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CHECK YOUR WATERSHED DAY
DETAILED PROTOCOL

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APPENDICES

Appendix I. Reconnaissance Survey Field Sheet

Appendix II. Converting data to measures of discharge

1 Author: Stanfield, L. W.
INTRODUCTION

This module describes a methodology for evaluating the flow condition of all stream crossings within a watershed. This protocol is designed to be applied within a single watershed, at a time when the stream is approaching its summer low flow discharge\(^2\). Under these conditions the flow in the stream is mostly from groundwater discharge. These surveys will provide a measure of the contribution of flow from headwater systems\(^3\). These small streams are the life blood of rivers and their flow condition is variable. The variability is a consequence of differences in local geology, depth of the water table, aquifer pathways and land/water use. The consequence of this variability is that existing information and planning tools cannot adequately identify stream condition in headwater systems. This information is required to ensure that planning protects critical habitats for fish and identifies areas of lesser concern.

With this tool, headwater systems will be evaluated for flow status on a date that generally falls within the period summer low flow discharge. This tool is best applied through a collaborative effort, involving enough surveyors to ensure that the entire catchment can be surveyed in one day.

This technique is an extension of the reconnaissance survey techniques and follows the site documentation procedures described in the Ontario Stream Assessment Protocol.

A stream crossing is defined as a location where drainage features with clearly defined banks cross a road (generally at right angles). This protocol should not be applied on drainage features that run parallel to a road (see figure 1) and need not be applied where crossings occur in close proximity to one another. It is best applied on small streams (< 3 m width) and as such an ideal scenario will have this protocol applied in conjunction with more rigorous sampling that evaluates discharge at the larger stream crossings. In this way an inventory of the low flow conditions across the entire watershed can be obtained that ensures that all measures are relative to one another because of being measured on the same day.

In some areas crossings will occur for drainage features that are not streams (i.e., wetlands, swales etc.). Where these occur, crews are asked to simply document the type of feature at the crossing.

PRE-FIELD ACTIVITIES

This module requires a crew of two people and data collection can be completed in 5-10 min at each site/stream crossing.

Pre-field activities should include:

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\(^2\) The methods are equally applicable for surveys conducted at any time of year or conditions that characterize relative conditions of flow in the watershed.

\(^3\) Headwater streams are those from small catchments (< approx. 10 km\(^2\)) that provide the source water to the main stream systems.
• Documentation of site access and appropriate stream identifiers (see Section 1)
• Equipment check

For this protocol, the following equipment is required:

1. Metre stick (wooden)
2. Watch, with seconds indicator
3. Rubber boots or waders
4. Buckets and or funnels
5. Tape measure
6. Field sheets and HB pencils

Additional equipment for site location documentation:

7. GPS unit (optional)
8. Maps
9. Camera

Crews should adhere to safety precautions and requirements set forth by their project managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

We recommend that project managers provide maps to crews that “cover” the watershed (Figure 1). This map should include all roads and stream crossings from the most accurate water layer available. Also included are existing site codes from previous surveys and the routes to be covered by each crew. Note that most municipalities have identifiers for stream crossings and inclusion/use of this information will enable further sharing of data.

Each crew will be provided with field sheets that contain the key stream identifier information (Stream name, stream code, watershed code) and either a list of pre-identified sites or a process for identifying unique site codes to be used in the survey.
Tips for good data collection

Before leaving each site, check over the field sheet and make sure all the boxes have been filled out. If a field is not measured at a site, put a line through that box. Remember, 0 (zero is a number) but if you do not record it, there is no way to determine whether there truly was no flow (for example) or whether you measured flow and forgot to write it down. Clearly and legibly record all data with a sharp pencil. If you must erase data, make sure the correction is legible. Use capital letters for text records as this will improve legibility. Use only the measurement units on the field forms (e.g., mm and m) and make sure they are consistently applied by all crew members.

At the end of the day, have someone else check your field sheet for legibility, accuracy and completeness.
Figure 1. Example map for identifying sample zones.
FIELD PROCEDURES

On the sample day, crews will develop a travel route for conducting the survey and then at each stream crossing the following information will be documented:

1. Stream crossing identifiers and location (including marking location on a map)
2. width and depth of wetted stream (0’s indicate dry conditions)
3. stream discharge using the most appropriate method for each site
4. channel width and maximum depth
5. height of the drop from perched culverts

Documenting the sample site location:

At each stream crossing surveyors will document the site location by marking the location on a map, along with the appropriate site code if it is a new location, or by recording the existing site code (if available) on the data sheet and crossing this site off your field map. Ensure that a process is established so new site codes are unique for each watershed. You can’t have two sites with the same identifiers in a watershed! For our example, crews will use the zone number as the first identify and then a crossing number (e.g. Z1C1) where the last number increases sequentially with each new site visited (e.g. Z1C2). If available use a GPS unit to obtain the UTM coordinates for each site visited. Also record the 911 address in rural areas or street address in urban address for the closest unit to the stream crossing. Record this information in the comments section for each site (e.g., 24 inch culvert 40 m S of 1356 Ochonski Rd). Record the site code and location information on the Reconnaissance Survey Sheet. If GPS units are available, record the UTM coordinates on the field form. Finally mark the site location and site code on your map.

