a DCE for the WHM program. This method is applied to a portion of the site that is free of side-channels. This SOP requires that the WHM Site Verification & Layout SOP EAP106 (Merritt, 2017) has already been performed for the DCE.

3.0 Definitions

3.1 DCE: The *Data Collection Event* is the sampling event for the given protocol. Data for a DCE are indexed using a code which includes the site ID followed by the year, month, day, and the time (military) for the start time of the sampling event. For example: WAM06600-000222-DCE-YYYY-MMDD-HH:MM. One DCE should be completed within one working day, lasting 4 – 6 hours, on average.

3.2 Narrow Protocol: The set of Watershed Health Monitoring SOPs that describe data collection at wadeable sites with an average bankfull width of less than 25 m at the index station.

3.3 QAMP: Quality Assurance Monitoring Plan. The QAMP for WHM is Cusimano *et al.* (2006). An updated version is in early stages of development.

3.4 Site: A site is defined by the coordinates provided to a sampling crew and the boundaries established by the protocol's site layout method (Hartman, 2017 (SOP EAP105) for the Wide Protocol; Merritt, 2017 (SOP EAP106) for the Narrow Protocol. Typically, a site is centered on the index station and equal in length to 20 times the average of 5 bankfull width measurements. Sites cannot be longer than 2 km nor shorter than 150 m. Narrow protocol sites range from 150 m to 500 m long. Wide Protocol sites are up to 2 km long. The most downstream end of a site coincides with major transect A; the most upstream end coincides with major transect K.

3.5 Thalweg: Path of a stream that follows the deepest part of the channel (Armantrout, 1998). For WHM, we emphasize Armantrout's use of the word "path" because the thalweg longitudinal profile excludes (sometimes deeper) side pools that are not part of the dominant flow path.

3.6 WHM: Watershed Health Monitoring, a status and trends monitoring program within the Environmental Assessment Program at the Washington State Department of Ecology

3.7 Wide Protocol: The set of WHM SOPs that describes the sample and data collection at non-wadeable sites or sites wider than 25 m bankfull width. It is an abbreviated version of the Narrow Protocol and is typically accomplished by use of rafts.

4.0 Personnel Qualifications/Responsibilities

4.1 This SOP pertains to all Natural Resource Scientists, Environmental Specialists, Administrative Interns, and Environmental Technicians in Ecology's EA Program or any staff using WHM protocols.

4.2 All field staff must comply with the requirements of the EA Safety Manual (Ecology, 2015). A full working knowledge of the procedures in Chapter 1 "General Field Work," especially the sections "Working in Rivers and Streams," and "Fall Protection," is expected.

4.3 All field staff must have completed the annual WHM field training and be familiar with the full Narrow Protocol.

4.4 All field staff must be familiar with the electronic data recording tablet and web-based WHM field forms.

4.5 The field lead directing sample collection must be knowledgeable of all aspects of the project's Quality Assurance Monitoring Plan (QAMP) to ensure that credible and useable data are collected. All field staff should be briefed by the field lead or project manager about the sampling goals and objectives prior to arriving at the site.

4.6 Field staff must be annually trained to minimize the spread of invasive species. See SOP EAP070 (Parsons et al., 2016).

5.0 Equipment, Reagents, and Supplies

5.1 Velocity-Area Method

- 5.1.1 Field tablet with the most current WHM e-forms
- 5.1.2 Distance-measuring device (50 m tape or stadia rod)
- 5.1.3 Flow meter (set to measure in ft/s)
- 5.1.4 Top setting wading rod (with depth increments in tenths of feet)
- 5.1.5 Spare batteries

5.2 Timed Float Method

- 5.2.1 Neutrally buoyant object (e.g. whiffle ball)
- 5.2.2 Distance-measuring device (50 m tape or stadia rod)
- 5.2.3 Stop watch

5.3 Timed Fill Method

- 5.3.1 Bucket of known volume
- 5.3.2 Stop watch

5.3.3 Access gear (waders and boots). This should be pre-cleaned to avoid the spread of invasive species. See SOP EAP070 (Parsons et al., 2016) for more information.

