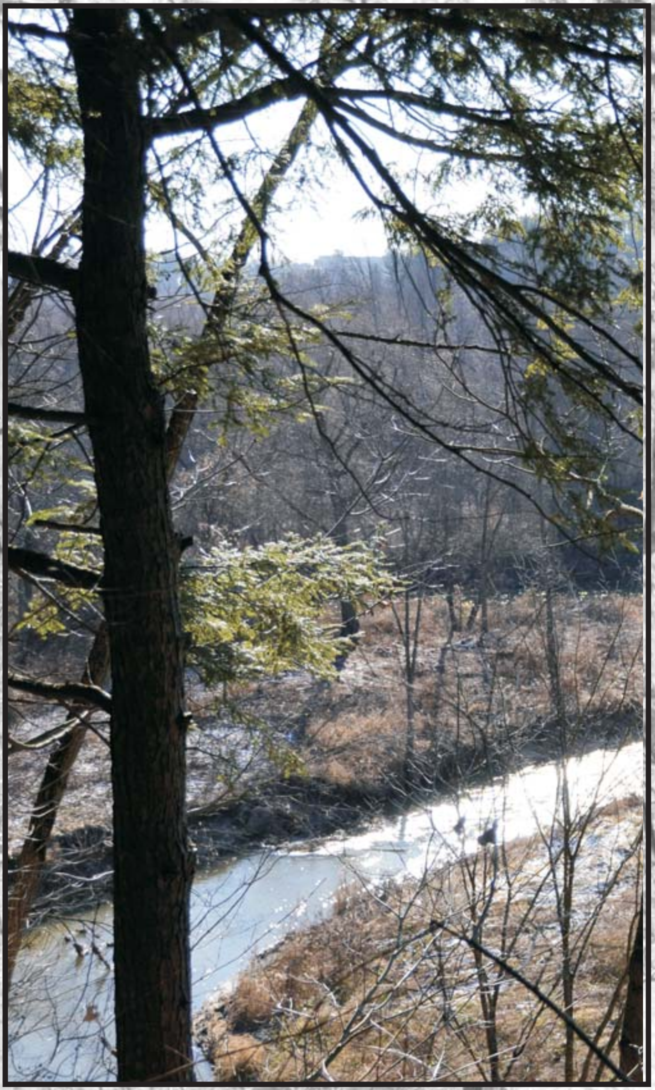
Ontario



OSAP

Ontario Stream Assessment Protocol

Version 10 - 2017 - Edited by Les Stanfield

ONTARIO STREAM ASSESSMENT PROTOCOL
VERSION 10.0
2017

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ONTARIO STREAM ASSESSMENT PROTOCOL

VERSION 10.0

2017

General Introduction

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1.0 BACKGROUND

The Ontario Stream Assessment Protocol (OSAP) contains a series of standardized methodologies for identifying sites, evaluating benthic macroinvertebrates, fish communities, physical habitat, geomorphology, hydrology, and water temperature in wadeable streams and within headwater drainage features. A foundation of OSAP is that where feasible all sampling is conducted within site boundaries that are defined based on a geomorphic unit and with the premise that sample sites should be as short as possible to inventory local conditions. This supports the concept that an optimal strategy for characterizing conditions across larger spatial units is one that applies sampling multiple independent sample sites so that variance can be calculated.

The OSAP was designed to address a variety of stream assessment issues, ranging from very specific questions (e.g., determining maximum summer water temperature) to broader issues (e.g., changes in fish community composition over time). There are also modules to document site features that influence stream conditions such as local land or water use, groundwater upwellings, presence of restoration activities or barriers to fish migration, and invasive species. These additional modules provide information to better understand the factors that influence stream condition and are designed to be applied in concert with other modules with minimal additional effort. Protocols are organized into sections containing multiple methods (modules) which vary in the amount of effort required to collect data, and the interpretations that can be made from them. These standardized methods attempt to maximize data repeatability. Use of these standard methodologies allows data to be shared, used for multiple purposes and stored in a common database.

An OSAP method represents a component of a module that when applied is carried out consistently by users. Modules contain a series of nested methods designed to measure specific attributes of streams. The modules are designed to be conducted in whole or in part, individually or in combination. This flexibility is intended to maximize the ability of the methods to meet users study design needs. Study design is determined by project managers and indicates which modules should be completed and to help future users of data. It will soon be a mandatory module for data that is included in the provincial repository. Efforts are underway to post hoc develop metadata for all historic OSAP datasets available in the Flowing Waters Information System (FWIS), the system that is used to manage the information collected using these methods.

Within each module enough information is provided to help users understand the background diagnostic capabilities, linkages to other modules and limitations of the module, so that users might decide its appropriateness to answer specific questions. Additional guidance on study design is provided in the compendium manual, “Guidelines for Designing and Interpreting Stream Surveys” (edited by Stanfield 2003), available from the Toronto Region Conservation Authority webpage (www.trca.on.ca/osap).

1.1 Changes and additions to Version 10.0

The OSAP manual is continually evolving to reflect changes in the science and technology related to stream assessment. Changes to protocols are made carefully to maintain integrity of data between versions. Two new modules have been added for the 2017 OSAP manual including: S1.M5: Restoration Activity and Issue Documentation and S4.M11: Unconstrained Headwater Sampling. Additionally, with the addition of S4.M11, the earlier S4.M10 module has been renamed to S4.M10 Constrained Headwater Sampling to differentiate the two modules.

Several changes have been made to Section 1. First S1.M2 has been split to better reflect the fact that site features are a distinct module that does not need to be done with the mandatory site documentation module. The new titles are S1.M2 Screening Level Site Documentation and S1.M3 Site Feature Documentation. The version 9 module S1.M5 Site Features for Water Quality Surveys has been merged with S2.M3 Transect Travelling Kick and Sweep Survey for Macroinvertebrates to better reflect how the data is collected and to be more consistent with the Ontario Benthic Biomonitoring Network. Finally, S1.M4 Diagnostic Procedures for Site Feature Documentation has been removed from this version as the methods contained within it are now largely redundant with the addition of the various site feature and barrier modules.

- The majority of the field forms have been changed in this version in order to improve consistency across the modules. Some of these changes are minor and some are more significant so be sure to use the new field sheets when out in the field.

- An alternate site code designation has been added to the Site Description field form and other field sheets where this information is stored to facilitate more efficient sharing of data between organizations.

- Section 4 Substrate measurements have been revised to better reflect northern Ontario sampling regimes. To accommodate these needs a new code for flocculent detritus (gavia feces) has been added and new direction as to how to ensure that movable bed material is identified when sampling in bedrock type streams. These designations will also improve measures in other areas of the province as well, with minor impact to historical data.

- Section 6 (OSAP Data Management) has been updated to reflect changes in how electronic data is shared and stored. The FWIS now supports multiple approaches for uploading all OSAP data and its functionality continues to improve. A user's manual that is available on the website (www.comap.ca/fwis) will continue to be updated as the system is improved.

Many of the modules are linked and can be done in conjunction with each other. For example the tracked species module should be completed when incidental observations of tracked species (endangered, invasive or priority species) are made, and this could occur while assessing habitat, doing a benthos survey or electrofishing.

2.0 ORGANIZATION OF THE OSAP MANUAL

The OSAP is organized into sections (e.g., for evaluating benthic macroinvertebrates, fish communities, physical habitat, and water temperature in wadeable streams). Each section contains multiple methods (modules) which are classified by the amount of effort required to conduct the survey (and the interpretations that can made from the data) according to the following:

- Screening Surveys: These methods enable users to perform rapid inventories. Screening surveys tend to be visually based. They are useful for the collection of information for 'state of the resource' reports and for identifying future collection efforts.

- Assessment Surveys: These methods require more effort than Screening Surveys. They are recommended for monitoring or impact assessment studies.

- Diagnostic Surveys: These methods provide detailed data and a higher degree of interpretative power than the Screening or Assessment Surveys, but require more effort to conduct.

The component sections include:

Section	Title
0	Study Design Metadata
1	Site Identification and Documentation
2	Benthic Macroinvertebrate Assessment
3	Fish Community Sampling
4	Assessing Physical Processes and Channel Structure
5	Water Temperature Assessment
6	OSAP Data Management

Section 0: Study Design Metadata

This section provides guidance for documenting study design metadata associated with surveys on flowing water. Metadata describes the project for which data was initially collected, including its geographic extent and the factors considered in designing the study. The standard set of metadata descriptors used in this module was developed in consultation with key persons involved in flowing waters research in Ontario.

Section 1: Site Identification and Documentation

This section describes a standard set of procedures for locating sites on streams, defining the boundaries of the sampling station and documenting landuses that may influence the biophysical conditions at a site. The first module, S1.M1 - Defining Site Boundaries and Key Identifiers, must be completed when additional sampling modules used require site boundaries to be determined. Either the S1.M2 - Screening Level Site Documentation or S1.M3 – Detailed Site Documentation must be completed with every visit to a site. Modules S1.M4 (Site Feature Documentation), S1.M5 (Restoration Activity and Issue Documentation) and S1.M6 (Tracked Species) provide information to better understand stream condition and to begin tracking stressors over time. Study objectives will determine which modules to use.

Section 2: Benthic Macroinvertebrate Assessment

This section describes a number of standard tools for assessing benthic macroinvertebrate composition. Benthic macroinvertebrates can be used to evaluate water quality. Physical habitat conditions (depth, velocity and substrate) are measured to characterize background conditions and to assist in interpreting data.

Section 3: Fish Community Sampling

This section describes standard methods for sampling fish communities in streams. The first module, Fish Community Sampling using Screening, Standard and Multiple Pass Electrofishing Techniques (S3.M1), describes three electrofishing approaches. The three approaches are described in one module, as the procedures are similar, with the exception of sampling effort. The seining module for sampling fish assemblages standardizes how this technique is applied and includes techniques for matching catches to habitat conditions and area sampled.

Section 4: Assessing Physical Processes and Channel Structure

The modules in this section provide standard methodologies for assessing habitat and some stressors (e.g., barriers) in wadeable streams and headwater drainage features. The data collected will allow analysis of the channel structure (e.g., cover, substrate), channel processes (e.g., hydrology, sediment transport), and the stream's suitability for biota. Standardizing data collection procedures enables comparisons to be made across spatial and temporal scales by reducing error and controlling biases. Providing standard methodologies that vary in the accuracy of the data collected offers flexibility for users to accommodate different study designs.

Section 5: Water Temperature Assessment

This section describes techniques for assessing water temperature and estimating summer maximum water temperatures. Water temperature strongly influences the composition of aquatic communities. Knowledge of aquatic thermal regimes is important for predicting species composition, activity level, behaviours and life cycle events.

Section 6: OSAP Data Management

This section provides detail on how to manage the data collected using the OSAP using the Flowing Waters Information System (FWIS). FWIS is a web based platform that enables users to enter data online or to upload data from parallel databases, provided formats are comparable and key fields are provided.

Section 7: Glossary and List of Acronyms

The glossary provides definitions of all the major terms and acronyms used in OSAP.

Section 8: Blank Field Forms

This section includes a copy of each of the revised field forms that have been developed for Version 9.0. Crews are encouraged to make copies of these forms for use in the field since they are the most current versions. Electronic (pdf) copies of the field forms will be posted on the Toronto Region Conservation Authority webpage (www.trca.on.ca/osap).

In each section, tips are provided to help with surveys and a general list of tips is presented at the end of this section (Appendix 1). Crew members are encouraged to review these periodically during the sampling season.

3.0 TRAINING

It is recommended that all crews complete OSAP training, but at minimum a crew leader should be certified to level 1, so that they can train and provide quality assurance to data collected by crew members that they train. The Ontario Ministry of Natural Resources and Forestry, Fisheries Policy Section should be contacted for information on upcoming courses.

4.0 SAFETY CONCERNS

Crews should adhere to safety precautions and requirements set forth by their employers /managers (i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone, etc.). Field staff and supervisors should be aware of the hazards in their work environment (e.g. poison ivy, working on ice, working in fast flowing water, risk of heat stroke/hypothermia, etc.) and have plans in place to mitigate these hazards.

5.0 OBTAIN YOUR PERMITS

A Scientific Collector's Permit (SCP) is required for anyone intending to capture or transport fish as defined under the Ontario Fishery Regulations.

Section 3.(1) of the Ontario Fishery Regulations (OFRs) under the federal *Fisheries Act* state that " No person shall, except as authorized under a licence, (a) fish; (b) ship or transport or attempt to ship or transport live fish other than baitfish". The *Fisheries Act* defines fish as "(a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans, and marine animals". The OFRs (s.29. (4)) also state that "No person shall transport crayfish overland except under a Licence to Collect Fish for Scientific Purposes issued under the Fish and Wildlife Conservation Act, 1997, Statutes of Ontario, 1997, c. 41".

Therefore, SCP's are required for anyone applying modules within Sections 2 or 3 or if they intend to keep voucher specimens of clams, mussels or crayfish. Practitioners should include all targeted fish and proposed methods to be employed on their application for a SCP and specifically request "permission to transport crayfish" where it is likely that benthic material will be transported to the lab for analysis and/or where surveyors have the potential to observe new records of rusty crayfish.

Surveyors must also consider whether there is a probability of capturing listed species of mussels or other benthic animals in benthic samples and request special permits under the *Endangered Species Act* or the *Species at Risk Act*, accordingly.

6.0 CLEAN YOUR EQUIPMENT

When multiple sites are visited during a sampling survey, there is a risk that monitoring practitioners could transplant potentially invasive biological material (e.g., whole live animals, plants, or microbes, or their propagules). Individuals or organizations conducting OSAP surveys should write standard operating procedures that seek to minimize the risk of such transplants. Such procedures should be tailored to the risks present in the area where the surveys are being undertaken, and should be followed during all sampling surveys. In addition to removing any aquatic plants, animals, and mud, the following approaches are suggested (in decreasing order of risk avoidance):

1. Dedicated gear: a full set of sampling gear for each site, such that any gear item (e.g., waders, metre stick, measuring tape) is used only at a single site
2. Cleaning and disinfection of gear at the end of a site visit and before leaving a location
3. Gear used at multiple sites in close proximity within a watershed and thorough cleaning and disinfection after a subset of sites has been sampled.
4. Sterilize all equipment after each survey day and only survey in one watershed on an individual day.

Common disinfection agents include bleach or hydrogen peroxide solutions. Air drying is also essential for all equipment between site visits.

7.0 ACKNOWLEDGEMENTS

For this version of the manual, the acknowledgements of the many contributions from various technical experts have been added to the specific modules where their input and assistance has been directed. The OSAP team would like to acknowledge the efforts of TRCA for their continuing support in helping organize and administer the OSAP training courses and for facilitating the review of this version.

APPENDIX 1

Tips For Collecting High Quality Field Data

Clearly and legibly record all data with a sharp pencil.

USE CAPITAL LETTERS FOR TEXT RECORDS.

Make corrections neatly.

Once they are completed, data sheets should be checked by another person for legibility, accuracy and completeness.

Field forms can be photocopied onto waterproof paper and if multiple sheets are being used at each site, use different colours for each type of sheet.

Check all stream names, stream and site codes, and sample numbers to ensure they are correct on all forms.

Use an equipment checklist.

Record '-99' ('-999' for depth) to indicate that a measurement could not be performed and put dashes (---) through logical fields for which a feature is not present.

Only use codes that are specified in the protocol or on the data forms.

Additional information should be noted in the comments box.

Use only the measurement units on the field forms (e.g., mm, m, etc.). All depths are measured in millimetres; all lengths and widths are measured in metres.

DON'T leave a blank field on a data sheet. Always record a value for a numeric field or a dash for a presence/absence field if the object (e.g., a cover type) is absent.

DON'T ASSUME anything. Check the manual, or with your partners or your supervisor.

DON'T record personal information (names, addresses, phone numbers, etc.,) in sketches or into databases that could be accessed by the general public

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 0: MODULE 1

Study Design Metadata
"Compilation for Flowing Waters Surveys"[1]

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[1] Authors: Stanfield, L, Ball H, R. Mackereth,

1.0 INTRODUCTION

This module provides guidance for documenting study design metadata associated with surveys on flowing water that use any provincially or federally endorsed protocol. Metadata describes the project for which data was initially collected, including its geographic extent and the factors considered in designing the study. The standard set of metadata descriptors used in this module was developed in consultation with key persons involved in flowing waters research in Ontario (see list of acknowledgements).

The metadata descriptors provided in this module correspond with those of a database that has been developed to accommodate data collected on flowing waters in Ontario (the Flowing Waters Information System or FWIS). As such, the descriptors are intended to be broad in scope and capture a variety of potential study designs and data collected using a variety of protocols and types of habitat associated with flowing waters.

It is recognized that each protocol and study design is subject to bias and researchers attempt to minimize or control such bias to answer specific research questions. Documenting study design metadata for each project will enable future users to understand why data were collected, evaluate potential biases and determine whether data are appropriate for further analysis. Implementation of this module will also allow users of FWIS[2] to view and/or extract the subsets of data applicable to their specific study or question.

2.0 COLLECTING AND RECORDING STUDY DESIGN METADATA

Study design metadata should be documented by the project lead or the individual who is most knowledgeable about the study design for the project. Study design information should be recorded on the 'Study Design Metadata Form' prior to initiating sampling or soon after sampling is complete. This provides project managers with a hard copy record and will facilitate data entry into FWIS (where metadata will be stored with and linked to each sampling event).

Over time and through extenuating circumstances some components of a project's metadata might change. There are two types of changes that are managed differently in the database. The first involves additions or deletions of strata in a long term study.

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[2] A partnership of agencies has developed the Flowing Waters Information System (FWIS) to facilitate data discovery amongst stream practitioners in Ontario. See data management section or go http:\\comap.ca\fwis for more details.