Whether you go up or downstream of the road will depend on which location offers the best spot for observing and measuring flow. Look for a section that is easily accessed and includes a length of stream that is of uniform depth and generally smaller substrate (sand to fine gravel), such that flows will be relatively uniform. Ideally there should be no obstructions to flow within 5 m of either side of where measurements are being made. This will generally be at a crossover. A crossover is identified as the location on a stream where the flow is in the middle of the channel, the banks are of equal height and the stream bed is of uniform depth across the channel. Generally this is mid point between two pools.

If there is no clearly defined channel with banks, simply record in the comments section whether the drainage feature is a:

- **Wetland**: contains obvious water tolerant or dependent plants and/or water observed
- **Swale**: A shallow troughlike depression that carries water mainly during rainstorms or snow melts.
- **Worked Areas**: areas where there is no evidence of flow under summer conditions and are therefore available to be worked by land owners

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4 These areas are typically found in the transitional area between a riffle and a pool often referred to as a flat or glide.
**Recording the wetted width and depth of the stream**

For each site with water, stretch a tape measure across the stream at the crossover and measure and record the width of the wetted stream to the nearest 0.1 m. If the stream is dry record a 0 (zero) in the appropriate box on the field sheet.

At three approximately equal spaced locations across the stream measure and record water depth to the nearest 2 mm (in headwater areas), 5 mm in larger streams (Figure 2).

![Figure 2. Location of measurements for wetted width and water depth.](image)

**Measuring stream velocity/Discharge**

If there is visible flow at the site make an effort to estimate the amount of discharge by using one the following techniques. We describe them in the preferred order that they should be applied, since each provides a different level of accuracy for this measure. If there is no flow at the site, record a 0 in the velocity box.

**Technique 1: Measuring Discharge using the Volume/Time Method**

For those locations where the stream is sufficiently small and flowing through a drop structure (e.g., perched culvert or weir) or has sufficient head to enable a drop structure to be temporarily installed, a bucket and a stopwatch can be used to measure discharge. In some situations a funnel can be used to direct the water into a measuring device.

Measure the time it takes to collect a known volume of water. Record the volume and the time to fill on the Reconnaissance field sheet (Appendix I).

**Technique 2: Area and velocity method, Hydraulic Head**

If there is no drop structure and there is at least 20 mm of depth and the water is moving well (> 10 cm/s) use hydraulic head to measure velocity.
Hydraulic head (HH) is measured in “mm” at the same location as water depth is measured. Place the wooden ruler so that it is vertical and the wide side with the markings is on the downstream side (Figure 3). Measure the maximum height difference observed over a 3-5 second period (more time in faster water) between the front and back of the ruler. For example, if the upstream reading is measured as 35 mm, the downstream as 16 mm, the hydraulic head is 19 mm. Record the hydraulic head to the nearest mm in the box marked ‘Hydraulic Head (mm)’ on the Reconnaissance Survey Sheet Form.

Avoid standing in front or too close behind the ruler as this can obstruct the flow. It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the differences out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down).

Background on Hydraulic Head:
Flowing water is “pushed up” against any object that it comes into contact with. The magnitude of the head varies with velocity. We use a ruler to measure the Hydraulic Head such that the height the water climbs is used as a measure of velocity.

![Figure 3: A point measurement of hydraulic head.](image)

### Technique 3: Area and velocity method, Floating objects

Where flows are too slow to create sufficient hydraulic head to enable accurate measurement, crews can use floating objects to estimate velocity. Water velocity is determined by timing the movement of a floating object such as a small leaf or twig over a fixed distance. The measurements are made over a length of river that has relatively laminar flow and similar width and depth across the channel. This is typically located close to the cross over points such that the maximum depth of the stream is in the middle of the channel. The length measured need only be long enough to ensure the time interval is at least 3 seconds long. This ensures accuracy of the velocity measurement. These measurements should be made at the same location where...
width and depth are recorded. In the smallest streams, you may need to modify the channel to create a uniform sampling area. That is, move objects that might interfere with flow and modify the channel to provide uniform width and depth. Drop the object upstream of the sample area and use a watch to measure the time for the object to pass through the sample area. Record the length of stream used to measure velocity and the time of three successful measures. A successful measure is one in which the object is able to pass from the start to the finish without being delayed by contact with any objects.

**Documenting channel dimensions**

At each site stretch a tape measure from the top of the bank on the left side to the top of bank on the right side of the stream (Figure 4). The specific location to place the tape measure is at the point where the stream channel begins to spill into its flood plain under high flow conditions. At this location the bank will change angles from steep to flatter and it is at the inflection point where the tape measure is placed. At the deepest part of the channel (generally the middle of the stream) measure the height from the stream bed to the tape measure (depth to top of bank). Record both the **channel width** and **channel depth** on the field sheet.

![Figure 4. Measuring bankfull width and depth.](image)
Documenting perched culverts

Perched culverts result from either improper installation (rare) or from erosion of the stream into its bed. The result is that the bottom of the culvert is higher than the bed of the stream. These can prevent fish from accessing upstream waters. Where perched culverts exist, record the height of the drop from the bottom of the culvert to the stream bed directly below the mid point of the culvert (Figure 5).