6.0 Summary of Procedure

6.1 Pre-Sampling Preparation

6.1.1 File an "Ecology Field Plan." Forms are available and should be posted on the EA Program SharePoint site.

6.1.2 Follow the method outlined in this SOP only after completing steps in SOP EAP106 for site verification and layout (Merritt, 2017).

6.2 General Considerations and Cautions

6.2.1 Never compromise your personal safety or that of field partners to complete a DCE. Always plan ahead to avoid falling and drowning hazards.

6.2.2 Be aware of wildfire activity. It may pose a safety threat or may change or limit access to certain areas.

6.2.3 Stand downstream of the probe when using velocity-area method to avoid influencing flow measurements.

6.3 Methods for Estimating Stream Discharge

6.3.1 Velocity-Area Method

6.3.1.1 Select a suitable stream cross section for measurements. Preference should be given to locations that are close to "X" and have most of the following conditions:

6.3.1.1.1 The stream is straight.
6.3.1.1.2 Depths are mostly greater than 0.5 ft (15 cm).
6.3.1.1.3 Velocities are mostly greater than 50 ft/s (0.15 m/s).
6.3.1.1.4 Local habitat is not a pool.
6.3.1.1.5 The channel is "U-shaped."
6.3.1.1.6 The streambed is uniform and free of objects that cause turbulence.

6.3.1.2 Place a stadia rod, or taut measuring tape, perpendicular to the stream flow, and parallel to the stream surface. Subtract the left edge wetted value from right edge wetted value to determine the wetted width. On the field tablet, navigate to the *Discharge Page* and select *Meter* under the *Select Discharge Method* button (Figure 1). Record the nearest station, instrument description, wetted width and units (m).

6.3.1.3 Define about 15 – 20 equally-spaced stations across the stream (fewer for very small streams). To determine spacing between stations, divide the wetted width by 20 and round up to a convenient number. Stations should not be closer than 10 cm to each other, even if this results in fewer than 15 stations. The first station is located at the left wetted margin, and the last station is located at the right wetted margin.

6.3.1.4 Use a calibrated flow meter equipped with a top-setting wading rod that has depth increments in tenths of feet. At each station, record the tape distance (cm) from left to right. Record the water depth (nearest 0.1 ft). Place the sensor 60% of the distance down from the surface (Figure 2). Measure and record water velocity (nearest 0.01 ft/s).