Depending on the magnitude of the change, the project lead can choose to simply modify the design and its description, or they can create a new linked project. This is accomplished by using a ‘similar’ code and name and description (e.g., ATS99 and ATS99_1 and by describing the difference in the “description’’ field.

The second situation applies to characteristics of individual sites and sample events that either provide more detail of the “role’ of a site in a study or that describe deviations from the project goal. For example, a project designed as a control-impact study assigns individual sites as either control or impact. So, the study is recorded as a control-impact study in the project metadata table and a specific sample site is recorded as being either a control or an impact site in the sample site project metadata table.   A second scenario applies to examples where local conditions or criteria associated with a sample site differ from the overall goal of a project (see examples in the text box below). Such local changes in study design enable project leads and future users to evaluate the significance of any deviations and help explain outliers during subsequent analysis.

Site Location and Boundary Deviation Example

A project with an overall goal of using sites that are randomly selected, may include data from historic sites that are of a different category of selection (e.g., unknown or representative).

For many reasons, for example, a beaver dam or deep section makes sampling impossible and results in site boundary locations differing between sites, thereby making a site a potential outlier. Such minor metadata differences are recorded at the sample event level.

These data are recorded in the sample event project metadata table (see Data Management 5.0 below and the Information Management Module (S6.M1).

Project leads or managers who intend to upload historic datasets into FWIS will be asked to document information for these projects in the same manner, using available knowledge.

2.1 Project Identifiers

A unique project code (acronym) and a project name must be assigned to each project and associated sample data. It is recommended that an organization identifier (i.e., Toronto Region Conservation Authority; TRCA) be used in the project name to facilitate querying the data (e.g., TRCA trend monitoring). More than one project code may be assigned to each sample as data may be collected for multiple projects. Record the ‘Project Name’ and ‘Project Code’ for the project on the S0.M1 Study Design Metadata Form (Appendix 1).

2.2 Project Leads and Partners

The project lead is the person responsible for the quality of and decisions pertaining to the study design for a particular project. In the database, this person is responsible for all aspects of the field data and the designation of individuals with editing rights. The project lead may or may not belong to the same organization who conducted the sampling for the project. If more than one organization is involved in the project, the names of the partners and their organizations also must be recorded in order that data access is provided to all partners in a project. Use of the same organization acronyms used in FWIS on the field sheet will assist with data entry.

When listing partner agencies, the project lead must indicate whether these organizations have editing rights for the project data. This is generally desirable if partners have been involved in sampling. Record the ‘Lead’ and ‘Organization’ represented as well as any ‘Partner(s)’ and ‘Organization(s)’ on the S0.M1 Study Design Metadata Form.

2.3 Project Description

Provide a brief description of the project in the ‘Project Description’ field. A good project description will provide insight to future users about the project objectives, geographic extent of the work and selected indicators (e.g., Waring Creek Brook Trout Restoration Program Monitoring).

2.4 Study Area

Record the geographic extent of the study under the ‘Study Area’ field. In most cases, this is either a watershed boundary (e.g., Saugeen River) or a municipality (e.g., City of Ottawa). For studies that occur over large geographic extents, list all areas included in the study (e.g., Region of Durham, Peel, York, and Toronto) or use an ecological descriptor (e.g., southern slope of the Oak Ridges Moraine). In unorganized areas, record the Ministry of Natural Resources and Forestry (MNRF) District the study area falls within.

2.5 Study Design Factors

Study design may require stratification or grouping of samples in order to address the specific questions of the study and control for potential sampling bias. However, the treatment of data to meet previous study objectives may introduce bias in subsequent studies. Documenting the factors used to stratify or group samples will allow future users of the data to understand and control for the bias inherent in the methods used.

While there are many factors that may be considered in study design, there are a number of common variables considered in the design of studies on flowing waters. These often include: where sampling will occur, the criteria used to select these locations (strata), the timing of sampling, and how sampling areas are established.

The following sections provide a guide to documenting many of the variables used in the design of a particular study including: geographic extent, administrative and political units, physical and chemical characteristics, site location, site boundary determination, and timing of sampling (Table 1). The intent of this section is to improve the accessibility and value of data to future users and increase efficiency by directing them to specific data sets and projects. As such, the focus should be on amalgamating characteristics rather than providing fine detail (e.g., stratified by geology is sufficient rather than the specific geologic units of each strata).

For each category described below, identify all factors that were used in the project design on the S0.M1 Study Design Metadata Form (Appendix 1).

2.5.1 Spatial Factors

Project leads are asked to identify all spatial factors employed within the project's study design. This category includes factors such as measures of stream order/position, geology, climate, land cover, and classification systems that rely on these data.

2.5.2 Management Factors

Sampling locations are often selected based on specific management strategies such as: evaluating stocking strategies, species interactions, or evaluating permitted water withdrawals.

2.5.3 Administrative/Political Factors

Specific administrative or political boundaries are often the final determinant of study boundaries (e.g. MNRF District, municipal or conservation authority boundaries).

2.5.4 Biological, Physical and Chemical Factors

Studies often target specific biological, physical or chemical parameters of flowing waters and use these characteristics to select target sites for sampling. Some examples include: specific widths or depths, sediment regimes, amount of woody material, proportion of canopy cover and levels of productivity. Identify all the factors used in the study to define the strata and ideally, also include a text definition in the Sample Site

Metadata table that describes the strata to which a sample site is associated (e.g., high wood, competitors present).

2.5.5 Temporal Factors

Most study designs employ controls for temporal effects; these may be due to staff availability, or be guided by target species migration patterns, etc. In this section, document the temporal criteria used by the project lead to initiate sampling activities (rather than specific sampling dates).

2.6 Primary Site Location Criteria

Depending on the type of data collected, the precise location where sampling occurs can greatly influence subsequent use of the data. For example, in order to build a water budget, specific locations within a watershed must be targeted. If surveys are conducted at the same locations in order to assess fish communities and predict conditions throughout the watershed, this would generate a biased view of where specific species may be located.

The ‘Site Selection Process’ is typically tiered in its application. For example, at the highest level sites are selected using either a targeted, random or targeted-random approach. An example of a targeted-random approach is one in which sampling is conducted at or close to road crossings and specific crossings are determined randomly. Record which of the three primary site location criteria best represents the study design applied.

2.7 Secondary Site Location Criteria

Secondary criteria are often applied to site selection criteria based on either specific objectives or limitations of a study. Some clearly define specific study designs, such as a control-impact study or a hypothesis test, but many others reflect accessibility and other logistic concerns. Record all of the secondary site location criteria used in a study using the definitions provided in Table 1. Note, biologists often sample sites that have been previously sampled as a means of assessing trends in time. In these cases, the metadata for site location becomes nested, with the original criteria having an influence over the secondary application. Project managers only record the data used in their study design, (e.g., targeted, previous sampling) enabling queries to extract the initial selection information (e.g., random and targeted) to evaluate the layers of effects.

2.8 Site Boundary Determination

Once the site location is selected, a variety of criteria may be applied to determine the boundaries or the extent of the area to be sampled. In some instances, sampling may be directed at a specific point (e.g. stream temperature) or transect location (e.g., discharge) while in others an entire portion of the stream or river is sampled (e.g., fish community sampling). It is critical to document the criteria used to define the sampling extent as they may affect the comparability of data. It is also important to document situations when no specific rules are used to define where sampling begins or finishes.

Table 1 - Definitions for Categories used to Define Study Sampling Design Criteria

Factor	Definition
Spatial Factors	
Geology	Surficial or bedrock geology types
Catchment size/stream order or position	Catchment size, stream order or position with a watershed (e.g. headwaters)
Ecological region	Defined by a characteristic range and pattern in climatic variables including temperature, precipitation and humidity (e.g., ecoregion 7E (Lake Erie – Lake Ontario). In Ontario, a hierarchy of classification is available for the landscape that includes: ecozone, ecoregion and ecodistricts.
Climate	Climatic zones, including precipitation or temperature areas, growing degree days, etc.
Watersheds	Individual catchments (e.g., Wilmot Creek), quaternary (e.g., 2hb-07) or tertiary watersheds (2hb)
Land cover	Land cover type (e.g., agriculture, urban, forested)
Stream or valley segments	Based on similarly classified valley segments. Valley segments represent lengths of rivers with similar hydrography and surficial geology.
Administrative/Political Factors	
Administrative or political boundaries	MNRF District or Regional boundaries, cities, counties, parks, Fisheries Management Zones, etc.
Management Factors	
Land use	Forest cutting history/practices; disturbance from any land/water use.
Barriers to migration	Permanent barriers to migration of fish (may be species specific).
Stocking strategy	Whether fish have been stocked and the stocking objective (e.g. rehabilitation).

Factor	Definition
Biological/Physical/Chemical Factors	
Species distribution	Determining species distribution or testing effects of a species on another.
Productivity	High or low productivity systems.
Thermal Regime	Thermal regime of system (e.g., cold, cool, warm).
Structure	Structural characteristics of a site (e.g. width, depth, wood supply).
Flow	Flow characteristics (e.g., baseflow)
Conductivity/Turbidity	High or low values, specific ranges
Temporal Factors	
Season	Specific season(s); may be weather dependent (e.g., ice free season, ice over season, fall, summer, spring).
Flow conditions	Specific flow conditions; may be high (e.g., after storm/melt event) or low flow (e.g., no recent storm events).
Date	Sampling directed by specific calendar date.
Temperature	Thermal condition; sampling initiated based on when water or air temperature meets specific criteria.
Site Location Guidelines	
Primary Selection Process	
Random	Randomly selected within each stratum or over entire study area (no stratification used).
Targeted	Selected in order to meet a specific need (e.g., all road crossings or property specific assessment) or answer a specific question (e.g., type of habitat condition).
Targeted-random	Selected using specific criteria (e.g., road crossings) but actual road crossings sampled were randomly selected from all possible locations.
Secondary Site Location Criteria	
Control - Impact	Sites are selected to act as controls or reference sites and impact sites from which comparisons are made. Ideally, the classification of each site will be documented in the database.
Boundary	Specific locations are sampled to characterize conditions expected to be related to some background condition. Examples include: outlets of streams, boundaries with geology or slope and change in land use.

Factor	Definition
Previous sampling	Specific locations are selected to take advantage of previously collected data.
Accessible	Selected based on accessibility and the appropriateness of the area to apply the selected methods.
Representative	Selected as representative sites or intended to capture typical or average conditions (e.g., typical trout habitat). Specific sampling location determined in the field.
Hypothesis Test- Gradient	To assess a specific question at a site, (e.g., stocking success, competition, comparison between two or more sites in a gradient of differences.
Other	Any other category not covered by the above criteria, define in the comments field.
Site Boundary Determination	
Ontario Stream Assessment Protocol	Begins at a crossover and ends at first crossover after 40 m stream length.
Point (no extent)	Sampled at one point that meets appropriate conditions for application of sampling method (e.g., water quality, temperature, etc.).
Bankfull widths	Starts at crossover, continues until a length of stream equal to a set number of bankfull stream widths is reached and ends at the closest crossover.
Wetted widths	Starts at crossover or riffle, continues upstream until a length of stream equal to a set number of wetted stream widths is reached and ends at the closest crossover.
Riffle to riffle	Starts at the midpoint of a riffle (shallowest depth) and continues until the midpoint of the next riffle is reached.
Riffle with set length	Starts at a riffle and continues until a set distance is reached (e.g., 40, 50, 100 m).
Access point with set length	Starts at the access point (regardless of habitat type) and continues for a set distance.
Habitat boundaries	Based on specific habitat boundaries (e.g. one riffle or one pool).
Road right of way	Sampling limited to road right of way.
Sampleable area	Boundaries are dictated by the type of sampling being conducted, (e.g. a change in either navigability or wadeability, barriers, etc).

Factor	Definition
Knickpoints	Sample all areas between two major changes in slope within the channel,
Entire strata	The entire reach length as defined sampled with the techniques,
Set length of representative habitat	Defined distance in a representative stream section (e.g., 30 , 40m, etc.).
None	Beginning and end of site is not determined by any physical or length determinate.

Note: In FWIS, drop-down lists will be available for each category. An option will also be available to add new criteria where necessary.

3.0 DATA ACCESSIBILITY AND PROPRIETARY RIGHTS

It is within this section that project leads can specify the accessibility rules for the datasets associated with each project. Options available include:

- Open: full accessibility with any user who has signed the data sharing agreement
- Proprietary: data associated with the project will not be shared for a 5 year period without the expressed written consent of the project lead.
- Prior notification: data can be shared provided a notification is sent to the project lead
- Agreement required: data can only be shared with a user upon a separate signed agreement being completed between the project lead and the user.

Check the appropriate 'Access Type' box at the bottom left corner of the 'S0.M1 Study Design Metadata Form' and ensure this box is filled when entering data into the database. Note, this tab specifies rules for data associated with a specific project. These are managed in concert with the FWIS data sharing agreement that guides the overall process of information management that each organization/project lead must initiate to enable automated sharing of datasets (see Section 6: Data Management for more details).

4.0 TIPS FOR USING THIS MODULE

This module is best filled out at the beginning of a study as a means to facilitate a clear and well thought out study design.

Don't forget to update these forms and the database if study design or data collection approaches change during the course of the study. As the originator of the data, you have a vested interest in ensuring that it is available to future generations.

5.0 DATA MANAGEMENT

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 from this module into an appropriate repository that will facilitate its long term storage and use by stream practitioners in the future. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies province wide.

At present FWIS is the only database repository for this information. However, the data structure is available should users wish to replicate this functionality in other systems and then utilize web mapping and uploading features to share this information. Additional information on using FWIS is available in section 6.

6.0 ACKNOWLEDGEMENTS

The authors are indebted to several prominent stream ecologists from Ontario who collaborated to generate the definitions and categories that form the core of this module (Table 1); Charles Hendry, Chris Jones, Nick Jones, Nick Mandrak, Scott Reid and Tim Haxton.

Box 1: Definitions

wetted width	the average width of the stream at the edges of the wetted channel, taken at right angles to the stream flow
knickpoint	a point along a river's length at which it suddenly begins to flow in a steeper course in the downstream waters. These represent high points in bed elevation

Appendix 1

Example of Study Design Metadata Form

Project Name ATLANTIC SALMON HABITAT STUDY	Project Code ATS-09
Lead S. SALAR	Organization CONSERVATION HALTON
Partner(s) TROUT UNLIMITED	Organization(s) OFAH

Project Description ASSESSMENT OF THE SUITABILITY OF BRONTE CREEK TO REAR ATLANTIC SALMON

Study Area HALTON CREEK FROM LAKE ONTARIO TO HWY 6, MAINSTEM ONLY

Location of Field Data Sheets HALTON REGION CONSERVATION AUTHORITY

Study Design Factors

Category	Factor	Used?	Comments
Spatial	Geology	☐	
	Catchment size/stream order/position	☒	
	Ecoregion	☐	
	Climate	☐	
	Watershed	☐	
	Land cover	☐	
	Stream/valley segment	☒	
	Other	☐	
Administrative/Political	Administrative/political boundaries	☐	
Management	Land use	☐	
	Barriers to migration	☒	STRATIFIED UP AND DOWNSTREAM OF LOWVILLE DAM
	Stocking strategy	☐	
	Other	☐	
Biological/Physical/Chemical	Species distribution	☐	
	Productivity	☐	
	Thermal regime	☐	
	Structure	☐	
	Flow	☐	
	Conductivity/turbidity	☐	
	Other	☐	

Temporal	Season	☒	SUMMER
	Flow conditions	☒	LOW FLOW CONDITIONS
	Date	☐	
	Temperature	☐	
	Other	☐	
Primary Site location Criteria	Random	☐	
	Targeted	☒	ALL REACHES TARGETED FOR SAMPLING UNLESS ACCESS DENIED
	Targeted-random	☐	
Secondary Site Location Criteria	Control-Impact Design	☐	
	Boundary	☐	
	Previous Sampling	☐	
	Accessible	☐	
	Representative	☐	
	Hypothesis test - Gradient	☐	
	Other	☐	
Site boundary	Ontario Stream Assessment Protocol	☒	RAM SUBSTRATE (S4.M8) AND RAM HABITAT (S4.M1), TEMPERATURE (S5.M2)
	Point (no extent)	☐	
	Bankfull widths	☐	
	Wetted widths	☐	
	Riffle to riffle	☐	
	Riffle with set length	☐	
	Access point with set length	☐	
	Habitat boundaries	☐	
	Road right of way	☐	
	Sampleable area	☐	
	Knick points	☐	
	Entire strata	☐	
	Set length of representative habitat	☐	
	No specific rules	☐	
	Other	☐	

Additional Comments
SOME UNSAMPLEABLE AREAS ASSESSED VISUALLY FROM SHORELINE

Associated References
ATLATNIC SALMON FEASIBILITY STUDY OF BRONTE CREEK 2015

Proprietary Rights Requested? ☐

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1

Site Identification and Documentation

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INTRODUCTION

This section describes a standard set of procedures for locating sites on streams, defining the boundaries of the sampling site and documenting land uses, biota and restoration activities that may influence the biophysical conditions at a site.

To standardize data collection and reduce sampling error, site boundary definitions must be consistently defined. The first module provides methods for uniquely identifying a sample site. The other modules describe the screening and assessment techniques that can document site location and adjacent land uses, invasive species and past historical activities designed to restore or improve habitat. Each module is described below.

The first module is mandatory for any sampling that is designed to capture at more than a point location or where multiple observations are being made along an extended reach or segment of a waterbody. The second module 'Site Identification' is a mandatory complement for all OSAP modules, and must be filled out at least once per sample year, although the data may be recorded on different field sheets. Module 3 describes a method to assist with tracking stream movement over time and should be carried out whenever data is collected at a site that corresponds to instream habitat or geomorphology, or for sites that are part of a long term monitoring program, Modules 4-6 describe methods to document physical or biological characteristics of sites and segments that are likely to influence the ecological state of a stream.