DATA MANAGEMENT

Upon returning from the field, have someone not from your crew check over your field sheet. Hand it over to the project manager who will:

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies in a separate location from the master copy.
By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

References

## Appendix I Example Field sheet for Reconnaissance Surveys

### Reconnaissance Survey Form

<table>
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<th>Stream Name</th>
<th>WILMOT CREEK</th>
<th>Stream Code (Unique Code)</th>
<th>WM1</th>
<th>Watershed Code:</th>
<th>2HB-02</th>
<th>Year:</th>
<th>2007</th>
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<tr>
<td>Surveyor Name(s):</td>
<td>KELLY WILLIAMS, RYAN LEONARD, ANNE CARMEN</td>
<td>Date (YYYY/MM/DD)</td>
<td>2007/07/21</td>
<td>Sample</td>
<td>1</td>
<td>Source of Coordinates (OBM, GPS unit, GIS)</td>
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<th>Wetted Width (m)</th>
<th>Bankfull Depth (m)</th>
<th>Crossover</th>
<th>Obs (#)</th>
<th>Depth (mm)</th>
<th>Hydraulic head (mm)</th>
<th>float velocity</th>
<th>Dist (m)</th>
<th>Time (sec)</th>
<th>Volume (L.)</th>
<th>Time (sec)</th>
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<td>Northing 450000 – 640000</td>
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<td>0</td>
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<td>0</td>
<td>----</td>
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</tr>
</tbody>
</table>

**Description:** 12 IN CULVERT 60 M NORTH OF 1245 OCHONSKI ROAD

| Site Code | Z1C1 | 899 | 0 | 4885350 | 0 | 0 | 0.12 | 0.12 | 1 | 0 | ---- | --- | --- | --- | ---- |
|-----------|------|-----|---|--------|---|---|---|---|----|---|---|---|---|

| Site Code | Z1C2 | 1150 | 690485 | 4867500 | 0 | 1.2 | 2.1 | 0.91 | 1 | 4 | 0 | --- | --- | --- | --- |

**Description:** 24 IN CULVERT 70 M SOUTH OF 1356 OCHONSKI ROAD, STANDING WATER, NO FLOW

| Site Code | W-060 | 234 | 690035 | 4867410 | 0 | 0.8 | 1.5 | 0.35 | 1 | 40 | 6 | --- | ---- | ---- | --- |

**Description:** 12 IN CULVERT 60 M NORTH OF 1245 OCHONSKI ROAD

| Site Code | W-061 | 1978 | 690356 | 4867560 | 0 | 0.8 | 1.4 | 0.40 | 1 | 35 | 7 | --- | --- | --- | --- |

**Description:** 24 IN CULVERT 40 M EAST OF 1470 CONCESSION ROAD 7

| Site Code | W-062 | 2245 | 690569 | 4867249 | 0.42 | 0.80 | 1.9 | 0.85 | 1 | --- | --- | ---- | ---- | ---- | 4.5 | 17 |

**Description:** 36 IN CULVERT 100 M WEST OF SQUIRES ROAD, ON CONCESSION 6, LIKELY A BARRIER TO FISH, ABLE TO CAPTURE ALL FLOW IN BUCKET

| Site Code | W-063 | 1345 | 690008 | 4867249 | 0 | 0.5 | 0.9 | 0.25 | 1 | 15 | --- | 50 | 5 | --- | ---- |

**Description:** 24 IN CULVERT AT NORTH EAST CORNER OF SQUIRES ROAD AND CONCESSION 6

| Site Code | Z1C3 | 511 | 690465 | 4865469 | 0 | 0 | 0 | 0 | 1 | 0 | --- | --- | --- | --- | --- |

**Description:** 12 IN CULVERT 100 M NORTH OF CONCESSION 6 ON SQUIRES R. No defined channel,
Swale on both sides of road

<table>
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<th>Comments: STARTED SURVEYING AT 1000 AND FINISHED AT 1145, ONE LANDOWNER ON OCHONSKI ROAD (CLIFF JOHNSON) ASKED TO BE EMAILED WITH RESULTS OF THE SURVEYS AND WAS INTERESTED IN VOLUNTEERING IF THIS IS DONE AGAIN (<a href="mailto:CJOHNSON@SYMPATICO.CA">CJOHNSON@SYMPATICO.CA</a>)</th>
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</thead>
</table>

<table>
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</tr>
</thead>
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</thead>
<tbody>
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</tr>
<tr>
<td>X</td>
</tr>
</tbody>
</table>

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Appendix II

Converting data to discharge

While it is not necessary for surveyors to convert the field observations to standardized measures of discharge, they may wish to know how the data is used to generate this information. A different algorithm is used for each technique.

**Technique 1: Volume/Time**

The volume measured is divided by the time taken to fill the container. For example, a 4.5 lt container took 25 s to fill to provide a discharge of 0.18 lt/s (4.5/25).

**Technique 2: Hydraulic Head**

When hydraulic head is used, it must first be converted to velocity using the formula such as \( v \text{ (m/s)} = 0.6 \times \sqrt{0.02 \times HH} \). Then velocity is multiplied by average width and depth. However, both velocity and area have to be corrected for the edge effects (that is while we make 3 observations we do so in 4 panels) and to standardize to m. So for the example at site W-060, where the wetted width is 0.8 m, the Hydraulic Head measurements are 6 mm, 8 mm and 5 mm, and the depth measurements are 40 mm, 60 mm and 50 mm. Therefore, the mean velocity is 0.18(i.e. \( v=0.6 \times \sqrt{0.02 \times (6+8+5)/4} \)) and mean depth is 37.5 mm (40+60+50/4) or 0.0375 m. Therefore discharge is estimated to be 0.0054 m³/s, or 5.4 lt/s (0.8 m*0.0375m*0.18m/s).

**Technique 3: Time by Distance**

Where velocity is measured by a time interval over a distance the velocity must first be converted to m/s. So if it takes 5 seconds for an object to travel 0.5 m, the velocity is 0.1 m/s (0.5m/5s). This value is then used in the same formula as above to convert the measure to a discharge.