6.3.1.5 Once all measurements have been recorded, press the “Calculate” button under the “Discharge” field.

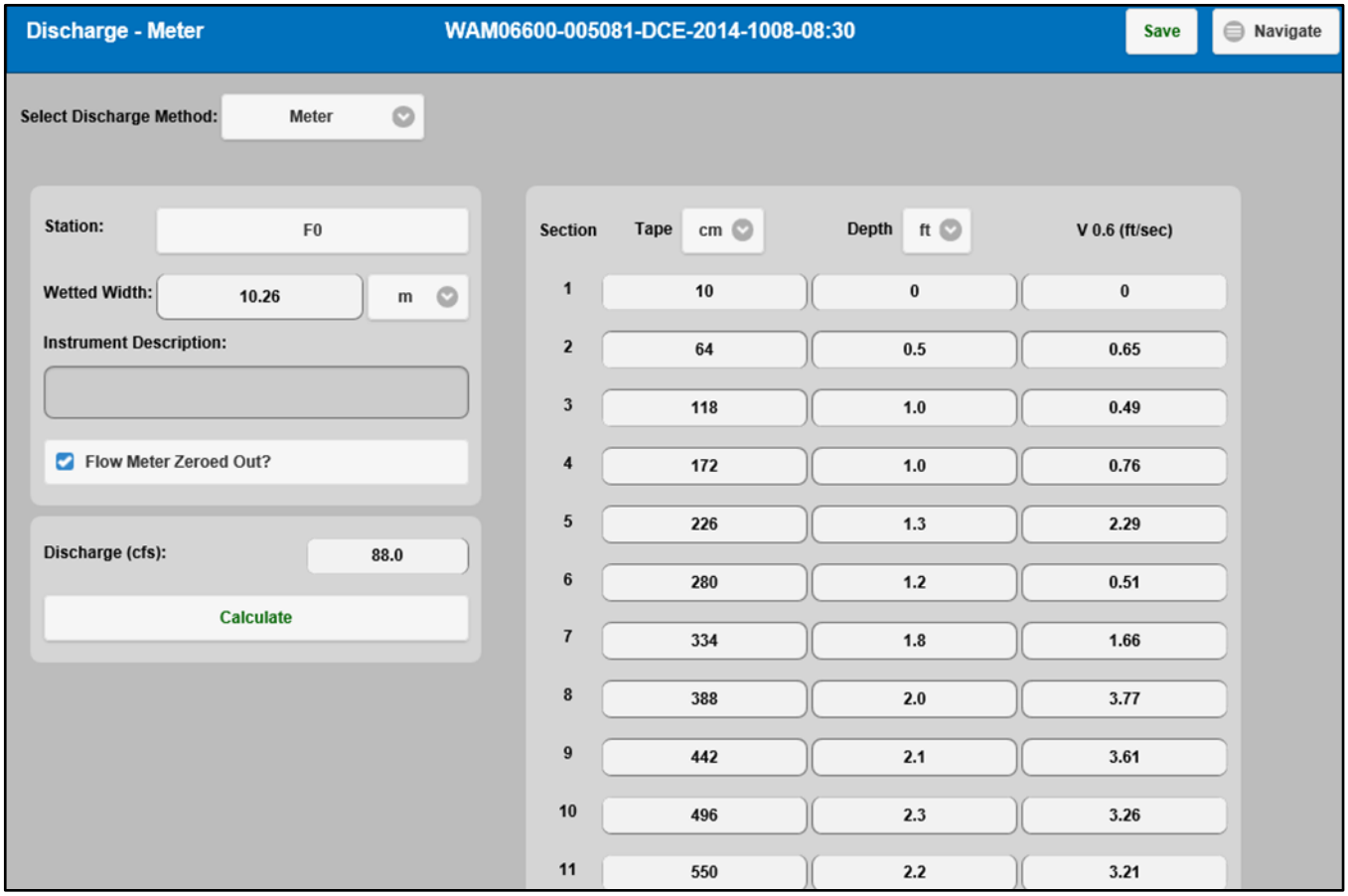

Figure 1. Discharge Page for Velocity-Area Method

NOTE: The field form is *flexible* for units, to allow for differences in equipment. However, **we seek depth in tenths of feet and distance in whole centimeters**. Ensure that the completed form is recorded in the same units that were measured. **Velocity is <u>always</u> measured in feet per second, to the nearest hundredth**. Be sure that the meter is set accordingly.

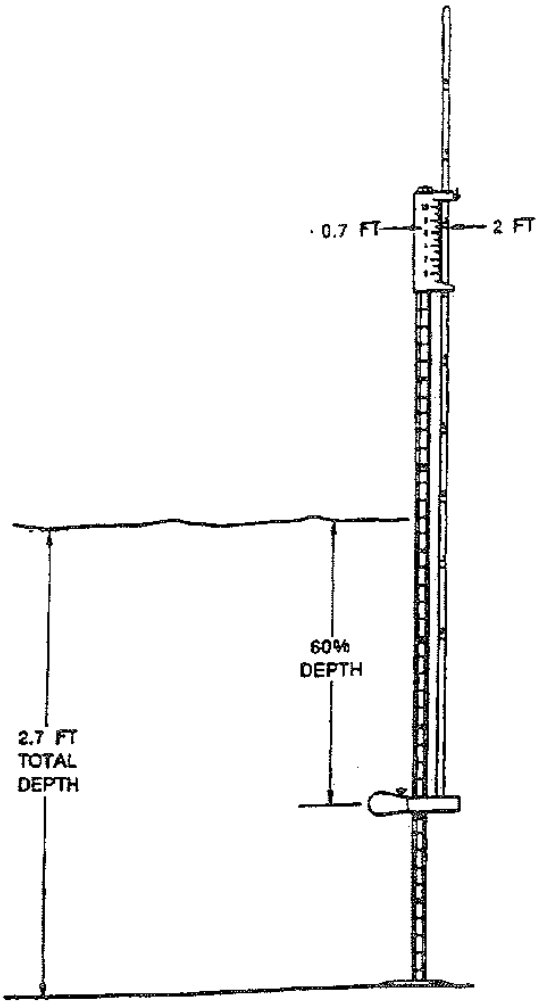

Figure 2. Setting the wading rod at 60% depth when at a station that is 2.7 feet deep. Modified from Marsh-McBirney (1990)