S1.M1: Defining Site Boundaries and Key Identifiers

This module defines a site as a geomorphic unit that begins and ends at a crossover (i.e., the location where the main concentration of flow is in the center of the channel when the stream is at bankfull flow) and is a minimum of 40 m long. Key identifiers that uniquely define a site are described (e.g., 'Stream Name', 'Stream Code (Unique Code)' and a 'Site Code').

S1.M2: Screening Level Site Documentation

This module describes the minimum information required to be collected in order to document and later verify a site location.

S1.M3: Detailed Site Documentation

This module describes techniques for precise documentation of site boundaries that increases the likelihood of relocating a site for subsequent resampling and for tracking channel migration.

S1.M4: Site Feature Documentation

This module provides techniques for the collection of information on adjacent land uses and activities that could affect site conditions and for documenting the riparian vegetation. It is recommended to be applied for any study attempting to assess or understand stream condition.

S1.M5: Restoration Activity and Issue Documentation

This new, long overdue, module for version 10 provides a tool for documenting where, what type and approximately when restoration works have been carried out on a stream corridor and for identifying existing issues that might benefit from future stream restoration. It is hoped that use of this module will further understanding of the effectiveness of restoration activities and the extent of ongoing issues. This module should be carried out at all sites where spatially extensive information is collected and any long term monitoring sites. It can also be applied retroactively where historic mapping of this information is available.

S1.M6: Tracked Species

This module identifies methods for recording incidental observations of tracked species (species at risk, invasive species and priority species). This module can and should be done in conjunction with any other module.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 1

Defining Site Boundaries and Key Identifiers[1]

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[1] Author: L. Stanfield

1.0 INTRODUCTION

The utility of data collected at a site is dependent on how well the site location, condition and surrounding environment are described. In this context, a site is a location on a stream where data from the application of a connected set of sampling protocols have been applied. Field studies, for which data will be compared to a standard or among sites/years, require that site boundaries be consistent between sampling events. The specific location within a site where data are collected vary with each module in OSAP from a single point location to a transect or an extended riffle-pool sequence. Since a core objective of the Ontario Stream Assessment Protocol (OSAP) is to enable data collected with different modules to be spatially comparable, a standard definition of a sample site has been developed and is described in this module.

Historically, site lengths tended to be standardized within a study regardless of stream width (i.e., 50 m) and sites would often start and finish in different habitats. Alternatively, sampling areas were chosen based on time constraints or focused on specific habitat types (i.e., pool or riffle) that were more prone to sampler bias in boundary determination (see Stanfield and Jones 1998). A more repeatable and less biased approach to determining sample units is to base the sampling site on geomorphic criteria, such as the riffle-pool sequence and allowing specific sample areas within the site to vary with module needs. This is the basis of the site definition in most of this protocol[2]. Defining sites by physical boundaries ensures that data will be comparable across stream types and sizes and through time.

2.0 PRE FIELD ACTIVITIES

This module takes 5 to 15 minutes to complete.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers:
    - check the FWIS database to see if the site has been previously described and obtain the unique identifiers for the site
    - if it is a new site, **ensure that an appropriate stream name and code** is determined and is used on all data forms.
- Equipment check

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[2] A different site definition is applied within modules where it is assumed that access is restricted and clearly defined geomorphic structure is not present (i.e. S4.M9 and S4.M10).

The following equipment is required:

1. Tape measure or hip chain
2. Metre stick

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone, etc.).

3.0 FIELD PROCEDURES

The application of any OSAP module requires that the sample must be uniquely identified within. Once data is within FWIS users and internal queries can be applied to ensure all sample site data are uniquely identified in a logical manner.

The ‘Organization Name’, is the name of the sampling organization or “agency” that will be recorded in the FWIS database as part of the meta-data associated with the site and the sample collected.

The ‘Stream Code’ allows differentiation between streams with similar names (e.g., Trout Creek). Using unique or comparable “Stream Codes” makes searching and tabular analysis much easier for everyone. Use the FWIS database to determine if a stream code already exists within the subwatershed where the sampling is to occur – if it has then use the code that has already been assigned to this stream. If an existing stream code does not exist in FWIS, then a new stream code may be entered along with a short description to help identify where in the province the stream is located (see S6 M1).

Within FWIS, the ‘Site Code’ must be unique for each stream. The ’Site Code’ should not exceed eight digits and can be any combination of letters or numbers. It is best to choose abbreviations that describe the location of the site. For example, a site on Wilmot Creek, downstream of the 3rd concession, could be ‘3CDW’. Project managers are encouraged to use the data discovery and mapping features in FWIS to first determine whether a sampling location exists already that is within 40 m of the mid-point of where sampling is intended to occur. If no station has been sampled where the project manager will be sampling then new codes can be assigned for this new site. However, sampling near road crossings imparts a greater likelihood that some form of identifier already exists for this location, either as an existing OSAP site or some other organizations code. Eventually, it is hoped that as information sharing becomes common place that site location identifiers will be discoverable through GIS analysis, however in the interim it is advised that project managers follow the hierarchy of naming conventions described below to ensure desired linkages between datasets are created. Note, at present, alternate site code identifier fields are not present on all field sheets, although the field is available within FWIS for all modules.

Site Code Naming Hierarchy:

1. Use the primary Site Code identified in FWIS (http://comap.ca/fwis) where available,
2. Where no primary site code exists but a local waterbody identifier or road crossing code exists, apply this as the primary site code,
3. Document any additional location identifiers (agency site codes, water crossing identifiers etc.,) in the alternate site code field.

Avoid using O's or 0's; I's or 1's; dashes ("-") or underscores ("_") as these could create data entry problems.

Record the site identifiers on the Site Identification Form (see Appendix 2 in S1.M2, Screening Level Site Documentation). It is important that the 'Stream Code', and 'Site Code' are consistently recorded on all data sheets. Recording the stream name on each field sheet is also recommended for quality control.

3.1 Identifying the Site Boundaries

A standard OSAP 'Sampling Site' should represent at least one riffle-pool sequence, be at least 40 m long, and begin and end at a crossover point (Figure 1). Measure the mid-channel length (Figure 1) by chaining the site from the bottom (i.e., the downstream end of the site) to the top. At some sites (channelized or highly unstable streams), it will be difficult to identify the crossover points. In these situations, an area with similar bank height on both sides and a relatively uniform depth profile across the channel should be chosen as the bottom of the site. Search for an area with similar conditions that is at least 40 m upstream and use this as the top of the site. For example, if crossover points occur at the 0, 29 and 52 m marks, the site would end at the 52 m mark. When study designs require sampling much longer units of stream, managers are encouraged to create back-to-back sites meeting the criteria above.

Crossover Point

A crossover is the location where the thalweg (main concentration of flow, normally the deepest part of the channel) is in the centre of the channel during bankfull discharge. In 'meandering streams' this occurs when the flow "crosses over" from one side of the stream to the other. In step-pool streams crossovers occur at the crest of the step, Crossovers are usually but not always associated with riffles and the banks on either side of the stream are very close to the same height. In both stream types they are generally associated with changes from deposition to erosion areas. Crossover points will be separated by half-meander lengths (Figure 1) and therefore all sites will be multiples of half-meander lengths. The crossover point represents an area with a slower, uniform flow that occurs when the stream has its greatest erosive ability. These flows cause materials to be deposited across the stream (i.e., towards the middle of the channel), resulting in relatively uniform material sizes and depth at the crossover.

A video is available at: https://trca.ca/conservation/environmental-monitoring/technical-training/ontario-stream-assessment-protocol/ to further explain how to identify crossovers.

Procedures for Chaining Site Length

Site length is measured by chaining up the center of the stream (Figure 1). Use the outer boundaries of the wet channel to determine 'stream width'. This measure includes undercuts and islands in the interpretation of stream width. It does not extend beyond the wetted channel.

One person stands at the bottom of the site in the middle of the stream to mark the starting point. A second person proceeds upstream until the stream changes direction (or until the end of the tape). The second person marks the point, measures the distance, and waits for the first person to reach the mark before proceeding upstream to the next mark location. At the centre of each curve in the stream, the second person marks the location and calls for the first person to move up. Do not stretch the tape around corners.

This process is repeated until the total site length is measured. Unless the station boundaries have already been marked, crews will typically chain the length of the site and identify the upper

The spacing of crossovers is related to stream width and stream type. For many stable meandering streams, the spacing of crossovers will be 7 to 10 times the bankfull stream width. For example, if the stream width at a crossover is 9 m, the next crossover should be between 63 and 90 m (longitudinal distance) upstream. In step-pool streams, this relationship decreases to about 3 to 5 times the stream width. To select site boundaries on a braided stream either choose the largest channel or sample each braid as a unique site. Crossovers do not occur in cascade type streams where spatially extensive OSAP modules cannot be safely applied.

Do not shorten the site length as this may bias the surveys because certain habitats may be under- or over-represented.

3.2 Tips for Applying this Module

If sampling near road crossings, look for numbered tags (typically placed at the top of rebar) in proximity to culverts that provide local identification identifiers that can be applied as either a primary or alternate site code identifier.

If working near any infrastructure on a stream such as a bridge or dam, look for any identification codes/numbers that identify the feature and can be used as a site code and a possible station marker (see S1.M3).

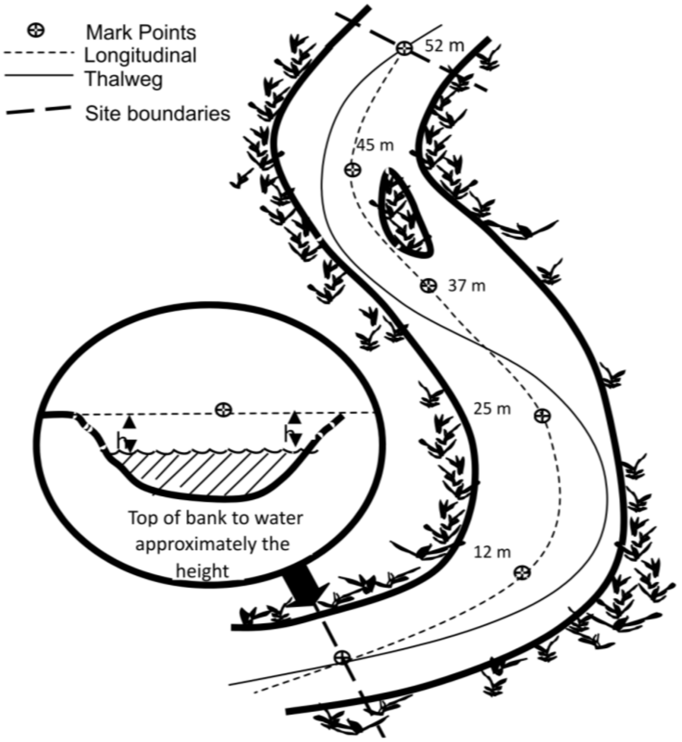

Figure 1: Site Boundaries and Length Determination.

The first crossover point (half-meander length) occurs at 27 m, therefore must continue to next crossover.

4.0ACKNOWLEDGEMENTS

The development of the concept of a standard site definition derived based on geomorphic principles emerged through conversations with John Parish, Jack Imhof, Bob Newbury and Dave Rosgen.

5.0 REFERENCES

Stanfield, L. W. and M. L. Jones. 1998. A Comparison of Full-Station Visual and Transect-Based Methods of Conducting Habitat Surveys in Support of Habitat Suitability Index Models for Southern Ontario. North American Journal of Fisheries Management 18: 657-675.

Appendix 1

Rationale for Site Boundary Definitions

1. Crossovers can be found in all flowing waters and even the most disturbed systems will begin re-establishing crossovers where velocities are the slowest (under high flow conditions).

2. Use of geomorphic boundaries standardizes definitions across disciplines and promotes multi-disciplinary studies of flowing waters.

3. The 40 m minimum length optimizes the balance of variance and effort for a variety of parameters (fish community, instream habitat, and substrate).

4. This length of stream can be sampled in a single day using the methods described in this manual.

5. Sampling multiple sites within a longer stream segment provides a more rigorous evaluation than just sampling a larger section of stream. This enables local variances in the biophysical properties of the stream to be measured, whereas sampling one long stretch of stream homogenizes the results[3].

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[3] Some measures must be made over longer stream sections, for example, the longitudinal profile of riffle and pool sequences, or sinuosity. These should be measured using Geographical Information Systems or Global Positioning Systems.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 2

Screening Level Site Documentation[1]

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes how to record the minimum information required for site location documentation for all new or modified sample sites for which the location has not been documented[2]. A modified site is one in which station boundaries or lengths change. This module should be used when no station markers are to be installed at a site or when a site is found to be unsampleable. This module relies on accurate geocoordinates being obtained for a site and recommends that crews record as much additional information as necessary to ensure that future users of the data will have confidence that the coordinates recorded are an accurate description of the site location.

Occasionally, selected sites cannot be surveyed due to access constraints or field conditions. Alternatively, an established site that has been sampled in the past may be deemed unsuitable for sampling on a specific date, due to beaver activity, turbidity, flows, etc. Regardless of whether a site is permanently or intermittently unsampleable for specific modules, it should be recorded in order that project managers have a record of which and why selected sites are not part of the dataset. Over time and by documenting the rationale for the unsampleable classification, future researchers will be able to greatly increase efficiencies of sampling by excluding these sites from study designs.

Recent advances in GIS provide tremendous opportunities for illustrating and analyzing spatial data. Trend analysis (in time or space) is feasible only if accurate descriptions of the location of the sites are available. Application of this module will enable future surveyors, with the aid of a GPS, to locate the approximate location of a sampling site. For more precise locations of site boundaries, it is recommended that the 'Detailed Site Documentation' (S1.M3) be used.

2.0 PRE-FIELD ACTIVITIES

This module should be performed in conjunction with S1.M1 ('Defining Site Boundaries and Key Identifiers') where applicable. Geographic coordinates can be obtained in several ways. With the following materials available, each technique typically takes less than five minutes.

1. Site Description form
2. GIS with water flow and roads layer (e.g., FWIS, Google Maps)
3. GPS unit (differentially corrected), and/or
4. Maps that are of sufficient scale to locate the site within 50 m

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[2] Many thousands of sample sites have been well documented and surveyors can save time by utilizing the existing information available within the Flowing Waters Information System (http://www.comap.ca\fwis).

3.0 FIELD PROCEDURES

At each site, fill out the mandatory site descriptors (i.e., ’Stream Name’, ‘Stream Code’, ‘Site Code’, Date’ and ‘Sample #’. If an alternate site code is known, record this as well. Both uncorrected (i.e., obtained in the field) and validated geocoordinates are mandatory for this module. Site description and access route information is also recommended to provide a means of validating the site location, but is not mandatory for screening level surveys[3]. Study design will also dictate the degree to which each additional section is completed. For example, site sketches are considered mandatory for partners of the Ontario Benthos Biomonitoring Network.

3.1 Access Route and Site Description

A concise and accurate description of the route taken to the site from a major intersection is used to validate the geocoordinates and to help future surveyors access a site by the most efficient route. Similarly describing the best route to get to a site and providing some description of key landmarks will help future surveyors locate the site (see Table 1 for more details). Where sampling is conducted at road crossings, access route is a sufficient descriptor. Ensure that all descriptions are in compass bearings and distances.

3.2 Georeferencing the Site Location

Geographical coordinates (e.g., Universal Transverse Mercator (UTM) or latitude and longitude) are usually collected using a Global Positioning System (GPS; see Appendix 1). Some units provide uncorrected coordinates and considerable effort may be needed (up to 15 minutes per site) to correctly locate these sites. Correcting these coordinates is necessary before the data can be confidently used in Geographic Information Systems (GIS).

3.2.1 Using a GPS

Obtain and record coordinates for the bottom of the site. When sufficient satellites have been received, the GPS will provide the UTM coordinates. Please record the UTM zone and coordinates using the NAD 83 datum. If the site is in a heavily forested area, is isolated from beacons, or is in a steep valley, the GPS unit may be unable to read enough satellites to obtain a position. This is a good reason to bring a copy of an appropriate web based map (e.g., Google Map or digital ortho-image) or an Ontario Base Map (OBM) with sufficient scale to correctly locate your site as a backup.

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[3] The degree of detail provided will vary depending on where the work is being done in the province. In some instances it will be sufficient to name a road crossing or proximity to a significant feature. Remember, the information is not being recorded for the crews needs, but for future users of the data.

3.2.2 Using a Map

Obtain a copy of a web based or georeferenced map that includes the location of the site. Locate the site on the map and then use this detail to determine the site coordinates using a GIS in the office. If using an OBM, the site coordinates can be obtained from the map using a straight edge to read the UTM coordinates for the bottom of the site (to the nearest metre, following the standard of two digits for the grid, six digits for the easting, and seven digits for the northing; see Appendix 1 for a discussion on UTM grid coordinates).

Note: be sure to record the observations in the correct format, for example, 50 seconds are recorded as 0.83.

3.2.3 Using a GIS

Many offices have access to a GIS and associated water flow and roads layers. Project managers will often identify the location of a site using a GIS and provide a map with the site location and coordinates to field crews. Crews must record new coordinates if the location differs from the coordinates provided. If no map or coordinates are provided, use a GIS to identify the site location when the crew returns from the field.

3.3 If the Site is Unsampleable

In these cases, the site may be inaccessible for a season, but may be revisited in subsequent years. If the conditions persist, making sampling permanently unsafe or ineffective, the site may then be considered unsampleable. Such data is useful for ensuring that these reaches are excluded from future sampling strategies and that these segments can be excluded from predictive modeling initiatives.

If the site is found to be unsampleable, check the box on page one of the Site Identification form, then indicate the reasons on the back side using the check boxes provided (Table 1). Additional information on the rationale may be included in the comments fields.