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5 This formula represents the original formula published in OSAP and a correction factor (0.6) that recognizes that HH tends to overestimate velocity by this factor. This was determined from some as yet unpublished work, by Stanfield (Ontario Ministry of Natural Resources, 2007), which compared HH and velocity measurements taken at the same location.
Crest stage gauges (CSG) provide a means of quantifying the maximum cross sectional area occupied by flow during a sampling period. This data provides a measure of the response of a stream to a flow event. Depending on the type of event being assessed (i.e., spring runoff, rain events), the data provides a measure of the relative surface runoff response or flashiness of a stream. This information can be combined with estimates of water velocity in the channel to provide an overall measure of velocity using Manning’s equation.

If one of the goals of the study is to generate measures of discharge for each storm event, the user has the option of applying modeling approaches to estimate velocity or to use Manning’s equation and field observations. If the choice is to use Manning’s formula the user might consider using the draft protocol for estimating stream velocity for a stage response (Stanfield 2008).

Site Selection:

The sample location should have well defined banks and be at a narrowing of the stream. In general cross over locations work well in highly sinuous incised channels, but each stream offers different situations. The key is that it should provide an ability to measure changes in cross-sectional area with changing stage height. Note that the cross-sectional area of channel filled with water from each flow event is related back to the readings on the pipe through a series of related measures. CSG’s can be operated in any stream type, although in streams with more power and larger floating material, devices will need to be installed in backwater or protected locations. The site is as defined in OSAP (that is a minimum of 40 m beginning and ending at a cross-over, however many of the field observations are made within shorter lengths of stream within the site. Follow the standard guidelines in module S1M1 for defining and naming the site.

Considerations for where to install the CSG’s are:

access – typically studies using these devices will be spatially extensive (to provide comparability between sites, therefore pipes will be installed where there is good access, such as at road crossings.

Land ownership: if on private property, the devices will be less prone to vandalism, so obtaining land owner permission and stewardship is always helpful. On government land crews must also be cognisant of potential conflicts, if for example lands are owned or managed by levels of government where permissions are required. Note that these devices are prone to vandalism so site location should consider the amount of pedestrian traffic in the area.

Channel characteristics:
Ideally the device would be located on or close to a cross over, where the flow in the channel is likely to be level at all flow elevations. This location will also provide a relatively flat and homogenous cross section and both banks should be of equal height. These conditions will facilitate a more accurate measure of the cross-sectional area in the channel. See section one of OSAP for details on identifying a cross-over.
Substrate Composition:
Since rebar is used to install the device the bed materials at the sampling location need to be firm and penetrable. Therefore avoid areas with silt or boulders as bed material.

Bank Height:
The CSG measures maximum stage height most accurately at levels that are below bankfull level. Therefore the CSG should be installed at locations with the best defined bank profile that provide the closest approximation of a 2:1 ratio in height to width measures of width and depth. That is a relatively narrow, flat and deep channel.

1. Actions: Once located fill out modules 1, 2 and 3 section 1 of OSAP (i.e. site definition, documentation and site features) and when available fill out the expanded site features form for headwater drainage features. Make sure to take photos of the stream up and downstream of the device, ensuring that the device is included in the picture for scale and to document installation features.

2. Record the length in mm of the pipe. On the pipe setup form

Installation of a CSG:
While a variety of devices can be used as a CSG, work in 2007 determined that an optimal design involved using clear 5cm diameter polyethylene pipes (Figure 1). These pipes are typically used in the design of central vacuum cleaners and come in 2.6m lengths. Cut the pipe to lengths that are appropriate for each study site, using shorter ones in small streams and longer ones in more entrenched channels. Drill a series of 5-7 mm holes through both sides of the pipe in the bottom 20 cm of the pipe. These will ensure flow of water into the pipe should the bottom become plugged with sediment. Put holes through at approximately 2 cm and 6 cm from the bottom. More holes may be necessary in streams with very high bed loads. Label the CSG with information about its purpose, the owner and contact information and the stations unique site code (figure 2). Pound in 2 rebars to a depth of at least 20 cm at locations that are at right angles to the flow (Figure 2). Mark one of the bars as the reference bar, or the one from which measurements will be made. Tie the pipe firmly to the rebars using zip ties and pliers, leaving about a 1 cm gap from the stream bed and the bottom of the pipe. This helps with circulation inside the pipe and reduces the potential for sediment to plug the pipe’s bottom. Sponge out the pipe using either a wet paper towel or cloth that is tied to the end of a plunger (i.e., a meter stick). Wait about 30 seconds or until the inside is wet but not running with water and squirt a good dose of talc based baby powder into the pipe (available as the hypoallergenic version from Shopper’s drug mart). Note that corn starch powder attracts slugs and worms that enjoy digesting this material! Finally, place a cover over the pipe to keep it dry and yet is not too tight that it still permits air to escape. Plastic water bottles, especially the type that are hour glass shaped work excellent because they “cling to the tube. Try to put the rebar at a distance from the top of the pipe that enables you to slide one side of the bottle into the gap between the pipe and the rebar, thus providing additional friction to hold the bottle in place.

Take the following initial measurements.

1. Note that the headwater steering committee is developing a modified site features protocol to include more details of drainage features (DelGuidice 2008).
1. Record the distance from the bottom of the pipe to the current water level and the distance (including 0 if the stream is dry).
2. the distance from the top of the pipe to the reference bar. This will be used to ensure the gage does not move in a storm event.

