DEPARTMENT OF ECOLOGY
State of Washington

# Standard Operating Procedure EAP122, Version 1.1

# Measuring Stream Slope (Narrow Protocol)

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# 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

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Standard Operating Procedure EAP122, Version 1.1: Measuring Stream Slope (Narrow Protocol)

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*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.*

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*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 | Rev number | Summary of changes | Sections | Reviser(s) |
|---|---|---|---|---|
| 3/7/17 | 1.1 | Updated title, removed drafted dates, added footers, updated glossary terms and references, general formatting | All | Meghan Rosewood-Thurman |
| 3/15/17 | 1.1 | Changed “meter” to “degree” | 6.3 | Meghan Rosewood-Thurman |
| 3/20/17 | 1.1 | Replaced “site” for “reach”<br>Edited eye height definition<br>Edited increment length definition<br>Simplified<br>Trademark<br>Metric units<br>Added measure increment length<br>Simplified text; “site” replaces “reach”<br>Simplified text; moved figure 1 earlier<br>Added notes<br>Nikon discussion fully into Note<br>Added flagging; changed caption<br>Changed caption<br>Changed caption<br>Simplified text. Renumbered<br>Note allowing for approximate increment distance if total sums to site length<br>2016 | 1.1<br>3.4<br>3.5<br>4.1<br>5.3<br>5.5<br>6.3<br>6.3.1<br>6.3.2<br><br><br>Figure 1<br>Figure 2<br>Figure 3<br>6.3<br><br><br><br>10.8 | Glenn Merritt |
| 3/20/17 | 1.1 | Initial approval | | Kammin |
| 6/7/2019 | 1.1 | Accessibility and formatting updates | All | Ruth Froese |
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## 1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for field measurement of the total site slope for a stream site during a Data Collection Event (DCE) for the Watershed Health Monitoring (WHM) Program. This method is only intended for sites sampled with the Narrow Protocol.

1.2 This SOP describes two different field procedures for measuring slope. Either method is a valid option for sites sampled with the *Narrow protocol*. See SOP EAP105 (Hartman, 2017) for office-based measurement of slope when using the *Wide Protocol*.

## 2.0 Applicability

2.1 This SOP is used in conjunction with several others to complete a DCE for the WHM Program. Several discrete slope measurements are taken, and when combined, span from the most upstream end of the reach (transect K) to the most downstream end (transect A). The number of individual slope measurements may vary from site to site, but the whole reach (A to K) must always be assessed. Follow the method outlined in this SOP only after the site verification and layout procedures have been completed (see SOP EAP106, Merritt 2017).

2.2 Data collected with the methods outlined in this SOP are used to calculate the total slope of the stream reach (Janisch, 2013). Slope is a component of several habitat metrics including Relative Bed Stability (RBS) and Residual Pool Area (ResPoolArea).

## 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 that 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 EAP: Environmental Assessment Program

3.3 Ecology: The Washington State Department of Ecology

3.4 Eye height: Vertical distance from the bottom of someone’s heel to their pupil, when they are standing erect.

3.5 Increment length (for this SOP): The distance between technicians 1 and 2 for each portion of slope measurement. The sum of all increment lengths equals total site length.

3.6 Index station: The distinct point location mapped by the site coordinates obtained from the Washington Master Sample List. The index station is called "X" and is generally located at major transect F; however the point may occur at any elevation in the stream between transects A and K.

3.7 Major transect: One of 11 equidistant transects across the length of a site. These transects run perpendicular to the thalweg and are labeled as follows: A (furthest downstream), B, C, D, E, F, G, H, I, J, and K (furthest upstream).

3.8 Minor transect: One of 10 equidistant transects across the length of a site that is sampled using the Narrow Protocol. Each minor transect is located midway between major transects. Minor transects are A5, B5, C5, D5, E5, F5, G5, H5, I5, and J5.

3.9 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.

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

3.11 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 and most frequently longer than 500m. The most downstream end of a site coincides with major transect A; the most upstream end coincides with major transect K.

3.12 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.

3.13 Transect: A straight line along which observations are made or measurements are taken. This line spans the stream channel and is perpendicular to the direction of flow.

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

3.15 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 All field staff must comply with the requirements of the most current EAP Safety Manual (Ecology, 2019).

4.2 All field staff must have completed the annual WHM Program field training and be familiar with the set of SOPs that combine to describe a full DCE for the WHM Program.

4.3 All field staff must be familiar with the electronic data recording tablet and web-based field forms that one uses to record and submit data for the WHM program.

4.4 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 on the sampling goals and objectives prior to arriving to the site.

4.5 All field staff must comply with Ecology's SOP *EAP070: Minimizing the Spread of Aquatic Invasive Species* to the level described in the QAMP (Parsons et al., 2016).