At least one photo should be taken of the site for future reference. In some cases, it will not be possible to assess the entire site (e.g., area is flooded, permission denied). In this situation, a photo should be taken from the road crossing or other safe location.

Complete the comments field with additional useful information. This may include but is not limited to weather conditions, landowner comments/observations.

Table 1: Criteria and definitions for Unsampleable sites.

UNSAMPLEABLE	REASON
Stream Dry or insufficient water to sample effectively	There is insufficient water to sample effectively. Water must be present and of sufficient depth and clarity to enable crews to sample > 90% of habitats safely, while in standard chest waders.
Steam is no longer at location	System has been tiled or relocated, etc.
Naturally unwadeable	System is too deep or fast to be sampled safely using chest waders.
Unwadeable due to ponding from a temporary barrier	E.g., Beaver dam, construction works, blocked culverts.
Unwadeable due to ponding from a permanent barrier	E.g., Dams, weirs or bedrock cause ponding that makes site too deep
Landowner could not be contacted	Landowner permission is required for access to all private property. Landowner could not or was not contacted to obtain permission
Landowner refused access	Landowner was contacted and refused access
Inaccessible for safety reasons	Crew felt their safety was at risk and chose not to access the site. Examples could include: poisonous plants, steep gradients, no safe parking, aggressive dogs, bulls, etc.
Stream is wadeable but not appropriate for sampling that was intended.	Site may be wadeable and sampleable by OSAP, but not a suitable site based on project objectives

3.4 Validating the Site Location

The most reliable process for validating site locations is to compare coordinates recorded on the data sheet to the locations in a GIS or on an OBM. If either of these were used to initially locate the site, it is recommended that the alternate technique be used during the validation process. This reduces reader error and the effects of drift. Drift refers to the error introduced into a GIS from overlaying maps of different resolution. The Flowing Waters Information System (FWIS) is operational for this purpose and correcting sites in this utility ensures the corrected locations are incorporated in the master database (see Section 6: OSAP Data Management) of the FWIS webpage (http://www.comap.ca\fwis) for further information.

3.5 Filling out the Site Identification Form

Complete each key field on the Site Identification form and as many of the additional fields as the study design dictates. Include a sketch of the site and if access by road is an issue, or not easily accessed via GIS mapping, include a second sketch to guide crews to the sample location by vehicle. The ‘Crew Leader’ should also be filled out on all data sheets to ensure that future users of the data have the opportunity to try to access surveyors memories of site conditions.

Record the photo number and description under “Comments”. It is a good practice to rename the files after downloading the pictures to correspond to the site name and description (e.g. streamcodesitenameLUP). Try to ensure no personal information or pictures of people appear in the photos.

Table 2 identifies **in bold** what must be recorded; in *italics* what should be recorded in each box and; an example form is provided in Appendix 2. Site access and description as well as the unsampleable information are not mandatory but are important pieces of information that surveyors should consider recording.

Table 2 - Guidelines for Filling out Site Identification Form

‘Stream Name’	Record as shown in the Master Stream Name Database (see S1.M1).
‘Stream Code (Unique Code)’	Enter appropriate three character code as per Master Stream Name Database (see S1.M1).
‘Site Code’	Assign appropriate code, descriptive of site location (see S1.M1).
‘Date’	Record as year/month/day
‘Alternate Site Code’	Any known site codes that have been previously used to describe a sample site.
‘Sample’	A sample event is one completion of the protocol, regardless of how many days it takes to finish it. A second sample would be a repeat assessment or a sample conducted in a different year.
‘Uncorrected UTM Coordinates’	For uncorrected UTM coordinates, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven).
‘Latitude’ and ‘Longitude’	As an alternative to the UTM coordinates, record the latitude and longitude of the site to the nearest decimal second (at minimum).
‘Corrected UTM Coordinates’	Once corrected, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven) in the ‘Uncorrected UTM coordinates’ boxes. Note decimal places can be added for eastings and northings.
‘Source of GIS Stream Layer’	The name of the GIS layer and its origin should be recorded to enable users to address drift issues during applications.
‘Source of Uncorrected	Record which method was used to obtain the uncorrected geocoordinates (i.e., FWIS, GPS unit, GIS, OBM or topographical map.

UTM Coord’	
‘Source of Corrected UTM Coordinates’	Record the source of corrected UTM coordinates (i.e. FWIS, Ortho-photos, GIS). If a GIS layer was used, please provide the name of the layer used for the correction.
‘Access Route’ and ‘Site Description’	Describe the access route taken to drive to the site, beginning at a major interchange or reference point. Include distances between turns in rural areas. Remember that the data will also be used to verify the location of the site on a GIS, so record distances, not just 911 addresses. Also describe the walking or access route from the parking location to the site in the site description field and provide landmarks for locating the site (see example in Appendix 2).
‘Unsampleable’	If the site is found to be unsampleable, check the box on page one and identify reasons on page two by selecting applicable option(s) and comment field.
‘Photo Name’	Record the file name of the photo if it is downloaded from a digital camera.
‘Photograph Description’	Describe the photograph taken so it can be accurately labelled when downloaded/developed.
‘Crew Leader’	First initial and last name of the crew leader.
‘Crew’	Initials of crew members.
‘Recorder’	Initials of the person entering the information on the sheet.
‘Date’	Record as year/month/day – include the slashes.
‘Comments’	Record any other relevant information here, such as the landowner’s name and phone number, special requests (i.e., wants to be contacted with results, etc.).

3.6 Tips for Applying this Module

Learn to identify giant hogweed, stinging nettles, water hemlock, and poison ivy.

On every data form, record the standard site identification data and the sample number.

Make sure that all fields have data recorded before leaving the site.

Finally, record any additional useful information in the 'Comments' field.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g., FWIS, or the MOE Portal), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca\fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to share provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

Appendix 1

Background on UTM Coordinates

The Universal Transverse Mercator (UTM) system was introduced to provide an accurate means of locating any position on the globe. The globe is divided into grids. Each grid square has a unique reference identifying its position on the globe. For example, Wilmot Creek is in grid square 10-17. Positions are identified relative to how far north or east they lie from established reference points.

UTM coordinates are often recorded to the nearest metre. However, maps such as the Ontario Base Maps (OBM) show the numbers in units of hundreds of metres. Users need to be aware of how obtaining data from different sources/scales affects the data quality. For example, a site located on the Ganaraska River was recorded from an OBM as having coordinates of 10-17-6548-48650, while a GPS recorded uncorrected UTM coordinates of 17-654608-4865735 (ignoring decimals). The reading from the OBM would require two zeros to be added to the easting and to the northing distances in order to make the distances comparable to the same units and to meet the standards for this module (i.e., 10-17-654800-4865000). Finally, correcting the site to the water flow layer may result in the following numbers (i.e., 10-17-654856.4592-4865126.87356). Clearly, less accurate coordinates emphasize the need for good quality descriptions and sketches.

Appendix 2

Example Site Identification Form

Site Identification

Stream Code	Site Code	Sample	Date (yyyy-mm-dd)
WM1	3CDW	01	2000 - 08 - 01

Stream Name	Alternate Site Code	Site Length (m)
WILMOT CREEK	LOMU 23	44.0

*** Record using NAD83 datum

	Zone	Easting	Northing
Uncorr. UTM	17	690485.1	4867500.0
Corr. UTM	17	690483.8	4867510.2

OR →

	DD	MM	SS.sss
Lat.			.
Long.			.

Source of Uncorrected UTM Coordinates

GPS/DGPS ☒
GIS ☐
OBM ☐
Other

Source of Corrected UTM Coordinates

FWIS ☒
Ortho-photos ☐
GIS ☐
Other

Name of Layer Used for Correction: NRVIS 4

Access Route

4TH CONCESSION, WEST OF HWY 35/115. PARK IN CONSERVATION AREA LOT

Site Description

TOP OF STATION IS APPROXIMATELY 70 M SOUTHEAST OF PARKING AREA. fOLLOW TRAIL ON WEST SIDE OF STREAM

☐ Site Was Unsampleable - add reason(s) on reverse

Sketches

Site/Access Route Sketch

Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Comments

Crew Leader (init. & last name)		Crew	Recorder	Entered	Verified	Corrected
I	KELSEY	CVD, MS,	CVD	AUG 24	AUG25	AUG25

Site Marker Details

UPSTREAM SITE MARKER
(measure from stake to site)

Bearing (D)

Distance (m) .

Description

DOWNSTREAM SITE MARKER
(measure from stake to site)

Bearing (D)

Distance (m) .

Description

ADDITIONAL SITE MARKER
(measure from stake to site)

Bearing (D)

Distance (m) .

Description

Photos

	Photo No.	Photo Name	Photo Description
Upstream			
Upstream			
Downstream			
Downstream			
Upstream			
Downstream			
Other Features			

Site is Unsampleable Reason(s)

☐ Stream dry

☐ Insufficient water to sample effectively

☐ Stream is no longer present at location (tiled or relocated, etc)

☐ Naturally unwadeable (i.e. > 1.5 m deep)

☐ Unwadeable due to ponding from a permanent barrier

What is the permanent barrier?

☐ Unwadeable due to ponding from temporary barrier (eg. beaver dam)

What is the temporary barrier?

☐ Landowner could not be contacted

☐ Landowner refused access

☐ Inaccessible for safety reasons (add details in comments below)

☐ Stream is wadeable but not appropriate for the intended sampling

Modules to have been used (e.g. S2.M1, S3.M1):

Comments

WELL BEATEN TRAIL AND LOTS OF FISHING LINE/DEBRIS ON BANKS. STINGING NETTLES

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 3

Detailed Site Documentation[1]

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APPENDICES

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

Many monitoring initiatives require that sites be revisited, often by different surveyors. Unfortunately, field crews cannot always locate exact site boundaries due to insufficient or erroneous information. This limits the ability to evaluate trends through time at a particular site.

This module describes a detailed approach for describing the site location such that field crews will be able to confidently return to the exact location on a stream where data have been collected and if desired track changes in the site boundaries over time. The information in this module can also be used to confirm site locations using Geographic Information Systems (GIS).

This module is applied in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and should be applied at any site where data suitable for long term monitoring could occur and especially where detailed Point Transect Sampling for Channel Structure, Substrate and Bank Conditions (S.4.M2) is applied.

2.0 PRE-FIELD ACTIVITIES

This module takes 10-30 minutes to complete. With a three-person crew, the most efficient procedure is to have one person fill out the forms while the other two measure and mark the site. Ensure you have land owner permission to apply whatever technique is agreed upon for creating or installing permanent station markers.

2.1 Equipment Checklist

The following equipment is required:

1. ‘Site Identification’ field form (ideally copied onto waterproof paper)
2. HB Pencils
3. Tape measure or hip chain
4. Compass
5. Camera

Optional equipment,

6. Site markers
7. Flagging tape
8. .Spray Paint

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

This module should be initiated during the first site visit. Boundary locations and distances from permanent site markers should be checked and recorded on each subsequent visit to the site.

3.1 Georeferencing the Site Location

3.1.1 Using a GPS

Obtain coordinates for the bottom of the site. When sufficient satellites have been received, the GPS will provide the UTM coordinates. Please record the UTM zone and coordinates using the NAD 83 datum. If the site is in a heavily forested area, is isolated from beacons, or is in a steep valley, the GPS unit may be unable to read enough satellites to obtain a position. This is a good reason to bring a copy of an appropriate web based map (e.g. Google Map or digital ortho-image) or an Ontario Base Map (OBM) with sufficient scale to correctly locate your site as a backup.

3.1.2 Using a Map

Obtain a copy of a web based or georeferenced map that includes the location of the site. Locate the site on the map and then use this detail to determine the site coordinates using a GIS in the office. If using an OBM the site coordinates can be obtained from the map using a straight edge to read the UTM coordinates for the bottom of the site (to the nearest metre, following the standard of two digits for the grid, six digits for the easting, and seven digits for the northing (see Appendix 1 for a discussion on UTM grid coordinates)).

Note: be sure to record the observations in the correct format. For example, 48^{o} 24’ 50” should be recorded as 48^{o}24’.83” (50/60=0.83).

3.1.3 Using a GIS

Many offices have access to a GIS and associated water flow and roads layers. Project managers will often identify the location of a site using a GIS and provide a map with the site location and coordinates to field crews. Crews must record new coordinates if the location differs from the coordinates provided. If no map or coordinates are provided, use a GIS to identify the site location when the crew returns from the field.

3.2 Validating the Site Location

The most reliable process for validating site locations is to compare coordinates recorded on the data sheet to the locations in a GIS or on an OBM. If either of these were used to initially locate the site, it is recommended that the alternate technique be used during the validation process.

This reduces reader error and the effects of drift. Drift refers to the error introduced into a GIS from overlaying maps of different resolution. The Flowing Waters Information System (FWIS) is operational for this purpose and correcting sites in this utility ensures the corrected locations are incorporated in the master database (see Section 6: OSAP Data Management) for more details on this and or refer to the FWIS webpage (http://www.comap.ca\fwis).

3.3 Filling Out the ‘Site Identification’ Form

Complete page one and page two of the Site Identification form and ensure that each box from the ‘Stream Name’ down to and including the ‘Site Description and Access Route’ is filled out. Include a sketch of the site and if access by road is an issue, or not easily accessed via GIS mapping, include a second sketch to guide crews to the sample location by vehicle. The ‘Crew Leader’ and ‘Date’ must also be filled out on all data sheets.

Table 1 identifies **in bold** what must be recorded and in *italics* what should be recorded in each box and an example form is provided in Appendix 2.

3.4 Site Markers

3.4.1 Marking the Site for Future Reference

Clearly document the site location so that it can easily be relocated. The best option for permanently marking a site is to use existing structures such as: fence lines, healthy “distinct” trees or corners of buildings as reference points. If trees are used, be sure to select only trees that can be easily distinguished by field crews, e.g., a lone large maple tree in a pasture or the only hemlock tree in the riparian zone. Do not choose one white cedar in a cedar forest! Alternatives include:

- rebar placed well into the ground beside a tree or other objects
- spray-painted metal survey stakes that are driven into the ground
- coloured metal tree tags driven into a tree (ensure that enough space is left for the tree to grow) or
- spray paint on trees or large boulders (appropriate as short-term markers i.e., annual)

Flagging tape can also increase site visibility in the short term. It should be tied to a marker and the site name and date should be written on the flagging tape.

Important Terms for Describing the Site

When describing a site, make sure that the following terms are used consistently and correctly: top, bottom, left and right. The upstream end of a site is the top; the downstream end is the bottom. Left and right are defined when standing in the water and facing upstream.

Table 1: Guidelines for Filling out the Site Identification Form

Data Required	Instructions
‘Stream Name’	Record as shown in the Master Stream Name Database (see S1.M1).
‘Stream Code (Unique Code)’	Enter appropriate three character code as per Master Stream Name Database (see S1.M1).
‘Site Code’	Assign appropriate code, descriptive of site location (see S1.M1).
‘Alternate Site code’	Any known site codes that have been previously used to describe a sample site.
‘Date’	Record as year/month/day.
‘Sample’	A sample event is one completion of the protocol, regardless of how many days it takes to finish it. A second sample would be a repeat assessment or a sample conducted in a different year.
‘Uncorrected UTM Coordinates’	For uncorrected UTM coordinates, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven).
‘Latitude’ and ‘Longitude’	As an alternative to the UTM coordinates, record the latitude and longitude of the site to the nearest decimal second (at minimum)
‘Corrected UTM Coordinates’	Once corrected, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven) in the ‘Uncorrected UTM coordinates’ boxes. Note decimal places can be added for eastings and northings
‘Name of Layer Used for Correction’	The name of the GIS layer and its origin should be recorded to enable users to address drift issues during applications.
‘Source of Uncorrected UTM Coord’	Record which method was used to obtain the uncorrected geocoordinates (i.e., GPS unit, GIS, OBM or topographical map.
‘Source of Corrected UTM Coordinates’	Record the source of corrected UTM coordinates (i.e. FWIS, Ortho-photos, GIS). If a GIS layer was used, please provide the name of the layer used for the correction.
‘Access Route’	Describe the route taken to the site, beginning at a major interchange or reference point. Include distances between turns in rural areas. Remember that the data will also be used to verify the location of the site on a GIS, so record distances, not just 911 addresses.
‘Site Description’	Describe the walking route from the parking location to the site and provide a detailed description of landmarks for locating the site (see example in Appendix 2).
‘Unsampleable’	If the site is found to be unsampleable, check the box on page one and identify reasons on page two by selecting applicable option(s) and comment field.
‘Site Marker Description‘	Record the type(s) of markers used, locations, compass bearings, and distances (to the nearest 0.1 m) from the top and bottom of the site.
‘Photo No.’	Record the number of any photographs taken.
‘Photo Name’	Record the file name of the photo if it is downloaded from a digital camera.
‘Photograph Description’	Describe the photograph taken so it can be accurately labelled when downloaded/developed.
‘Crew Leader’	First initial and last name of the crew leader.
‘Crew’	Record the initials of all crew members.
‘Recorder’	Initials of the person entering the information on the sheet.
‘Comments’	Record any other relevant information here, such as the landowner’s name and phone number, special requests (i.e., wants to be contacted with results, etc.).
‘Site Length’	Record (to the nearest metre) the longitudinal length of the site as measured down the centre of the stream. Not required for modules which are not applied on a geomorphic unit.

Ask the landowner’s permission prior to putting in any permanent site markers. Some landowners would prefer that the markers be out of sight (i.e., at ground level or below). In these instances, the location should be clearly noted on the Site Identification form.