**PLEASE DO NOT DISTURB**

Stream flow monitoring device measures response to storm events installed by University of Toronto in partnership with local Conservation Authorities.

Contact Les.Stanfield@utoronto.ca for more information.

(613-476-8777)

Figure 1: Example label for Crest Stage Gauge

![Crest Stage Gauge in headwater stream](image1.png)

Figure 2: Crest Stage Gauge in headwater stream

**Measuring Cross-sectional profiles:**
To generate the area of the channel occupied by flowing water for each measured event requires a detailed profile of the channel that can be referenced back to the CSG stage measurements. The reference rebar is used to tie in all measurements as follows.

First, a cross sectional profile of the channel is carried out at right angles to the flow and at the location of the CSG. The profile is conducting using module S4M3 ensuring that the tape is extended above the bankfull height to at least the height of the pipe. This will ensure that major storm event heights are captured. Ensure that the tape is kept level during the survey as deviations could introduce substantial errors in measures of cross sectional area later on. Measure depth of the channel at every inflection point (change in profile such that no more than a 5 cm rise occurs on the bank without a measurement of the location of that rise is noted on the tape. In other words, generate a detailed measure of the bankfull profile at each site that will be used to accurately determine area of flow at each storm event height. This profile will identify the location and depth of the deepest part of the channel (1 in figure 3). This depth is used to determine the amount of the channel that remains dry after each flow event after first correcting any data for marginal movements in the device during a storm.

Standardization is achieved by ensuring that all measurements are tied to the reference rebar height. Therefore while the tape is in place (and level) record the distance to the tape from the top of the reference rebar. For this analysis a positive number for the height of rebar from bankfull indicates that the rebar is above the tape. If for some reason the rebar is below the tape (that is the rebar used is too short, or it has been driven into the bed too deep), then record the distance to the tape as a negative number.

![Figure 3: field measurements necessary for linking CSG measures to channel profiles](image)

1 = max depth of channel  2 = length of pipe  
3 = stage response per event  4 = rebar height to pipe  
5 = tape to rebar (+ve or –ve)  6 = dry channel height  
7 = stage height from tape

The formulas for generating the depth of the dry channel are summarized in Appendix I.
Figure 4: Measuring maximum channel depth on a cross-sectional profile.

**Measuring Height of Stage Events:**

Following a flow event (caused by rain or snow melt), measure the height from the bottom of the tube to the line that demarcates the stage height of flow (i.e., the extent of dissolved powder), from the middle of the pipe. Measurements are made in the middle because where velocities are great, the line can be higher on one side than the other (due to hydraulic head). Note that above this line the powder will often appear to be “clumped”. This is caused by water climbing up the sides of the pipe but since there is no lateral movement, the powder does not dissolve. **Also record, the distance from the top of the pipe to the top of the reference rebar.** Clean out the pipe with water and a plunger (paper towel tied to one end of the ruler with elastics works well), and refill it with powder. Measure and record the current distance from the bottom of the pipe to the water line. If the stream is dry or flows are below the pipe record a zero. In some instances the pipe will need to be reset (if it has slipped up or down the rebar). Therefore finish this task and record the new distance from the pipe to the rebar (rebar height).

To facilitate data entry and management a group field sheet has been generated. Recording the time of the recording provides a backup for the site identification and may be helpful in interpreting the results and the comments field is used to record pertinent information about the reading such as the quality of the mark (see attached field sheet).
Estimating stream velocity for each flow event

a. Obtain a measure of discharge using the most appropriate methodology as described in OSAP on the date that the devices are installed.

Since the intention is to relate peak height of flow to a measure of discharge a number of measures must be made to confirm both the slope and roughness of the channel, that are used in Manning’s discharge equation.

b. Measure slope at each site using either laser level (if available) or tape measure and hanging level (see draft OSAP section 4 module 7).

Roughness will be measured by assessing:

c. The amount of large wood material at the site. This will be inventoried using the CENFER protocol (Appendix II). The data fields will be photocopied onto the back of the RAM field sheet (S4M1). A spreadsheet will be developed to store this data for now.

d. Apply the pebble count survey as described in the RAM module of habitat assessment. This enables the sites to be classified into proportions of sand, gravel, cobble and bedrock. Additionally measure the size of the largest particle in each site (S4.M1).

e. For sites with no flowing water, record whether pools exist and if so the length, width and maximum depth of the largest pool.

Ideally, a landowner will be contacted that is willing to “watch” out for the equipment and if possible read the water gauge and provide the data to the field crew. The landowner will also be interviewed to assist with the filling out of the site features form. Specifically, landowners will be asked about whether they are aware of any water withdrawals, inputs, tiles, storm drains, or ditching in the upstream sections of the stream.

After a major storm event (minimum 2.5 mm in 24 hours), each gauge will be visited and the response from the event recorded at each site (height from the top of the tube to the top of the plug). Check to make sure the gage has not moved by re-measuring the distance from the top of the rebar to the wax pencil mark. If it has moved adjust the measure of the height moved accordingly (add or subtract the distance to the total measure). Reset the gage (making sure the plug is still functional) and mark/record new water level height. The gage will be visited within 2 days of the defined baseflow level for the summer (i.e. after a period of at least 7 days without rain) and again discharge will be measured and level of the gage recorded. Project lead will advise crews on dates to accomplish these tasks.
Calculation formulas

The formulas for extracting the dry channel depth for each event are summarized here and for convenience algorithms for extracting the data using Excel are also provided.