6.3.2 Timed Float Method

6.3.2.1 When conditions do not permit the use of a current meter, the transport time of a neutrally buoyant object can be used to estimate velocity. Select a suitable stream section for measurements. Preference should be given to locations that have a somewhat strait, uniform channel with non-turbulent flow. Select an upstream and a downstream cross-section and measure the distance between them. The segment should be long enough that it takes 10 to 30 seconds for the float to pass.

6.3.2.2 Select a semi-buoyant object that floats low in the water but does not drag along the bottom of the stream. Examples of suitable objects are an orange, a plastic golf ball, or a partially filled sample bottle.

6.3.2.3 Navigate to the *Discharge Page* (Figure 3) and select *Time of Travel* under the *Select Discharge Method* button. Record the nearest station and the average wetted width (m) where you measured flow.

6.3.2.4 Release the float at the upstream cross-section and record the time it takes to reach the downstream cross-section. Repeat this twice more, each time releasing at a different location across the stream channel where there are no obstacles or impediments, and record each trial on the *Discharge Page.*

6.3.2.5 Choose a cross-section that is representative of the time-of-travel segment. Measure the width from the thalweg to the wetted edge for both the left and right portions of the channel. At the same location measure the wetted depths at the thalweg: left wetted edge and right wetted edge. Record these values on the *Discharge Page* along with the units of measurement. For a visual guide to these measurements, click on the *Time of Travel Cheat Sheet* button (Figure 4).