Detailed Site Documentation

Removed version 9 site feature documentation April 2017

Markers should be placed at the top and bottom of every site (i.e., ‘Upstream Marker’ and ‘Downstream Marker’), above the high water mark on the bank associated with deposition (i.e., the convex bank). Measure the ‘Distance (m.)’ to the nearest 0.1 m from the marker to the edge of the water (for the closest bank that marks the bottom or top of the site). Record the side of the stream (left or right) and the compass bearing (‘Bearing (Degrees)’) from the marker to the bottom or top of the site (i.e., 10.2 m on a 272° bearing to the bottom right bank of the site).

Include the marker locations on the sketch of the site (see Section 3.2, ‘Making a Site Sketch’). Changing the location of the permanent site markers on subsequent visits should be avoided because these markers are used for monitoring channel movement. If a permanent marker must be moved, the location of the new marker (relative to the old one) should be recorded in the ‘Comments’ section of the field sheet and on the sketch.

Attach a labeled photograph (citing the site location and date of visit) to the Site Identification form. This photograph should be taken looking upstream from the bottom of the site. Additional photographs showing site features should also be taken (see Appendix 2, Example Site Identification Form). Record the photograph numbers on the form, and describe what they show[2]. The use of digital cameras or scanned pictures provides a permanent electronic image of the site.

3.4.2 Changing Site Markers at an Existing Site

Occasionally a site marker must be moved or is lost due to changes in the stream or surrounding environment (e.g. due to erosion or development).

If a site marker must be moved, complete a new Site Identification form and re-establish markers following the instructions provided above. Provide a distance measurement and compass bearing from the old location to the new marker and note the reason for relocation.

If a site marker is lost, locate the site to the best of your ability based on historical site identification information, remaining markers, and photographs (if available). Once the site is located re-establish markers following the instructions provided above. Note that the previous marker (or markers) has been lost in the comments field and whether the crew was able to “tie-in” the two stations or not.

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[2] One option is to record the site code and orientation of the photo (e.g., bottom of site facing upstream) onto either a piece of paper or a chalk board and include this in the photo.

3.5 Making a Site Sketch

Include a sketch of the site and if access by road is an issue, or not easily accessed via GIS mapping, include a second sketch to guide crews to the sample location by vehicle (see Appendix 3).

This sketch must include the following information:

- ‘Site Name’
- ‘Stream Code’
- ‘Site Code’
- ‘Date (yyyy/mm/dd)’ surveyed
- site boundaries
- location of site markers
- adjacent landscape features and land uses
- boundaries of vegetation types
- location of any buildings or fence lines
- route used to access the site
- direction of water flow
- a north arrow and relative scale

3.6 Tips for Applying this Module

Site markers should be painted before going into the field.

Make up cue cards that include the site name and orientation of where the photo will be taken in relation to the site (e.g., bottom site 3CDW looking up). These can then be held or placed in each photo to prevent site misidentifications.

Be clear and consistent with the words used to describe locations; use the convention for top, bottom, left and right. Words like close, far, large, small, etc., are ambiguous and confusing.

When describing a site, make sure that the following terms are used consistently and correctly: top, bottom, left and right. The upstream end of a site is the top; the downstream end is the bottom. **Left and right are defined when standing in the water and facing upstream.**

Make sure that road crossings and access points are clearly and accurately labeled on the site location sketch.

Following completion of the survey, always check over field sheets for completeness, particularly for the UTM coordinates on the ‘Site Identification’ form. In addition, have someone else review the field forms and **critically** assess them for clarity and completeness.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g., FWIS, or the MOE portal), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca\fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

Appendix 1

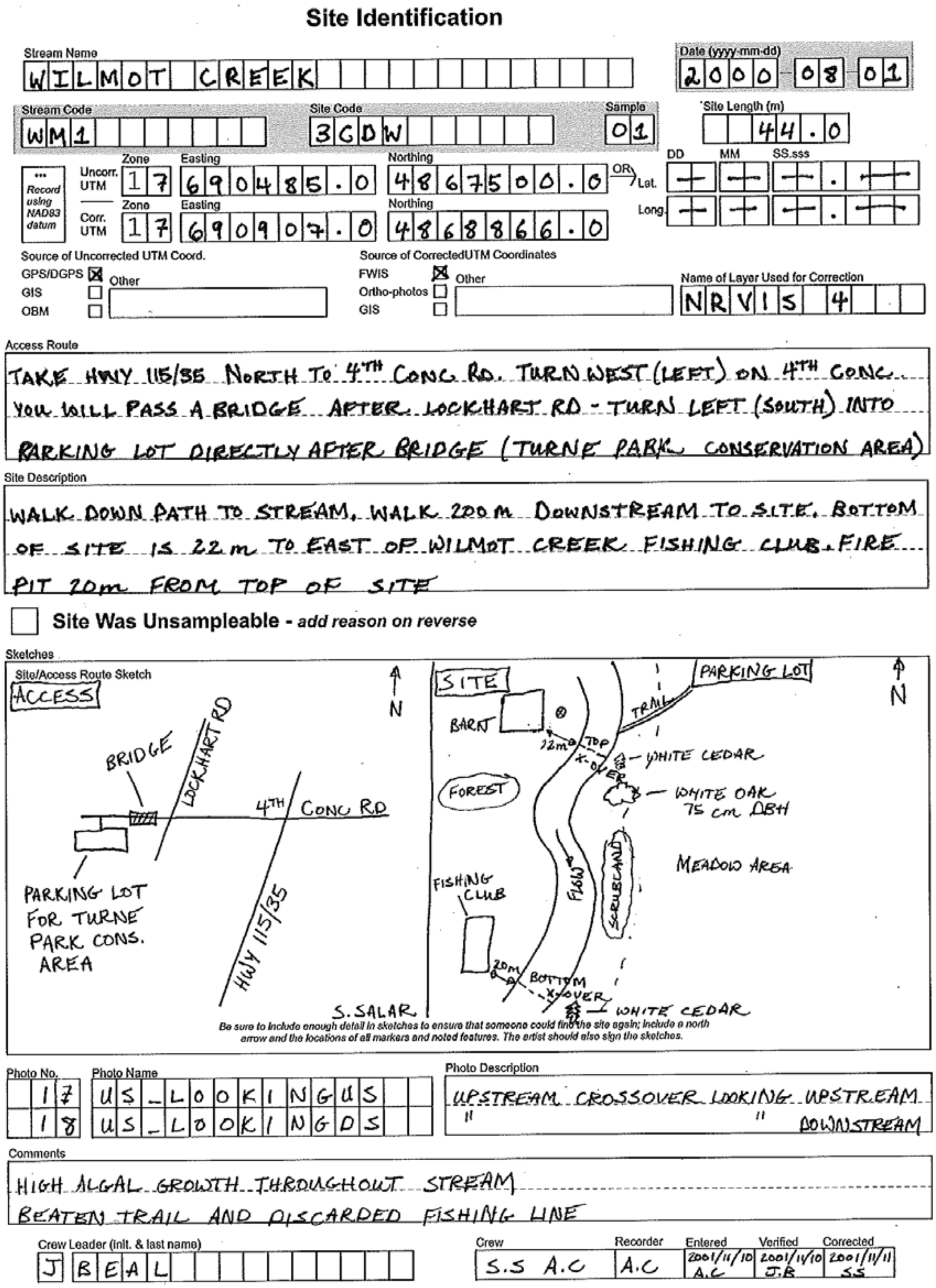
Background on UTM Coordinates

The Universal Transverse Mercator (UTM) system was introduced to provide an accurate means of locating any position on the globe. The globe is divided into grids. Each grid square has a unique reference identifying its position on the globe. For example, Wilmot Creek is in grid square 10-17. Positions are identified relative to how far north or east they lie from established reference points.

UTM coordinates are often recorded to the nearest metre. However, maps such as the Ontario Base Maps (OBM) show the numbers in units of hundreds of metres. Users need to be aware of how obtaining data from different sources/scales affects the data quality. For example, a site located on the Ganaraska River was recorded from an OBM as having coordinates of 10-17-6548-48650, while a GPS recorded uncorrected UTM coordinates of 17-654608-4865735 (ignoring decimals). The reading from the OBM would require two zeros to be added to the easting and to the northing distances in order to make the distances comparable to the same units and to meet the standards for this module (i.e., 10-17-654800-4865000). Finally, correcting the site to the water flow layer may result in the following numbers (i.e., 10-17-654856.4592-4865126.87356). Clearly, less accurate coordinates emphasize the need for good quality descriptions and sketches.

Appendix 2

Example Site Identification Form



Site Identification

Stream Name: WILMOT CREEK

Date (yyyy-mm-dd): 2000-08-01

Stream Code: WM1

Site Code: 3GDW

Sample: 01

Site Length (m): 44.0

*** Record using NAD83 datum

	Zone	Easting	Northing
Uncorr. UTM	17	690485.0	4867500.0
Corr. UTM	17	690907.0	4868866.0

OR Lat. DD MM SS.sss

Long.

Source of Uncorrected UTM Coord.: GPS/DGPS ☒ GIS ☐ OBM ☐ Other

Source of CorrectedUTM Coordinates: FWIS ☒ Ortho-photos ☐ GIS ☐ Other

Name of Layer Used for Correction: NRVIS 4

Access Route

TAKE HWY 115/35 NORTH TO 4TH CONC RD. TURN WEST (LEFT) ON 4TH CONC. YOU WILL PASS A BRIDGE AFTER LOCKHART RD - TURN LEFT (SOUTH) INTO PARKING LOT DIRECTLY AFTER BRIDGE (TURNE PARK CONSERVATION AREA)

Site Description

WALK DOWN PATH TO STREAM. WALK 200m DOWNSTREAM TO SITE. BOTTOM OF SITE IS 22m TO EAST OF WILMOT CREEK FISHING CLUB. FIRE PIT 20m FROM TOP OF SITE

☐ **Site Was Unsampleable** - *add reason on reverse*

Sketches

Site/Access Route Sketch

Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Photo No.	Photo Name	Photo Description
17	US_LOOKINGUS	UPSTREAM CROSSOVER LOOKING UPSTREAM
18	US_LOOKINGDS	" " DOWNSTREAM

Comments

HIGH ALGAL GROWTH THROUGHOUT STREAM

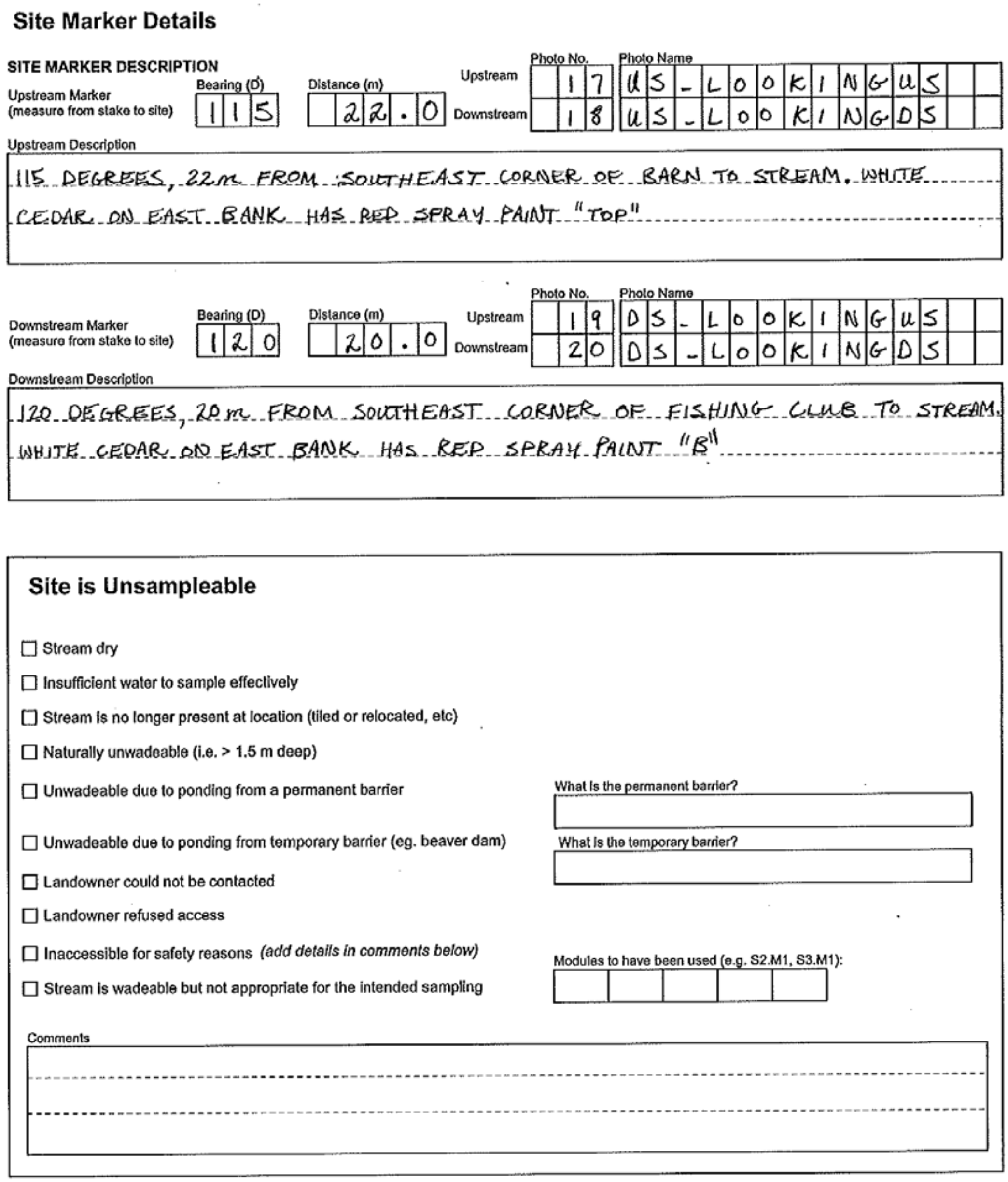
BEATEN TRAIL AND DISCARDED FISHING LINE

Crew Leader (init. & last name): J BEAL

Crew	Recorder	Entered	Verified	Corrected
S.S A.C	A.C	2001/11/10 A.C	2001/11/10 J.B	2001/11/11 S.S

Detailed Site Documentation

Removed version 9 site feature documentation April 2017



Site Marker Details

SITE MARKER DESCRIPTION

Upstream Marker (measure from stake to site)

Bearing (D)	Distance (m)		Photo No.	Photo Name
115	22.0	Upstream	17	US-LOOKINGUS
		Downstream	18	US-LOOKINGDS

Upstream Description

115 DEGREES, 22m FROM SOUTHEAST CORNER OF BARN TO STREAM. WHITE CEDAR ON EAST BANK HAS RED SPRAY PAINT "TOP"

Downstream Marker (measure from stake to site)

Bearing (D)	Distance (m)		Photo No.	Photo Name
120	20.0	Upstream	19	DS-LOOKINGUS
		Downstream	20	DS-LOOKINGDS

Downstream Description

120 DEGREES, 20m FROM SOUTHEAST CORNER OF FISHING CLUB TO STREAM. WHITE CEDAR ON EAST BANK HAS RED SPRAY PAINT "B"

Site is Unsampleable

☐ Stream dry

☐ Insufficient water to sample effectively

☐ Stream is no longer present at location (tiled or relocated, etc)

☐ Naturally unwadeable (i.e. > 1.5 m deep)

☐ Unwadeable due to ponding from a permanent barrier

What is the permanent barrier?

☐ Unwadeable due to ponding from temporary barrier (eg. beaver dam)

What is the temporary barrier?

☐ Landowner could not be contacted

☐ Landowner refused access

☐ Inaccessible for safety reasons *(add details in comments below)*

☐ Stream is wadeable but not appropriate for the intended sampling

Modules to have been used (e.g. S2.M1, S3.M1):

Comments

Detailed Site Documentation
Removed version 9 site feature documentation April 2017

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 4

Site Feature Documentation[1]

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APPENDICES

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes an approach for collecting information that might help to explain the biophysical condition of a site, such as surrounding land uses (current and historical) and unique features, are provided.

The information collected in this module reflects the effort by field crews and their diligence at researching historical information. Project managers must inform crew members how much effort should be applied to this portion of the survey. The procedures described in this module provide a qualitative description of the current and historical land uses that may influence a site.

This module is applied in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and is designed to be complementary to the Restoration Opportunities and Documentation Module (S1.M7). Temperature data collected using S5.M1 can be recorded on the field sheet of this module.

2.0 PRE-FIELD ACTIVITIES

This module takes 10-30 minutes to complete (depending on how much effort is used to document the landscape features). It is best applied by site description is being recorded and then updated as features are observed during the survey day. Equipment Checklist
The following equipment is required:

1. 'Site Features' field forms (ideally copied onto waterproof paper)
2. HB Pencils

Optional Equipment:
3. Camera
4. GPS

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone, etc.).

3.0 FIELD PROCEDURES

This module should be initiated during the first site visit and repeated or updated on any subsequent visits. Georeferencing the Site Location

3.1 Filling Out the 'Site Features' Form

3.1.1 Identifying the Site Features

For each site feature or land use activity listed on the 'Site Features' form (Appendix 3), record one of the following evidence categories (Table 1) by marking the appropriate code in the appropriate box.

Table 1: Evidence Categories for Site Features Identified at a Sampling Site

Code	Evidence Category	Description
1	'Ongoing and Active'	there is evidence of the feature at the time of the site visit
2	'Historical Evidence'	there are signs that the activity has occurred in the past
3	'No Evidence but Reported'	it has been historically reported, but no obvious physical signs exist
4	'No Evidence'	there is no current or historical evidence of this activity
5	'Unknown'	the feature has not been sufficiently evaluated.

In the 'Comments' field, describe the features and land uses observed. Table 2 lists some indicators for each feature. If the activity is not present, mark the 'No Evidence' box, otherwise it will be assumed that the site was not assessed for this activity. Other features observed near the site should be documented in the 'Comments' field at the bottom of the page.