**Calculation of dry channel depth:**

For each event the dry channel height is determined as follows:

\[ 6 = 2 - (3+4+5). \]

Where each number is defined in figure 4. However, since the CSG often slides up or down in major storms the distance of the pipe to the profile tape sometimes changes and needs to be accounted for in the formula.

**Standardization of formula:**

The formula for “correcting” the distance to the profile height is: Profile ht – (the observed rebar ht at the time that the cross-sectional profile was done – rebar ht for each event. For example: If the profile height to tape is 230 mm and the recorded rebar heights were 205 when profile was measured and 207 for an event: The profile height to tape would need to be corrected by adding 2 mm to the profile tape measure i.e., \((230-(205-207)) = 232.\)

The excel algorithm for extracting the dry channel height is: where cell references replace the formula codes:

\[ '='IF(3=-99, "-99", IF(3=0,"0",$2-(3+4+($5-(4-$4(original)))))). \]

**Calculating the Cross sectional area for each response:**

The formula of summing the mean depth and sectional width for all observations across the stream will be used with the simple modification that the dry channel height \((6)\) is subtracted from each depth measure. Since observation points were defined at changes in elevation (nick points), the truest description of the area within each “panel” is defined as the mean depth within a panel and its width. A panel here is the area between two observations moving from left to right in the stream.

The formula is:

\[ ECSA_{ie} = \sum_{n}^{i} ((H_{i} + H_{i+1})/2 - DCH) * (S_{i+1} - S_{i}) \]

Where \(i\) = each site and \(e\) = each rain event. ECSA = event cross sectional area in \(m^{2}\) (See figure below).

The algorithm also ensures that all negative depths are treated as 0’s and that events that flow above the profile tape are adjusted. The adjustment ignores flow in the flood plain beyond the widths measured in the channel profile. This in effect assumes that velocity and therefore discharge per unit of time is negligible (zero in fact) in these flood plain areas. However the area within the “bankfull” channel that is above bankfull is included in
the cross sectional area estimate. Because of the potential of having two negatives cancel each other out the excel algorithm was split in two:

Mean height of each observation panel:
\[ \text{MHT} = \frac{((\text{IF}(\$6<0, (\$6*(-1)+HT_0), (HT_0-\$6))) + (\text{IF}(\$62<0, (\$62*(-1)+HT_1), (HT_1-\$6)))}{2} \]

Panel Width:
\[ \text{PW} = \text{IF}(\text{DT2}<0,0,\text{DT2}*(J2-I2)). \]

Area of each panel:
\[ e' = \text{IF}(\text{MHT}<0,0,\text{MHT}*(\text{OB}_1-\text{OB}_0)). \]

where \( HT_0 \) and \( HT_1 \) represent the first two observation point heights and tape locations (\( OB_0 \) and \( OB_1 \)).

Total wetted area per event
\[ = \text{IF}(6=-99," ",\text{IF}(6=0,0,\text{SUM(panelarea}_1:\text{panelarea}_x))) \]
Headwater Drainage Feature
Sampling Protocol

1.0 INTRODUCTION

Used as a companion document to the Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines document, this protocol aids in the site specific evaluation and classification of drainage features for the purposes of addressing protection and conservation of fish habitat, mitigation of hydrologic function, and for monitoring purposes. The information and data compiled through the implementation of this protocol will guide management recommendations and decision-making.

This protocol serves as a methodology by which to survey and collect data relevant to the assessment of the ecological function of headwater drainage features (HDFs). The definition of an HDF is an ill-defined first-order or zero-order ephemeral or intermittent stream or swale. These features may provide direct habitat for fish by the presence of refuge pools, seasonal flow, or groundwater discharge, or indirect habitat through the contribution of flow, export of food (detritus/invertebrates), attenuation or storage role, and other functions. The objective of the data collection is to provide insight into the contribution of headwater drainage features to the overall health, water quality and fish habitat of their downstream systems.

To ensure consistency, please refer to the Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines for definitions and descriptions of flow (ephemeral, intermittent, permanent) and fish habitat (contributing, seasonal, and permanent).

Where methodologies have been previously described in the Ontario Stream Assessment Protocol (OSAP) and are appropriate to apply to HDFs, users are expected to follow these techniques (OSAP v.7, 2005). Further clarification is provided below.

2.0 PRE-FIELD ACTIVITIES

Pre-field activities are to include a preliminary screening to determine the extent of field assessment required for drainage features within the site. The objective of pre-screening is to determine the presence/absence of headwater drainage features, as feasible, and any preliminary attributes, such as potential to support fish permanently/seasonally, extent of the feature, land use, disturbances (e.g. ditching, channelization, potential tile drains, etc.), connections to main branches, catchment areas, and a preliminary assessment of flow (i.e. permanent, intermittent, ephemeral). This analysis should include ortho-photography interpretation, and the application of ArcHydro, if available. Note that ArcHydro does have limitations in internally draining area (i.e. straight lines are indicative of this). Field verification will be necessary to confirm this analysis.

3.0 IN-FIELD PROCEDURES

Based on the results of the pre-field analysis, examine the site and determine whether there is an identifiable drainage feature to assess. This includes minor swales and rivulets.