## 5.0 Equipment, Reagents, and Supplies

5.1 Field tablet, electronic field forms

5.2 Disinfection solutions, brushes, or other equipment necessary to minimize the spread of invasive species from site to site. See EAP Policy 1-15 (Ecology, 2015) for more information.

5.3 Tygon® tubing, 3/8 inch (10–15 meters)

5.4 Laser hypsometer

5.5 Stadia rod (m and cm)

5.6 Ruler (with cm measurements)

## 6.0 Summary of Procedure

6.1 Pre-sampling preparation

6.2 File a "Field Work Plan & Contact Person" form. Forms are available and should be posted on the EAP SharePoint site.

6.2.1 Follow the method outlined in this SOP only after completing site verification and layout procedures in SOP EAP106 (Merritt, 2017) and after determining that the Narrow Protocol should be used.

6.3 General considerations and cautions

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

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

6.4 Narrow protocol for measuring reach slope

6.4.1 Measure, in increments, the total slope of the stream site between major transects K and A. There is no prescribed increment length, and increments can vary within the site. However, it is convenient to have the measurements start and stop at major or minor transects. Combined increments must span the entire site length. Two people are required.

6.4.2 Measuring slope with a laser hypsometer

6.4.2.1 **Prepare equipment.**

6.4.2.1.1 Measure the eye-height of technician 1.

6.4.2.1.2 Tie a piece of bright flagging on Technician 2's stadia rod at this measurement.

6.4.2.2 **Get into position.**

6.4.2.2.1 Technician 1: Stand at water level (e.g., wetted margin) at the upstream transect and face downstream toward technician 2.

6.4.2.2.2 Technician 2: Stand at a convenient downstream location (the next major transect for example) and hold the stadia rod vertically, with the rod's bottom at water level.

6.4.2.3 Technician 1: Stand straight and hold the hypsometer to your eye. Point it downstream at the eye-level mark on the stadia rod (Figure 1). Measure slope (degrees or percent slope). Interpret measurements as positive values.

*NOTES: Get a stable posture by bracing with something like a walking stick. Measure several times to arrive at a consistent reading.*

*Be careful that the eye-height flagging does not change position during the procedure.*

*If using the Nikon Forestry Pro, it has both internal and external displays. For measurements ≤ 10°, the internal display will only show whole degrees. Look at the external display to obtain slope to the nearest tenth of a degree. Consult the user's manual (Nikon, 2012).*

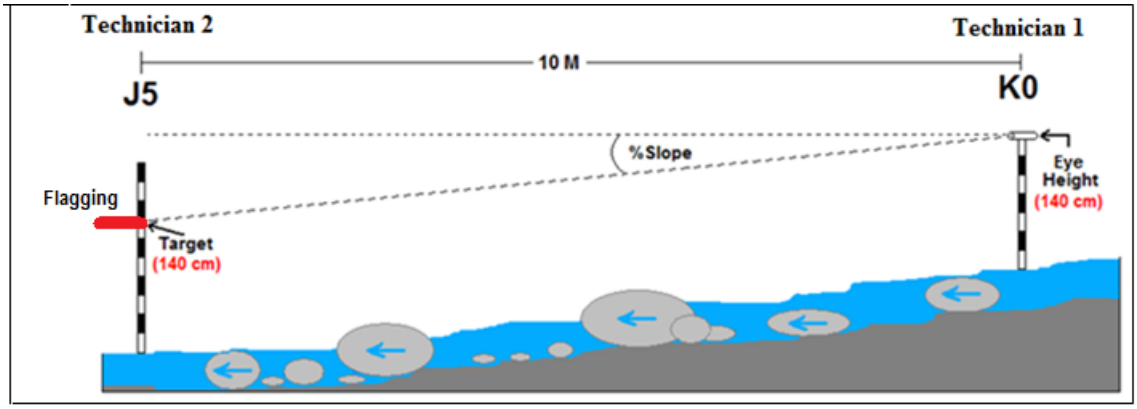


**Figure 1. Slope measurement using a laser hypsometer and a stadia rod, pre-marked to eye height of the hypsometer operator.**

6.4.2.4 **Measure increment length (m).**

6.4.2.4.1 If using the established Major Transects and Minor Transects as endpoints to the increment, new measurement is NOT required. Just use the known lengths. For example, insert 10 m for an increment between K0 and J5 on a site of 200 m total length.

6.4.2.4.2 If using new endpoints, you can use the hypsometer as a laser rangefinder. The upstream technician sites on the downstream technician.

6.4.2.5 **Record** the following on the Slope Form (Figure 2):

6.4.2.5.1 *Equipment Used* (laser),

6.4.2.5.2 *Value Units* (percent or degrees),

6.4.2.5.3 *Reach Length* (total site length in meters),

6.4.2.5.4 For each increment, record the slope *Value* (as positive), and

6.4.2.5.5 For each increment, record the *Increment Length* (m).

*NOTE: The form has 11 rows for increments and an "Add a Row" button if more rows are needed.*

6.4.2.6 **Move downstream** to the next increment.