Table 2: Definitions of Site Feature Attributes

Site feature	Diagnostic Indicators
‘Potential Point or Non-point Contaminant Sources’	Look for outlets from storm sewers, tile drains, or industrial discharge pipes. Note any obvious signs of discharge at the site (odour, staining, sheen, etc.).
‘Major Nutrient Sources Upstream’	Algal blooms or dense growth of aquatic macrophytes are indicators of upstream nutrient sources. If present, look for potential sources such as sewage treatment plants, processing plants, intensive agricultural operations (e.g. chicken ranches, livestock, feed lots) upstream of the site.
‘Channel Hardening or Straightening’	Hardening is indicated by rip-rap or gabion baskets. Straightened channels will often have dredged material piled adjacent to the stream, or will be atypically straight relative to the valley gradient.
‘Adjacent Land uses That Destabilize Banks’	This refers to unrestricted access (cattle, horses, humans, etc.) to banks, cutting or trampling of riparian vegetation.
‘Sediment Loading or Deprivation’	Evidence of sediment loading: mid channel bars; extended point bars around bends; pools filled with fines; sand dunes in shallow areas. Sediment deprivation can result in either hardening of the streambed (e.g. in high calcium areas), or boulders stacked like dominoes, (imbrication) where there are not enough cementing materials to hold larger particles in place.
‘Instream Habitat Modifications’	Debris or material removal, dam construction, habitat enhancement (lunker structures etc.).
‘Barriers and Dams in the Vicinity of the Site’	Often visible from roads or air photos; historical evidence includes elevated floodplains with an atypically flat gradient throughout the reach. There may also be evidence along the banks (e.g. elevated culverts, fallen timbers or old bridges that have been buried).
‘High Fishing Pressure’	Heavily packed trails, fishing debris, garbage, etc.
‘Log Jam Deflectors’	Fallen trees and/or woodpiles large enough to force water against the bank and cause lateral erosion. Record the number of occurrences within the site.
‘Springs or Seeps at the Site’	Abundant watercress in the stream; differences in stream temperature between sections (record temperatures in comments); a rust-coloured deposit on sediments surrounding the groundwater discharge zones in areas with high mineral content.
‘Impervious Substrate Limiting Burrowing Depth of Fish’	Exposed bedrock or hardpan (clay) within the site boundaries.
‘Fish Stocked Near Site’	Personal knowledge or anecdotal evidence such as the capture of fish with hatchery markings. Information is available from Ministry of Natural Resources.
Logging Activities	Intensive logging activities such as road construction, vegetation removal, clear cutting, ruts and other damage from machinery use that cause permanent ruts.
‘Other Activities	Any other features not already covered that could Influence biota or habitat.

3.1.2 Documenting Information Sources

Record the information sources used to collect this data, by marking an 'X' in the appropriate box, as defined in Table 3 below. 'Visual Immediate' observations are mandatory when conducting a survey.

Table 3 - Sources of Information for data collected on Site Features

Information Source	Definition
'Visual Immediate'	Observed within 50 m of the site.
'Visual Extended'	Observed beyond 50 m of the site.
'Interview'	Discussion with someone familiar with the land use history of the site (e.g. landowner).
'Maps/Photos'	Air photos or maps of the area (current and historical).

3.1.3 Recording the Riparian Vegetation Communities

Visually examine the vegetation communities occurring along each bank of the stream. Divide the bank into three zones based on distance from the water as follows: 1.5 to 10 m, 10 to 30 m, and 30 to 100 m. This can be done visually (where obvious) or by measuring the distance to zone boundaries. For each zone on each bank, record the dominant type of vegetation based on canopy cover (Table 4) by marking an 'X' in the appropriate box. Record the right and left bank separately.

When the majority of a zone is covered by one vegetation community, this community type is dominant. If it is not obvious which type is dominant, measure the area (total length and width) of each type, to sort out conflicts. Note that the classification is hierarchical, ensuring that all riparian zones meet one criterion only.

Table 4 - Types of Vegetative Communities

Vegetative Community	Description
'None'	Over 75% of the soil has no vegetation.
'Lawn'	Grasses that are not allowed to reach a mature state due to mowing.
'Cropped Land'	Planted in agricultural crops in most years; plants typically arranged in rows (due to machine-planting); may be subject to periodic tillage.
'Meadow'	< 25% tree/shrub cover; characterized by grasses and forbs
'Scrubland'	> 25 and < 60% trees or shrubs interspersed with grasses and sedges (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height).
'Wetland'	Areas that are seasonally or permanently flooded and support vegetation adapted to wet conditions
'Forest'	> 60% of the canopy is covered by the crowns of trees.

3.2 Tips for Applying this Module

Talk to landowners, anglers, and local conservation officers about the site for more information.

Look for evidence of historical activities (i.e. garbage piles, foundations, fence lines, dredging mounds, tree stumps of similar age). Presence or absence of vegetation types can provide indicators of past land use (e.g. missing deciduous trees imply grazing, lack of wildflowers implies that row-crops or hay have been planted).

Following completion of the survey, always check over field sheets for completeness, particularly for the UTM coordinates on the 'Site Identification' form. In addition, have someone else review the field forms and **critically** assess them for clarity and completeness.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

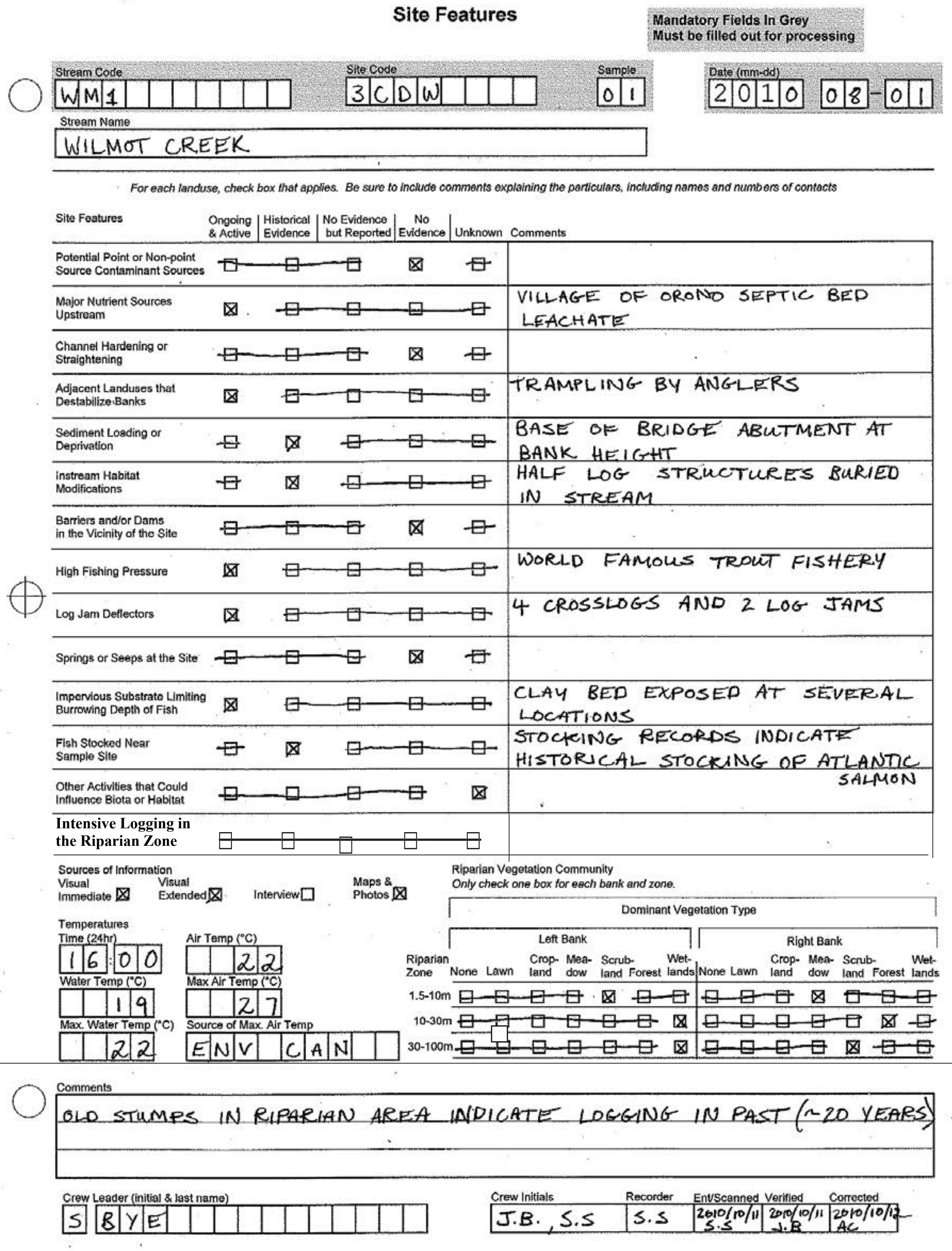
As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

Appendix 1

Example Site Features Field Form

It should be noted that this form may also be used to record temperature data (see S5, Water Temperature Assessment) and sample data of this type have been included in this example.



Site Features

Mandatory Fields In Grey
Must be filled out for processing

Stream Code: WM1
Site Code: 3CDW
Sample: 01
Date (mm-dd): 2010 08-01

Stream Name: WILMOT CREEK

For each landuse, check box that applies. Be sure to include comments explaining the particulars, including names and numbers of contacts

Site Features	Ongoing & Active	Historical Evidence	No Evidence but Reported	No Evidence	Unknown	Comments
Potential Point or Non-point Source Contaminant Sources	☐	☐	☐	☒	☐	
Major Nutrient Sources Upstream	☒	☐	☐	☐	☐	VILLAGE OF ORONO SEPTIC BED LEACHATE
Channel Hardening or Straightening	☐	☐	☐	☒	☐	
Adjacent Landuses that Destabilize Banks	☒	☐	☐	☐	☐	TRAMPLING BY ANGLERS
Sediment Loading or Deprivation	☐	☒	☐	☐	☐	BASE OF BRIDGE ABUTMENT AT BANK HEIGHT
Instream Habitat Modifications	☐	☒	☐	☐	☐	HALF LOG STRUCTURES BURIED IN STREAM
Barriers and/or Dams in the Vicinity of the Site	☐	☐	☐	☒	☐	
High Fishing Pressure	☒	☐	☐	☐	☐	WORLD FAMOUS TROUT FISHERY
Log Jam Deflectors	☒	☐	☐	☐	☐	4 CROSSLOGS AND 2 LOG JAMS
Springs or Seeps at the Site	☐	☐	☐	☒	☐	
Impervious Substrate Limiting Burrowing Depth of Fish	☒	☐	☐	☐	☐	CLAY BED EXPOSED AT SEVERAL LOCATIONS
Fish Stocked Near Sample Site	☐	☒	☐	☐	☐	STOCKING RECORDS INDICATE HISTORICAL STOCKING OF ATLANTIC SALMON
Other Activities that Could Influence Biota or Habitat	☐	☐	☐	☐	☒	
Intensive Logging in the Riparian Zone	☐	☐	☐	☐	☐	

Sources of Information
Visual Immediate ☒ Visual Extended ☒ Interview ☐ Maps & Photos ☒

Temperatures
Time (24hr): 16:00
Air Temp (°C): 22
Water Temp (°C): 19
Max Air Temp (°C): 27
Max. Water Temp (°C): 22
Source of Max. Air Temp: ENV CAN

Riparian Vegetation Community
Only check one box for each bank and zone.

Riparian Zone	Left Bank: None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands	Right Bank: None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands
1.5-10m	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐
30-100m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☒	☐	☐

Comments
OLD STUMPS IN RIPARIAN AREA INDICATE LOGGING IN PAST (~20 YEARS)

Crew Leader (initial & last name): S BYE

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected
J.B. , S.S	S.S	2010/10/11 S.S	2010/10/11 J.B	2010/10/12 AC

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 5

Restoration Activity and Issue Documentation[1]

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[1] Author: D. Forder and L. Stanfield

1.0INTRODUCTION

This module provides the opportunity for surveyors to document where and what types of restoration activities have been completed and where issues remain that could be addressed by restoration techniques. It is hoped that this module will help address a major gap in our collective understanding of the value and effect of restoration activities on streams and where such activities will be most beneficial. This module builds on earlier initiatives by the Ministry of Natural Resources (and now Forestry) that created the Stewardship Tracking System and the Redside Dace Restoration Opportunities database.

This module must be carried out in conjunction with one of the Site Identification options (S1.M2 or S1.M3). This is a rapid assessment module that is applied within the general boundaries of an OSAP site and its riparian corridor, but that can extend beyond the boundaries (see Recording Activity length below). This module complements the Site Feature Documentation module (S1.M4), providing more detail on the types of activities observed during that survey. This module also provides a means to document significant issues that could be addressed by restoration activities to support both spatial pattern analysis and prioritization of future projects. Users are encouraged to provide information about detailed reports or engineering diagrams in the comments fields and the metadata records for each project where appropriate.

In this module. a restoration category represents a suite of techniques that are designed to address a specific structural, pathways or processes important to river ecology. The techniques listed lump a number of specific methods used to address the issues identified within the restoration category. For example, the issue of fish passage/barrier mitigation can be addressed by the use of a bypass channel. Significant issues are defined as those that are likely limiting the ecological condition of a site in a measureable way2, or that are causing off-site impacts.

Although a background in restoration may be a benefit in completing this module, it is not a prerequisite. What is required is a keen eye to identify restoration activities and/or and some knowledge of river ecology. If you are interested in learning more about stream restoration or restoration techniques, both the Trout Unlimited Canada’s “Stream Rehabilitation Training Course”3 and Ontario Streams’ Online “Ontario Stream Rehabilitation Manual”4 are excellent sources for learning the science and best practices for this type of work.

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[2] Measureable implies that an ecological metric such as fish or benthos communities, habitat complexity or geomorphic stability would be quantitatively improved if an issue is addressed.

[3] http://tucanada.org/stream-rehabilitation-from-form-to-function-a-training-course/

[4] http://www.ontariostreams.on.ca/rehabilitation%20_manual.html

2.0 PRE-FIELD ACTIVITIES

It will typically only take 3 – 5 minutes to document each restoration activity and whether significant issues are present at a site. For safety purposes, we advise a two person crew be employed.

Pre-field activities should include:

- Landowner contact,
- Documentation of site access and appropriate stream identifiers (see Section 1, Site Identification and Documentation), and
- Equipment check.

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

3.0 INFORMATION COLLECTION

This module is designed to be completed concurrently with other modules as opportunities arise. It can also be applied as part of a more coordinated and extensive survey to identify both issues and existing activities along corridors. Finally, much historical restoration work is documented in reports. Another option for applying this module and thereby making this information available in a spatial database is to review reports and transfer the information to this field sheet and the database. Mark an X in the appropriate source of information box to indicate whether a 'Field Visit' or 'Office' exercise provided the data for each field sheet and if there is a report, record this in the 'reference' field.

Record the Site Identification data ('Stream Name', 'Stream Code', 'Site Code') and the date the information is collected at the top of the Restoration Activity and Issue Documentation Field Form.

3.1 Restoration Documentation

While conducting OSAP work, record any restoration activities or significant issues your crew observes. Since these activities and issues may be present anywhere within the stream or the riparian corridor, it is recommended that crews take some time to walk as far as 100 meters from the site into the riparian zone. Another source of information will be an interview with long term residents and local authorities from the area.

Record any issues you observe by marking an X in the appropriate issue box and any restoration techniques in the closest match following the definitions provided in Table 1. Where activities have been carried out that have not effectively addressed the issue, boxes may be marked in both columns and it is possible to have more than more technique used at a site. In each instance, provide any additional information in the comments field. Take and record photos of any restoration activities and issues that are observed, ensuring to record both the photo number on the camera and the name and description that this will be changed to in the database.

In each section below, the issue is described and a list of the restoration techniques are provided. Details are available in Table 1.

3.1.1 Fish Passage Barrier

Barriers can impede the movement of fish upstream or downstream. These barriers can include human made structures (e.g., dams, perched culverts), thermal barriers (e.g., online storm water ponds in coldwater streams), or other alterations (e.g., loss of the thalweg of the watercourse). A variety of activities can be used to mitigate these barriers including:

- Rocky ramp/Vortex weir,
- Bypass channel,
- Fishway,
- Dam removal, and
- Online pond removal.

3.1.2 Erosion

Some erosion is part of the natural cycle of a river, however, with development and altered hydrology bank erosion can be elevated to the point where it compromises habitat and also infrastructure. Distinguishing normal erosion rates from excessive may require special training. So, for this attribute, surveyors should only identify erosion issues where there is the potentiation for large amounts of sediment to enter the stream. Large, of course, is relative to the size of the channel, but will generally mean that this material has the potential to cover 10% of the stream bed. Additionally, record the location of any erosional area that is threatening infrastructure such as a bridge, pipeline, or building. Types of bank stabilization techniques likely to be encountered or recommended for use include:

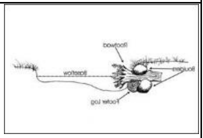
- Live fascines,
- Gabion baskets
- Tree revetments,
- Rootwads,
- Crib walls,
- Live staking,
- Riprap,
- Bank grading, and
- Concrete.

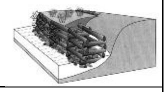
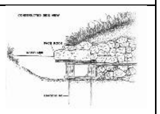
3.1.3 Instream Habitat

Instream Habitat varies across systems and can be impacted by many activities. Evidence of issues with instream habitat include: homogenous depth and or velocity, low amounts of cover, lack of or too much vegetation and lack of shade. Instream habitat restoration has been a cornerstone of stream ecology for many years and the common techniques that have been applied include:

- Spawning bed creation,
- Boulder placement,
- Half log cover,
- Woody material placement,
- Lunker structures,
- Log jam removal for flood control, and
- Debris removal.

Table 1: Descriptions of Restoration Techniques.