6.3.2.6 Once all measurements have been recorded, press the “Calculate” button under the “Discharge” field.

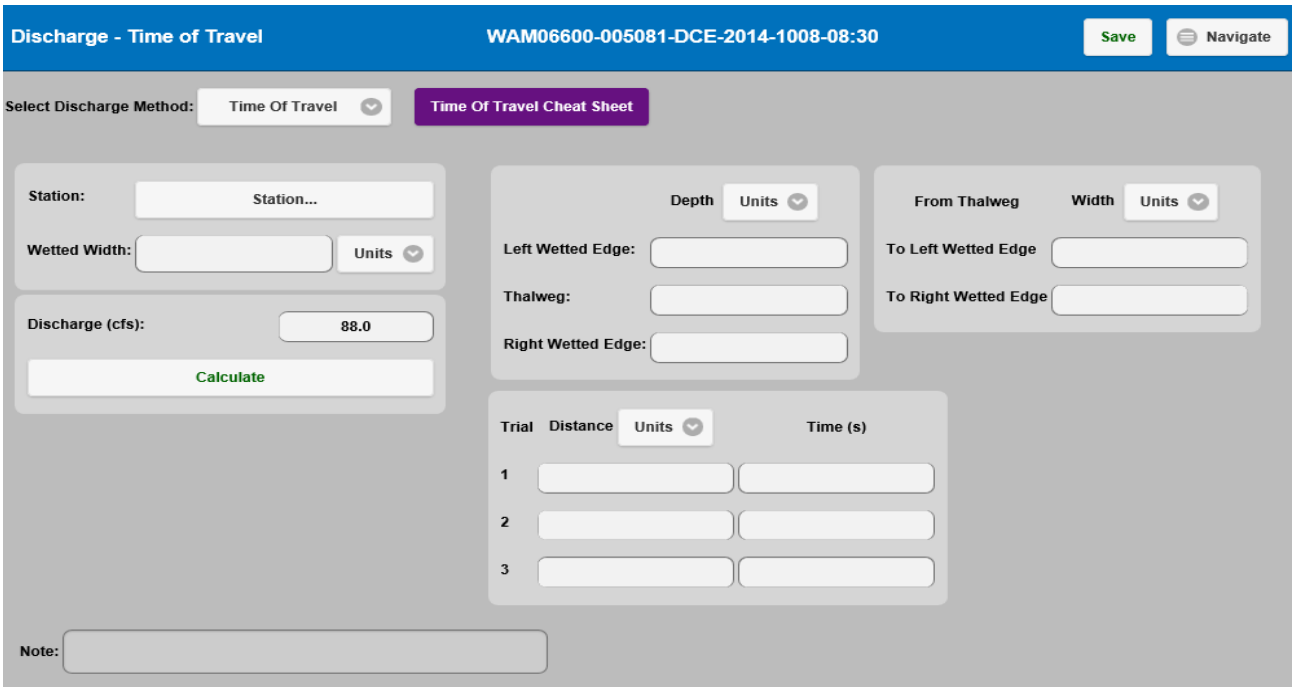

Figure 3. Discharge Page for Time of Travel Method

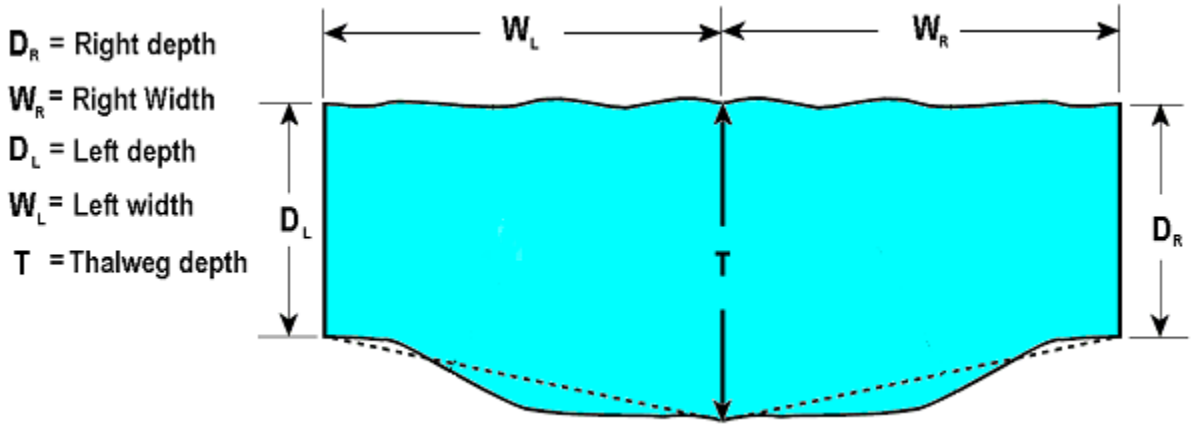

Figure 4. Time of Travel Cheat Sheet

6.3.3 Timed Fill Method

6.3.3.1 This method can only be used in situations with low flow when all of the flow can be caught in one container. For example, capturing flow from a culvert.

6.3.3.2 Using a bucket or container with a known volume, time how long it takes to fill the container. Repeat this method two more times.

6.3.3.3 Navigate to the *Discharge Page* (Figure 3) and select *Bucket* under the *Select Discharge Method* button. Record the nearest station and volume of the container used. Record the three timed bucket fills.

6.3.3.4 Once all measurements have been recorded, press the "*Calculate*" button under the "*Discharge*" field.

6.3.4 Estimating Discharge from a Stream Gage

6.3.4.1 For streams that have flow data already associated with them, navigate to the *Discharge Page* (Figure 3), and select *Gage* under the *Select Discharge Method* button. Enter the gage ID, gage owner, stage height or discharge value, and the location of the gage relative to the WHM samp4le site.

6.3.5 Stream Flow Too Low to Measure

6.3.5.1 Some streams lack the depth and velocity to accurately measure flow. In this case, flow can be estimated. Navigate to the *Discharge Page* (Figure 3) and select *Other* under the *Select Discharge Method* button. Enter the estimated discharge value, and describe the method from which it was obtained under the *Alternative Method* frame.

7.0 Records Management

7.1 Refer to the SOP EAP125 (Janisch, 2017).

8.0 Quality Control and Quality Assurance

8.1 QA/QC is discussed in the Quality Assurance Monitoring Plan (Cusimano et al., 2006), which will soon be updated.

9.0 Safety

9.1 For further field health and safety measures refer to the EAP Safety Manual (Ecology, 2019).

10.0 References

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