6.4.2.6.1 Technician 1: After recording the values for the first increment, move downstream and get into position at the exact location where Technician 2 is standing.

6.4.2.6.2 Technician 2: After technician 1 moves into your location, move downstream to the next transect (or other convenient, visible location).

6.4.2.7 **Repeat** steps 6.3.2.2 through 6.3.2.4 until technician 2 reaches Major transect A. Once all measurements have been recorded, press the calculate button on the Slope Form (green text in Figure 2).

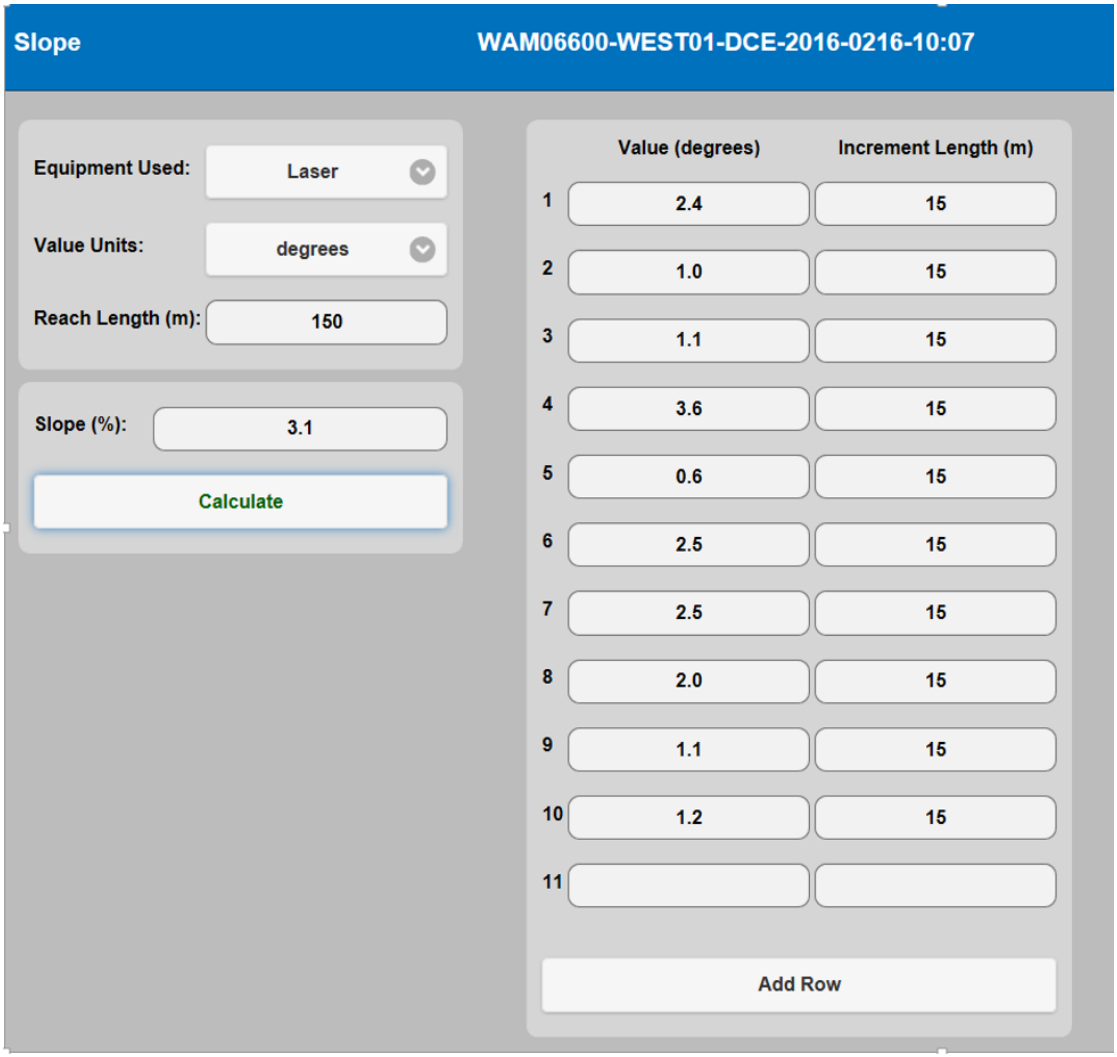


**Figure 2. The slope form.**

6.4.3 Measuring slope with a water level

6.4.3.1 **Prepare** the tubing by filling it with stream water and eliminating air bubbles. Some airspace will be needed at the ends, so fill the tube about 90% full. Keep the ends of the tube closed (usually with your thumbs), and prepare to move into the first position.