Issue Category	Restoration Technique	Description
Fish Barrier	Rocky ramp/Vortex weir	A grade control structure consisting of boulders that creates a back water behind it and fish can pass between the boulders.
	Bypass channel	A channel built on the side of a river to provide a lower gradient and longer distance that enables non-jumping fish to bypass a barrier.
	Fishway	Located within the stream of varying design to allow fish passage over barrier. Typically designed for some species but not all, for example jumping fish.
	Dam removal,	Removal of a dam, including beaver dams.
	Online pond removal	Any technique that disconnects an online pond from a stream.
Erosion	Live fascines	A rope-shaped bundle of **live** cuttings, lashed together with twine.
	Gabion	A wirework container filled with rock, broken concrete, or other material.
	Tree revetments	Anchored (either burial or cables) **trees** within a stream bank.
	Rootwads	Placement of the lower trunk and root fan of a large tree into a stream bank, often in conjunction with a support log that is buried into the stream bed, parallel to the bank. 

Issue Category	Restoration Technique	Description
Erosion	Crib walls	Logs or timbers built in a log cabin style that are anchored into a stream bank and filled with materials, usually riprap. 
	Live staking	The insertion of live, vegetative cuttings into stream banks. Look for regularly spaced or even aged vegetation
	Riprap,	Coarse rock material, usually of irregular angles placed on stream banks.
	Bank grading	Reduction of bank angle through the use of earth moving equipment, often done in conjunction with other techniques to reduce erosion risk.
	Concrete/steel	Short term armouring of stream banks with concrete or steel.
Instream Habitat Improvement	Spawning bed creation/ improvement	Placement or cleaning of substrate, and or enhancement of upwelling areas using perforated pipes to improve spawning success of fish.
	Boulder placement	Increasing the roughness of channels by the placement of large boulders.
	Half log cover	Increasing overhead cover by anchoring (usually rebar) of split cedar logs into streams, typically parallel with current and above the stream bed.
	Woody material placement	Strategic placement of logs, trees and brush piles on outside bends of streams to create overhead cover and or direct low flows to create scours.
	Lunker structures	Log structure that creates an undercut bank. Soil and vegetation are placed on top of the structure to create semi natural riparian conditions. 
	Log jam removal for flood control	Removal of some or all of a large log jam to address flooding or riparian zone damage. Ideally much of the wood would be redistributed in lower density.
	Debris removal	Removal of an overabundance of slash, twigs and other small wood material that is preventing sediment transport or causing channel widening.
Riparian Habitat Improvement	Riparian planting	Planting of vegetation anywhere within the riparian zone but typically in the phreatic area (active are of water mixing).
	Livestock fencing	Fencing of any type to remove cattle or horses from waterbodies.
	Tile drain rerouting	Rerouting of flows from a tile outlet from a stream to somewhere outside the active channel such that flows must pass through a berm or wetland prior to entering the stream.
	Garbage removal	Removal of garbage, including from relic dumps, from the site.

Issue Category	Restoration Technique	Description
	Invasive species control.	Successful efforts to remove invasive species. Provide names of the species removed in the comments section.
Channel Morphology	Meander enhancements	Activities usually utilizing heavy equipment that enlarges/reroutes meander patterns.
	Riffle-pool creation	Using heavy equipment to create distinct crests and troughs that create riffles and pools.
	Rock weir vortexes	A specific type of riffle pool creation that places rock or bolder materials at the crest of slope that increases local roughness, generates a riffle and encourages scouring downstream to create a pool. It does not generally require grade changes along an entire segment.
Channel Morphology	Flood plain enhancements	Lowering of bank heights or increasing depth of the stream bed to enable the watercourse to access to the flood plain.
	Wetland creation	Trapping or redirection of some water to facilitate the creation of a wetland.
	Creation of backwater and side channel habitats	Redirection of high water flows or use of heavy equipment to create a backwater or side channel area.
Storm Water and online Pond Issue Management	Bottom Draw	Installment of a bottom draw to deliver cooler water to the stream.
	Wetland creation	Enhancement in the pond or the outlet.
	Infiltration trenches	A low impact development technique to reduce runoff volume and improve water quality.
	Dredging	Dredging of a SWM pond to increase capacity and coupled with bottom draw to reduce temperatures.
	Vegetation Planting	Tree/vegetation planting for shade.
	Outlet naturalization	Creation of riffles and pools to aerate and cool water.
	Improved Access	Improving or restricting access by biota, depending on the situation.
	Water Quality	Other changes to existing ponds that improve water quality (e.g. sediment trap) or quantity reaching a stream.

3.1.4 Riparian Habitat

Riparian Habitat should include natural vegetation and wetlands although the age and structure of the habitat will vary considerably. Issues in the riparian zone include disconnecting the stream from riparian areas or wetlands or removing natural/indigenous vegetation. Riparian restoration techniques are variable depending on whether they target the hydrologic and water quality pathways, or shade and nutrient/allochthonous material pathways. These techniques can include:

- Riparian planting,
- Livestock fencing,
- Tile drain rerouting
- Garbage removal, and
- Invasive species control.

3.1.5 Channel Morphology

Many morphology includes the form and function of the stream channel. Issues with channel morphology include those that alter the meander pattern, riffle-pool condition, sediment and substrate composition and gradient. Evidence that there is an issue with channel morphology will generally be an imbalance in sediment (too much of one category of substrate) or too much erosion indicating the hydrology or gradient is disturbed. Natural channel design processes are often used to rectify issues of channel morphology. These techniques fundamentally address the geomorphic characteristics of sediment and water transport and include:

- meander enhancements,
- Stream grade improvements,
- rock weir vortexes,
- Flood plain enhancements,
- Wetland creation, and
- Creation of backwater and side channel habitats.

Other activities might include daylighting streams or expanding flood plain.

3.1.6 Storm Water and On-Line Pond Retrofit

There are many techniques that are used to reduce impacts from and improve habitat within stormwater and on-line ponds. Some techniques that are routinely used are:

- Addition of bottom draws,
- Wetland creation/enhancement,
- Infiltration trenches,
- Dredging,
- Tree/vegetation planting,
- Outlet naturalization to aerate and cool water,
- Improving or restricting access by biota, and
- Other changes.

3.1.7 Other

List any other issue and or restoration technique observed but not listed above.

3.2 Project Metadata

3.2.1 Site Ownership

If known, record the category of adjacent land ownership(s) for the site. Do not guess, if unknown record as such.

3.2.2 Project Name

If known, record the name or likely name of the program or project that enabled the restoration work to be completed (e.g., Community Fisheries Involvement Program). If unknown, put a line through this box.

3.2.3 Project Organization

If known, record the name of the lead and any partner organizations that coordinated and carried out the project. If unknown, put a line through this box.

3.2.4 Project Date

If known, precisely when the project was completed record this in the "known completion date" box. Otherwise, record the best estimate of the decade when the activity was carried out. If more than one activity has been carried out at the site, indicate all decades that apply and record in the specific rows the estimated time a project was completed (see example field sheet Appendix I).

3.2.5 Area of site "restored"

Record the approximate total "length" and "width" to the nearest metre of area restored by the various activities. This will provide a measure of the extent of activities at the site. If more than one activity is present, record the lengths and widths of each in the comments field of each row (see example field sheet Appendix I).

3.2.6 Geo-Coordinates

Surveyors should record the UTM coordinates of the location of the specific restoration activity in the 'Location' area of the field sheet. For any activities that cover a distance of greater than approximately 20 m, also record the 'Upstream' boundary of the activity.

3.3 Other Documentation Available

This section provides a checklist for the documents supporting the activities carried out, or to be carried out at a site. This information allows users to see what information is available for the project. The title of the documents and their availability can be listed in the comments section. Documents can also be made available by uploading them to FWIS.

3.4 Comments

This section is provided as a space to add any additional comments not already listed above or on the Site Features Form.

3.5 Tips for Applying this Module

Look for any features in the floodplain and channel that look ‘out of place’ and try to ascertain their origin and potential effects they historically or currently have on the system. Look for straight lines of trees as they tend to indicate locations of tree planting.

4.0 DATA MANAGEMENT

Upon returning from the field:

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 an appropriate digital storage system (e.g., FWIS or the Stewardship Tracking System), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca\fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The module emerged from recommendations from the ongoing Natural Channel Design Conferences as a multidisciplinary need. Jack Imhof, John Parish and Peter Ashmore were strong advocates for its development and we are grateful for their leadership on this front. We just apologize for taking so long. Critical review was received from Scott Jarvie, Richard Kavanagh, Sherwin-Watson Leung, and Joyce Chau.

Appendix 1

Example Restoration Documentation Field Form

Restoration Project Tracking Form

Stream Name	Stream Code	Site Code	Date (yyyy-mm-dd)
WARING CREEK	WC1	HAGU	2016-07-21

Project Name if known: WARING CREEK RESTORATION PROJECT

Project Organization: WARING CREEK IMPROVEMENT ASSOCIATION

Site Ownership ☐ Corporate ☒ Private ☐ Federal ☐ Provincial ☐ Municipal ☐ NGO ☐ First Nations

Location of activity

Zone		Easting	Northing
18	Downstream/ Point location	324525.8	4872035.7
	Upstream location	324540.7	4872017.9

UTM Source	Known Completion Date (yyyy-mm-dd)	Estimated Decade of Completion:
FWIS	2002-05-31	☐ 60's ☐ 70's ☐ 80's ☐ 90's ☐ 00's ☐ 10's

Restoration Length (m)	Restoration Width (m)	Source of Information	Reference:
200	3	Field Visit ☒ Office ☐	

Photo No	Photo Name	Photo Description
0 2 1	HAGUBRUSHBUNDLENS	BRUSH BUNDLE NEAR CULVERT NORTH SIDE OF STREAM

Issue	Restoration Techniques
☐ Fish Barrier	☐ Rocky Ramp/Vortex Weir ☐ Bypass Channel ☐ Fishway ☐ Dam Removal ☐ Online Pond Removal ☐ Other: ___
☐ Erosion	☐ Live Fascines ☐ Gabion ☐ Log jam ☐ Tree Revetment ☐ Rootwads ☐ Crib Wall ☐ Live Staking ☐ Riprap ☐ Bank Grading ☐ Concrete ☐ Other: ___
☒ Instream Habitat	☐ Spawning Bed Creation ☐ Boulder Placement ☐ Half Log Cover ☒ Woody Material Placement ☐ Lunker structures ☒ Debris Removal ☒ Other: CHRISTMAS TREE SWEEPERS
☐ Riparian Habitat	☒ Riparian Planting ☐ Cattle Fencing ☐ Tile Drain Removal ☐ Wetland Restoration ☐ Garbage Removal ☐ Invasive Species Removal ☐ Other: ___
☐ Channel Morphology	☐ Meander Enhancement ☐ Riffle/Pool Creation ☐ Rock Weir Vortex ☐ Backwater Creation ☐ Flood Plain Enhancement ☐ Bed Stabilization ☐ Wetland Creation ☐ Other: ___
☐ Storm Water & Online Ponds	☐ Bottom Draw ☐ Wetland ☐ Infiltration Trench ☐ Dredge ☐ Tree Planting ☐ Outlet Naturalization ☐ Sediment Trap ☐ Improve Access ☐ Other: ___
☒ Other (Please Describe)	INSTALLED NEW CULVERT DOWNSTREAM THAT HAS LOWERED GRADIENT AND IMPROVED FLUSHING
☐ Other Documentation Available	☐ Eng. Drawings ☒ Report ☐ Pre-Post Monitoring Plan ☐ Environmental Impact Study ☐ Video ☐ Legal contracts ☐ other: ___

Comments

Report: Waring Creek Stream restoration Plan and Draft Fisheries Management Plan both describe the rationale for the restoration work. Spruce trees now over 20 feet high and channel narrowed by approximately 50%. More debris removal would be beneficial

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1: MODULE 6

Tracked Species[1]

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Appendices

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[1] Authors: I. C. Petreman and L. W. Stanfield

1.0 INTRODUCTION

This module describes methods for documenting observations of priority, tracked species in Ontario to support the documentation of expansions and contractions of species ranges. These species are of particular concern to biodiversity of streams and their riparian zones and most are readily identifiable with minimal training and hence are appropriate in a rapid assessment module. The module recognizes that practitioners vary in taxonomic abilities, and is, therefore, only applied to species for which crews have confidence in identification. With time, training and use, the number of species tracked by crews will increase. Species included in this category are:

- species that are listed in the provincial *Endangered Species Act,* 2007 (ESA) or federal *Species at Risk Act* (SARA);
- select species defined by the OMNRF's Invading Species Awareness Program as being 'invasive' and potentially detrimental to Ontario's biodiversity; and
- indicator species of particular habitats.

This module creates a means to rapidly and effectively report the observations of tracked species at a stream site. It is intended to provide a means of documenting the presence and relative abundance for tracked species that are observed "incidentally" while crews are carrying out other OSAP modules. Regardless of which other sampling modules are conducted during the visit, there is always an opportunity to passively observe rare or invasive species when in the field. With the increasing costs of stream sampling, an opportunity to report the presence of a tracked species is an optimal use of resources. These data will provide information on species distributions and ranges for both species at risk and invasive species. There are hundreds of tracked species in the province that are being observed through other programs such as the vegetative sampling protocol (Puric-Mladenovic *et al.*, 2008) or NHIC. However, such in-depth protocols rely on extensive training and are not a component of OSAP. Although OSAP's list of tracked species focuses on aquatic species, other observations of tracked species are still valuable and desired. The field sheet has been designed to enable such species to be listed in the event that practitioners can reliably identify other tracked species not listed on the form.

Note: that this module represents a rapid assessment module for recording incidental observations of species at risk and invasive species and is not to be used as a survey protocol to determine species occupancy (i.e., presence or absence) at a site.

2.0 PRE-FIELD ACTTIVITIES

This module takes 2-30 minutes to complete depending on the complexity of the habitat and the number of species that may be encountered. Depending on the nature of the organism being observed, it will generally be performed concurrently with other modules.

It is stressed that each surveyor should be knowledgeable with the key identification features and current distribution of as many of the tracked species listed on the field sheet as possible (Appendix 1), but at this stage, validated observations of any of these species will be of value. To assist users in identification a series of fact sheets are available online for aquatic[2] and terrestrial[3] species. Crews should pay special heed to the ‘prevention’ section on each species’ fact sheet; many of these guidelines require individuals to kill and remove invasives from new locations (e.g., Rudd, Ruffe). The list of tracked species may change annually as emerging species become new management priorities. Ontario’s Field Guide to Aquatic Invasive Species[4] is an excellent source of identification characteristics for aquatic invasive species. The list of species at risk in Ontario is available from the Ontario Ministry of Natural Resources and Forestry’s Species At Risk page[5]. It should be noted that, if a surveyor intends to perform a targeted search for a particular species, an ESA or SARA permit may be required (depending on the species) and surveyors are encouraged to contact their local Ministry of Natural Resources and Forestry and DFO office to determine if a permit is needed.

The intent of this module is to document the incidental observations of a tracked species during a sampling event for a *seasonal* period. Therefore, one ‘sample’ for the purposes of this module may cover multiple days of sampling if the sampling is carried out in concert with other OSAP modules over a period of about a week (< 10 days). In this case, multiple tracked species observations should be recorded on the same form (representing one sample) with the first-day date acting as the “sample” identifier. The module can also be used to record findings from more targeted sampling directed to provide a more comprehensive list of tracked species found at a site.

3.0 FIELD PROCEDURES

This module must be completed in conjunction with a site description form as defined in S1.M2, Screening Level Site Documentation, or S1.M3 Assessment Procedures for Site Feature Documentation. Record the site identification data (‘Stream Name:’, ‘Stream Code’, ‘Site Code’), and the date at the top of the Tracked Species field sheet.

Working within an OSAP site, surveyors will search for and report on the absence or presence of one or more of the species listed on the Tracked Species form that is *within the site boundaries*. Recording a code beside a species confirms that it was searched for (see below) and conversely leaving a box blank indicates that a species was not searched for. Targeted surveys will have more species boxes marked off.

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[2] URL:http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STDPROD_068689.html
[3] URL:http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STDPROD_068690.html
[4] URL:http://www.invadingspecies.com/GetFile.cfm?ID=27868_FieldGuide2010_FINAL.pdf
[5] URL: http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/276722.html

Box 1. Examples of Using Existing OSAP modules to Enumerate Tracked Species

Electrofishing (S3.M1)

While conducting electrofishing surveys, capture and keep a number of crayfish for species identification. The number of crayfish to be kept will depend on the likelihood of capture of a rusty crayfish. If they have never been observed in the sampled watershed keep around 10 crayfish; if the watershed is in proximity to an area where they have been observed recently, keep all of them. During processing, sort the crayfish into their own bucket, identify them and count them by species. If a subsample is being retained, also ensure to keep any crayfish which are unique in appearance and euthanize and preserve all potential invasive species before you transport them.

Benthic Kick and Sweep methods (S2)

Young crayfish are particularly vulnerable to capture during benthic surveys. Depending on how a sample is processed, not all crayfish would routinely be assessed for species identification. Surveyors should ensure that all captured crayfish are assessed and the number of rusty crayfish is enumerated on site or in the lab. This may require some field identification if subsampling is carried out at site, otherwise, sort through the entire sample in the lab.

Channel Morphology and Rapid Substrate Assessment Modules

The three "point transect" modules that require surveyors to assess instream conditions using a spatially extensive survey design (i.e., S4.M1: Rapid Assessment Methodology for Channel Structure; S4.M2: Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions; and S4.M8: Rapid Assessment Methodology for Instream Substrate Sampling) offer an opportunity to assess the abundance of stationary tracked species. Should the project lead desire such data, these modules can be readily adapted to note the presence or absence of species such as: Zebra mussels; didymo; water hyacinth; European common reed; and European frog-bit. For each tracked species that is present at the site, maintain a dot tally of their occurrence in each of the observation point areas (i.e., 25 cm diameter circle). Record the exact abundance in the comments field along with the 'observed' category as defined in Table 1.