3.1 Characterizing the Site

A walkabout of the headwater drainage feature should be conducted prior to the selection of a sample site. The walkabout should extend far upstream that the feature is no longer identifiable (i.e. farm field is...
indistinguishable from localized depression), and as far downstream to the confluence with the main branch (if possible). Record attributes such as seepages and/or groundwater indicators (i.e. watercress, iron floc), significant changes in land use, riparian cover, slope, substrate, channel form, etc. Once the walkabout is complete, site boundaries will need to be established within the study reach. Follow OSAP S1 (minimum M1 and M2).

3.2 Timing

This protocol is designed to evaluate conditions in both perennial and temporary headwater drainage features, which can vary considerably over time. Therefore, multiple site inspections conducted at different times of the year are necessary to ensure that the classification of features is appropriate. Ensure that antecedent (at least 1 week) and/or occurring precipitation is recorded by cross-referencing data from the nearest climatological station. Some criteria only need to be assessed once because the data are unlikely to significantly change over the assessment period. The preferred timing for the Evaluation Criteria are identified in Table 1 below.

Table 1: Preferred timing for Evaluation Criteria

<table>
<thead>
<tr>
<th>Preferred Timing</th>
<th>Flow Assessment</th>
<th>Fish Habitat Assessment</th>
<th>Vegetation Assessment</th>
<th>Linkage</th>
<th>Channel Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Assessments</td>
<td>Spring Freshet or Antecedent Rainfall, Late April-May, July-August</td>
<td>Late April-May</td>
<td>Growing season</td>
<td>Growing season</td>
<td></td>
</tr>
<tr>
<td>Single Assessment</td>
<td>Late April-May</td>
<td>Growing season</td>
<td>Growing season</td>
<td>Growing season</td>
<td></td>
</tr>
</tbody>
</table>

3.3 Evaluation Criteria Requiring Multiple/Continuous Assessments

3.3.1 Flow Assessment

In order to determine whether the feature is ephemeral, intermittent, or perennial, observations need to be conducted at various times of the year. Ideally, continuous flow measurements should be made for a minimum of one average year using a pressure transducer or crest stage gauge and/or a mini-piezometer connected to data loggers. These devices will determine duration of flow within the feature and whether groundwater levels are seasonally above the invert of the feature, respectively. Pressure transducers and crest stage gauges should be placed at a cross-over (i.e. where the streamflow occurs at the centre of the channel) at the lowest and narrowest point in the stream. A well-defined rating curve for the stream will need to be developed.

In the event that continuous water level monitoring is not possible, multiple assessments at different times of the year will be required in order to determine the flow regime (see Table 2). During each site assessment, discharge should be measured using one of the methodologies identified in OSAP (S4.M5) or using the dye technique (see below). The dye technique allows an estimate of velocity to be obtained even if the flow is minimal. Additional qualitative measurements can be used to assist in differentiating between intermittent and ephemeral systems (see ORMCP Technical Paper 12).

Dye technique – Use an inert dye, such as food colouring, to estimate the velocity of the stream flow. Put a couple of drops of dye into the stream at a marked location. With a watch or stopwatch, measure

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7 In specific studies, rain gauge stations may need to be established to capture the spatial and temporal variability in storm events.
the time it takes for all the dye to travel a known distance such as 1 metre, which has been previously measured and marked. Divide the distance in metres by the time in seconds to obtain a velocity (m/s). This may need to be repeated several times to ensure a reasonable average velocity can be obtained.

### Table 2: Flow Assessment

<table>
<thead>
<tr>
<th>Flowing Conditions*</th>
<th>Perennial</th>
<th>Intermittent</th>
<th>Ephemeral</th>
<th>Not an HDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshet or Antecedent Rainfall</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Late April – May</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>July-August</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

*Flowing conditions assumes no antecedent precipitation (1 week) in an average year

Record qualitative information only if it is not possible to obtain quantitative measurements at the site, according to the following categories:

- Surface flow continuous
- Flow only interstitial
- Surface water present but no visible flow
- Surface water in pools only
- No surface water

### 3.3.2 Fish Habitat Assessment

Similar to assessing flow, in order to determine whether the feature provides permanent, seasonal, or indirect fish habitat, observations need to be conducted at various times of the year. Snowmelt during the spring freshet, March to early April awakens the ecosystem downstream. However, fish may not be using seasonal habitats at this time, as they will respond to warmer water temperatures and slower flow velocities occurring slightly later in the year. The initial observation of flow and fish use should be established in late April and May; however this may need to be flexible in response to local climatic conditions. To confirm fish use of refuge pools (including online ponds) and to improve the understanding of flow conditions, further assessments should be completed during June. Flow during this time usually suggests a sustained flow due to seasonally high groundwater levels. August through September is typically the driest time of year. At all times, refugia such as ponds, wetlands and pools should be sampled. Sampling should be completed using methods appropriate for the site conditions. Observations during this time will permit the distinction between permanent and seasonal fish habitat according to Table 3 below.

If there is sufficient flow to adequately electrofish the stream, follow the procedures outlined in OSAP (S3.M1). If there is insufficient flow to successfully employ these methods, minnow traps or D-net sweeps could be used. Processing of collected fish will be the same as for the procedures outlined in OSAP.

**Minnow trap method:** this method may need to be employed in areas with significant instream vegetation. The trap may need to be counter-sunk or notched to ensure that water level will be high enough to permit entrance by fish into the trap opening. Employ baited (dead fish, sardines) minnow traps at the lowest point in the channel or in existing pools within the site. Use enough traps to ensure all diversity in habitat features will be sampled. Label and tag all traps. Ensure that the traps are checked daily and are left in place for at least 24 hours per assessment period.
D-net sweep method: if there is continuous flow, block nets should be employed at the upstream end of the site. Various d-net sizes are available; select the most appropriate d-net size that would allow the majority of the flow to pass through the net. Begin at the downstream end of the site and sweep the net upstream ensuring that the bottom of the net is flush with the streambed.