*NOTE: When moving, coordinate with the other technician. Work together to ensure you don't spill any water or introduce air bubbles.*

6.4.3.2 Hold the water-filled, closed tube **in position** between technicians for the first increment (Figure 3). The maximum distance between the technicians is determined by the length of the tube.

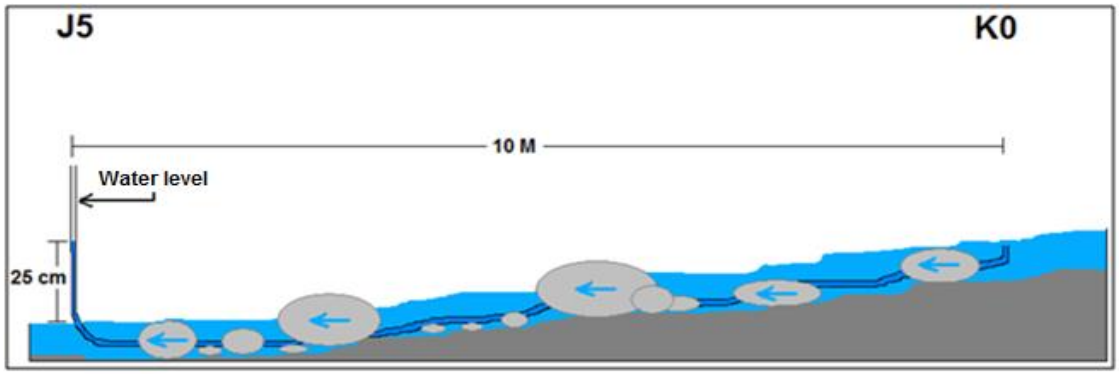


**Figure 3. Measuring the first increment slope with a water level (Tygon® tubing) and ruler. Transect J5 is just an example, not a required location.**

*NOTE: Keep spacing between technicians short enough to leave enough tubing to accommodate water level rise and easy manipulation of the tube. For example, if the tubing is 16 meters long, you might consider about 15 meters or less distance between technicians.*

6.4.3.3 **Allow water displacement** after following these steps.

6.4.3.3.1 Start with both ends of the tube underwater.

6.4.3.3.2 Technician 1 (upstream): Keep your end of the tube just under the surface of the water.

6.4.3.3.3 Technician 2 (downstream): Bring your tube end up out of the water in a vertical position.

6.4.3.3.4 Now, both technicians lift your thumbs off the tube ends so that water level occurs as illustrated in Figure 3.

6.4.3.4 Using a ruler at the downstream end of the tube, **measure** the vertical water displacement (cm) in the tube above the stream surface.

*NOTE: In turbulent streams, the water in the tube may bounce up and down. When this happens, use the modal (most common) height.*

6.4.3.5 Once the vertical height is measured, **close off both ends** of the tube to prevent air bubbles from entering the tube.

6.4.3.6 **Measure increment distance (m) with a stadia rod or laser range finder.**

*NOTE: Approximate increment distance is acceptable when using the water tube, as long as all increment distances sum exactly to total site length.*

6.4.3.7 On the Slope Form (Figure 2), **record the following:**

6.4.3.7.1 *Equipment Used* (water level),

6.4.3.7.2 *Value Units* (cm),

6.4.3.7.3 *Reach Length* (m; this is total site length),

6.4.3.7.4 For each increment, record the *Value* (displacement height in cm).

*6.4.3.7.5* For each increment, record the *Increment Length* (m).

*NOTE: The form has space for 11 slope increments and an "Add a Row" button if more rows are needed.*

6.4.3.8 **Move to the next increments.** Measure and record.

6.4.3.8.1 Technician 1: Once you have recorded the data for the first measurement, move downstream and place your end of the tube exactly where Technician 2 is holding their end, but under water.

6.4.3.8.2 Technician 2: Wait for Technician 1 to find your spot before moving downstream to the bottom of the next increment.

Repeat steps 6.3.3.2 thru 6.3.3.7 until completing an increment with its bottom at Major Transect A.

*NOTE: Coordinate your movements to make sure you don't spill any water from the tube or introduce air bubbles.*

## 7.0 Records Management

7.1 Refer to SOP EAP125 (Janisch, 2017), which describes the process for validating, loading, and committing completed WHM electronic field forms to the WHM database.

## 8.0 Quality Control and Quality Assurance Section

**8.1** QA/QC procedures are addressed in the QAMP for this project (Cusimano et al., 2006).

## 9.0 Safety

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

9.2 All field staff must comply with the requirements of the EAP Safety Manual, especially Chapter 1 "General Field Work," which includes special circumstances like fall protection and working in rivers and streams.

## 10.0 References


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