3.4 Evaluation Criteria Requiring Single Assessment

Field work for the following criteria only need to be conducted once, as it is unlikely for the attributes to change over the growing season. It is expected that data collection for these criteria will be executed during any of the visits required to complete the “multiple assessment” criteria:

3.4.1 Vegetation Assessment

The vegetation assessment will be used to characterize fish habitat and distinguish between complex contributing and simple contributing habitat. Refer to OSAP S4.M2, 3.5.4 and 3.6.4 for guidance on assessing bank vegetation cover and type, and aquatic vegetation, respectively. Bank and aquatic vegetation types should be reported for all habitat categories, however complex and simple contributing habitat are to be distinguished using the following table (Table 4). Record the type of dominant vegetation. If one of either dominant bank or aquatic vegetation types falls under the complex contributing category, the feature is to be deemed complex contributing and not simple contributing.

<table>
<thead>
<tr>
<th>Dominant Vegetation Type</th>
<th>Complex Contributing</th>
<th>Simple Contributing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Vegetation Type</td>
<td>Meadow, Scrubland, Forest</td>
<td>Cultivated, None</td>
</tr>
<tr>
<td>Aquatic Vegetation Type</td>
<td>Macrophytes, Watercress</td>
<td>Grass, Terrestrial Plants, Moss, Algae, None</td>
</tr>
</tbody>
</table>

3.4.2 Linkage

Map all terrestrial and aquatic linkages on an orthophoto. Identify the locations of other drainage features, confluences with streams, ponds, wetlands and tile drains. Identify any barriers to fish movement as well using appropriate protocols (TRCA has a barrier form). Use Ecological Land Classification to delineate terrestrial vegetation units. Include mapping of any species observed through terrestrial inventories. Follow the protocols outlined in TRCA’s Environmental Impact Study Guidelines for terrestrial surveys.

3.4.2 Channel Form

Measure relevant morphological attributes of the channel in order to characterize the habitat and provide additional evidence for categorizing the flow regime. Some features may not be well-defined, however there may still be morphological features that can be measured or described. For well-defined channels, use the appropriate sections of OSAP and procedures outlined below. Ill-defined channels, such as swales, are not presently addressed in OSAP; additional guidance is provided below.
Channel Width and Depth – See OSAP S4.M1, page 7 for defined channels, except instead of measuring the wetted width, measure the top of channel bank width (this is particularly important given the variable nature of flows in HDFs). For swales and ill-defined channels measure the width of the channel by identifying the cross-sectional limits of the flood-prone area. This can be done by one of two ways:
  a. determine where there is a change in vegetation from upland to wetland/wet tolerant species (e.g. cattails to goldenrods). Use Ecological Land Classification or Ontario Wetland Evaluation Manual for Southern Ontario for further guidance;
  b. identify the extent of previous floods, such as the limit of where vegetation has been bent over from flows, or where depositional materials occurs (i.e. sediment or debris).

Once the extent of the flood-prone area is identified, mark the outer limits with rebar or stakes and measure the distance between the rebar using a measuring tape to determine the channel width. Channel depth will be measured by holding the measuring tape at ground level at the outer limits of the flood-prone area as taut as possible. Hold a metre stick vertically against the measuring tape and find the deepest point in the channel. Record this value to the nearest 5 mm.

Channel Slope - Measure the channel slope using appropriate surveying equipment such as a laser level and a stadia rod. Measure the bed elevation at the top and bottom ends of each site. Slope will then be calculated as follows:
  Slope = (downstream stadia reading - upstream stadia reading)/site length

Channel Stability – Swales should not have any erosion issues. For defined channels, follow OSAP S4.M1, 3.3.4.4.

Substrates – Follow OSAP S4.M1, 3.3.3 to complete this. Use as much of the OSAP protocol as possible for swales.

Refuge Pools – Measure the depth and wetted width of all pools within the site to the nearest centimeter using a measuring tape and/or metre stick.

Discharge areas – Map the location of all discharge areas, as noted by watercress beds, iron staining, etc.

4.0 REPORTING

A report should be submitted that summarizes all the data collected and provides an analysis of the results. Ensure that the following information is included in the report:

1. Date and time of each survey;
2. Names of surveyors and qualifications;
3. A map of each headwater drainage feature assessed and the sampling locations; All fisheries sampling locations should be geo-referenced, and digital data should be provided using UTM Zone 17 NAD83 ESRI Native File data (shapefiles);
4. A map of all linkages including ELC units, and flora and fauna points;
5. Antecedent precipitation records, preferably in graphical format;
6. Graphs of all available continuous or discrete water level and mini-piezometer data;
7. List and abundance of all fish species recorded;
8. Status of any species of conservation concern;
9. Locations and abundance of any observed spawning redds and relevant species;
10. A description of aquatic sensitivities and critical habitats;
11. Length of surveyed site and an indication of the catch per unit effort;
12. Survey methodology employed;
13. A description and analysis of the existing habitat and any restoration or enhancement opportunities;
14. The completed Table as outlined in *Evaluation, Classification, and Management of Headwater Drainage Features: Interim Guidelines.*