Keep in mind that an OSAP site includes the riparian area that extends 100 metres on either side of the stream for the purposes of documenting terrestrial organisms. Searches can be targeted to specific habitats where tracked species might be found, but will most often be observed incidentally while other OSAP modules are being carried out. For example, the presence of tracked algae and aquatic plant species may be easily discovered while conducting instream habitat surveys (Section 4). Also, if practitioners intend to use and report results to the Ministry of Natural Resources and Forestry (MNRF) from a fisheries survey (e.g., S3.M1: Fish

Community Sampling Using Electrofishing), catches of rare or invasive fishes ***need not be recorded on the Tracked Species form*** as this would duplicate the observation. Such observations should be recorded on the electrofishing module field sheets with greater detail. If a tracked fish species is observed while completing an unrelated module (e.g., an incidental tracked fish observation while doing benthic sampling), it is then appropriate to record this on the Tracked Species form.

In the interim, if there is any doubt of the authenticity of an invasive species observation, take a photograph, or if it is not unsafe or illegal to do so, keep a voucher specimen or a piece of material for genetic identification. Note that keeping a voucher specimen will most often be inappropriate when observing species at risk, rather take a high-definition picture. If surveyors are not in possession of a scientific collection permit that specifically permits the transport of an invasive fish, including crayfish, high resolution photographs must be used to confirm observations (see OSAP General Introduction for additional information).

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

Tracked invasive species observed outside of the sampling site (e.g., in transit to the site), are still valuable observations, but should be reported to one of the following:

- Directly to the OFAH/MNRF Invading Species Hotline [6] (preferred method) OFAH and MNRF's web-based reporting service[7];
- Using the georeferenced 'Early Detection and Distribution Mapping System '[8]; or
- By establishing a new OSAP site (if appropriate) and filling out both the site description (S1.M2: Screening Level Site Documentation) and Tracked Species module forms.

Likewise, sightings of species at risk that are outside the site boundaries should be reported to:

- Natural Heritage Information Center website[9] (preferred method); or
- Your local OMNRF[10] office or Conservation Authority

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[6] OFAH's hotline: 1-800-563-7711

[7] OFAH's invasive species web-based reporting forms: URL: http://www.invadingspecies.com/Report.cfm

[8] The Early Detection and Distribution Mapping System (EDDMapS) Ontario URL: http://www.eddmaps.org/Ontario

[10] NHIC's web-based rare species reporting form URL: http://nhic.mnr.gov.on.ca/MNR/nhic/species/species_report.cfm

[11] OMNRF district offices and their phone numbers can be looked up at: URL: http://www.mnr.gov.on.ca/en/ContactUs/2ColumnSubPage/STEL02_179002.html

3.1 Documenting Observations

Crews should always be on the lookout for any peculiar species, and in particular, the species listed on the field sheet. These non-targeted surveys imply that crews will persistently be on the lookout for tracked species while carrying out other OSAP modules. For occurrences of species, provide a measure of the abundance using the criteria provided in Table 1 and record this information in the appropriate “observed” box beside the species listed. In most situations, it will be best to wait until the entire site has been surveyed before estimating the number observed of each species. The ‘observed’ metric is not meant to be a true measure of the species’ abundance at a site, but acts as an approximate, rapidly assessed measure of this parameter. This is primarily intended to inform researchers and managers of the extent of an invasion but may also assist in tracking occurrences and population sizes of species at risk. Some examples of how crews might incorporate more quantitative surveys for tracked species while carrying out various OSAP modules are provided in Box 1.

For occurrences of tracked species which are not pre-printed on the field sheet (most species at risk), two blank rows per taxon are provided. It is important to enter both the common and scientific names as a means of record validation. Once any tracked species has been identified, the crew should take one or more pictures of the organism which focuses on its identifying features. In the case of invasive species only, keeping a voucher specimen is also recommended. Invasives found in waters where they have not previously been detected should always be collected and reported (see scientific collector’s permit above).

Table 1 - Species Observation Codes

Code	(#) Observed
(blank)	Unknown: insufficient confidence in species identification or sampling effort is insufficient to confidently assess species presence
0	Zero individuals observed, despite sufficient surveying
1	Few: one or two individuals have been observed
2	Common: some individuals have been observed
3	Highly abundant: numerous and dominant presence within the site

3.2 Documenting Species Absence

Crews are encouraged to examine all habitats, including the riparian zone to a 100 m distance looking for the presence of terrestrial tracked species. However, it is critical that if surveyors do not search all viable habitats for a species, or if crews are uncertain of its identification, that it’s “observed” box remains empty (rather than marking it as “0”). Where a targeted species sampling method is used (e.g. electrofishing for Rusty crayfish), an absent (0) code is appropriate when no individuals are observed.

Zeros are to only be entered where sufficient observation effort has been performed to claim that the species is most likely not present. This will only be the case for the species for which crews are confident with identification and sufficient sampling has been conducted to justify a reasonable assertion of absence.

Some species may be easier to document absence than others. For example, the absence of floating European frog-bit is easily noted during the summer months, yet the absence of the fishhook waterflea may be more difficult to claim without an accompanying targeted procedure. Regarding this, surveyors are asked to record observations of species absence conservatively. The comments field on the field sheet should be used to describe what targeted sampling procedures have been utilized for a given species.

3.3 Tips for Applying this Module

Field guides and print outs of descriptions of the target species should be a part of the field equipment and crews are encouraged to take a hike through the riparian zone during “breaks”.

4.0 DATA MANAGEMENT

Upon returning from the field:

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 an appropriate digital storage system. The Early Detection and Distribution Mapping System[8] is an easy to use smartphone App that is recommended for use, particularly if only a few species are detected. Alternatively, for sites with multiple occurrences the Flowing Waters information System can be used to efficiently upload the data and share it with the EDD database through a bulk transfer. Regardless of which system is used, save backup copies in a separate location from the master copy. See Section 6 for details on information management using FWIS.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

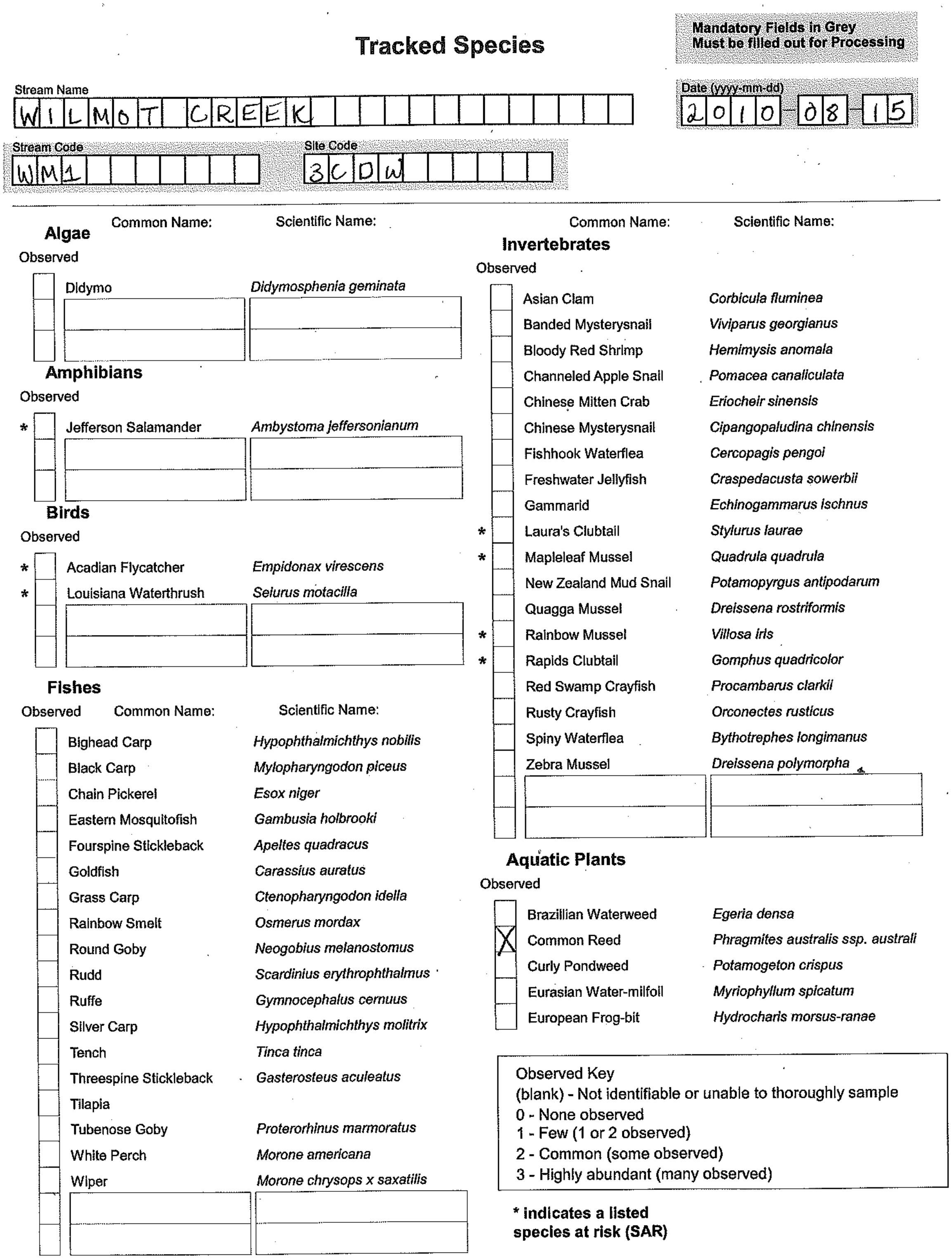
5.0 ACKNOWLEDGEMENTS

The tracked species module was sponsored by the Invasive Species Centre and would not have been developed without the support of Donna Wales. Review of the draft module and helpful comments on implementation were provided by: Jon Clayton, David Copperfield, Scott Gibson, Chris Jones, Rachel Martens, Darryl Mitchell, Marina Petrovic, Chris Wilson and Rob Wilson. 2017 updates were provided by Alison Morris.

6.0 LITERATURE CITED

Puric-Mladenovic, D., Lee, H., Bradley, D., Arends, R., Strobl, S., and MacIntosh, A. 2008. Vegetation Sampling Protocol (VSP). Information Management and Spatial Analysis, Southern Science and Information Branch, OMNR.

Appendix 1
Example Tracked Species Form (Page 1)



Tracked Species

Mandatory Fields in Grey
Must be filled out for Processing

Stream Name: WILMOT CREEK

Date (yyyy-mm-dd): 2010-08-15

Stream Code: WM1

Site Code: 3CDW

Algae

Observed	Common Name:	Scientific Name:
☐	Didymo	*Didymosphenia geminata*
☐		
☐		

Amphibians

Observed	Common Name:	Scientific Name:
* ☐	Jefferson Salamander	*Ambystoma jeffersonianum*
☐		
☐		

Birds

Observed	Common Name:	Scientific Name:
* ☐	Acadian Flycatcher	*Empidonax virescens*
* ☐	Louisiana Waterthrush	*Seiurus motacilla*
☐		
☐		

Fishes

Observed	Common Name:	Scientific Name:
☐	Bighead Carp	*Hypophthalmichthys nobilis*
☐	Black Carp	*Mylopharyngodon piceus*
☐	Chain Pickerel	*Esox niger*
☐	Eastern Mosquitofish	*Gambusia holbrooki*
☐	Fourspine Stickleback	*Apeltes quadracus*
☐	Goldfish	*Carassius auratus*
☐	Grass Carp	*Ctenopharyngodon idella*
☐	Rainbow Smelt	*Osmerus mordax*
☐	Round Goby	*Neogobius melanostomus*
☐	Rudd	*Scardinius erythrophthalmus*
☐	Ruffe	*Gymnocephalus cernuus*
☐	Silver Carp	*Hypophthalmichthys molitrix*
☐	Tench	*Tinca tinca*
☐	Threespine Stickleback	*Gasterosteus aculeatus*
☐	Tilapia	
☐	Tubenose Goby	*Proterorhinus marmoratus*
☐	White Perch	*Morone americana*
☐	Wiper	*Morone chrysops x saxatilis*
☐		
☐		

Invertebrates

Observed	Common Name:	Scientific Name:
☐	Asian Clam	*Corbicula fluminea*
☐	Banded Mysterysnail	*Viviparus georgianus*
☐	Bloody Red Shrimp	*Hemimysis anomala*
☐	Channeled Apple Snail	*Pomacea canaliculata*
☐	Chinese Mitten Crab	*Eriocheir sinensis*
☐	Chinese Mysterysnail	*Cipangopaludina chinensis*
☐	Fishhook Waterflea	*Cercopagis pengoi*
☐	Freshwater Jellyfish	*Craspedacusta sowerbii*
☐	Gammarid	*Echinogammarus ischnus*
* ☐	Laura's Clubtail	*Stylurus laurae*
* ☐	Mapleleaf Mussel	*Quadrula quadrula*
☐	New Zealand Mud Snail	*Potamopyrgus antipodarum*
☐	Quagga Mussel	*Dreissena rostriformis*
* ☐	Rainbow Mussel	*Villosa iris*
* ☐	Rapids Clubtail	*Gomphus quadricolor*
☐	Red Swamp Crayfish	*Procambarus clarkii*
☐	Rusty Crayfish	*Orconectes rusticus*
☐	Spiny Waterflea	*Bythotrephes longimanus*
☐	Zebra Mussel	*Dreissena polymorpha*
☐		
☐		

Aquatic Plants

Observed	Common Name:	Scientific Name:
☐	Brazillian Waterweed	*Egeria densa*
☒	Common Reed	*Phragmites australis ssp. australi*
☐	Curly Pondweed	*Potamogeton crispus*
☐	Eurasian Water-milfoil	*Myriophyllum spicatum*
☐	European Frog-bit	*Hydrocharis morsus-ranae*

Observed Key
(blank) - Not identifiable or unable to thoroughly sample
0 - None observed
1 - Few (1 or 2 observed)
2 - Common (some observed)
3 - Highly abundant (many observed)

*** indicates a listed species at risk (SAR)**

Example Tracked Species Form (Page 2)

Tracked Species (Page 2)

	Common Name:	Scientific Name:
☐	European Lake Sedge	*Carex acutiformis*
☐	European Water Chestnut	*Trapa natans*
☐	Fanwort	*Cabomba caroliniana*
☐	Flowering-rush	*Butomus umbellatus*
* ☐	Heart-leaved Plantain	*Plantago cordata*
☐	Himalayan Balsam	*Impatiens glandulifera*
☐	Mosquito Fern	*Azolla pinnata*
☐	Parrotfeather	*Myriophyllum aquaticum*
☒	Purple Loosestrife	*Lythrum salicaria*
☐	Water Hyacinth	*Eichhornia crassipes*
☐	Water Lettuce	*Pistia stratiotes*
☐	Water Soldier	*Stratiotes aloides*
☐	Watermoss	*Salvinia spp.*
☐	Yellow Floating-heart	*Nymphoides peltata*
☐	Yellow Iris	*Iris pseudacorus*
☐		
☐		

Reptiles

Observed		
* ☐	Snapping Turtle	*Chelydra serpentina*
* ☐	Spotted Turtle	*Clemmys guttata*
* ☐	Gray Ratsnake	*Pantherophis spiloides*
☐		
☐		

Terrestrial Plants

Observed	Common Name:	Scientific Name:
☐	Amur Honeysuckle	*Lonicera maackii*
☐	Climbing Nightshade	*Solanum dulcamara*
☐	Common Buckthorn	*Rhamnus cathartica*
☐	Cow Vetch	*Vicia cracca*
☐	Creeping Jenny	*Lysimachia nummularia*
☐	Dame's Rocket	*Hesperis matronalis*
☐	Dog-Strangling Vine	*Cynanchum rossicum*
☐	European Barberry	*Berberis vulgaris*
☐	European Privet	*Ligustrum vulgare*

	Common Name:	Scientific Name:
☒	Garlic Mustard	*Alliaria petiolata*
☐	Giant Hogweed	*Heracleum mantegazzianum*
☐	Glossy Buckthorn	*Rhamnus frangula*
☐	Green Spurge	*Euphorbia esula*
☐	Guelder rose	*Viburnum opulus*
☐	Japanese Barberry	*Barberis thunbergii*
☐	Japanese Honeysuckle	*Lonicera japonica*
☐	Japanese Knotweed	*Polygonum cuspidatum*
☐	Kudzu	*Pueraria montana var. lobata*
☐	Lily of the Valley	*Convallaria majalis*
☐	Morrow's Honeysuckle	*Lonicera morrowii*
☐	Mossy Stonecrop	*Sedum acre*
☐	Multiflora Rose	*Rosa multiflora*
☐	Norway Maple	*Acer platanoides*
☐	Oriental Bittersweet	*Celastrus orbiculatus*
☐	Tartarian Honeysuckle	*Lonicera tatarica*
☐	White Sweet-clover	*Melilotus alba*
☐		
☐		

☐ Kept voucher specimens ☐ Took pictures

Comments

PURPLE LOOSESTRIFE AND COMMON REED
ON LEFT BANK, GARLIC MUSTARD IN
FORESTED AREAS ON BOTH BANKS

Identifying Crew Member

S BANKS

Observed Key
(blank) - Not identifiable or unable to thoroughly sample
0 - None observed
1 - Few (1 or 2 observed)
2 - Common (some observed)
3 - Highly abundant (many observed)

*** indicates a listed species at risk (SAR)**

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2

Benthic Macroinvertebrate Assessment

TABLE OF CONTENTS

APPENDICES

INTRODUCTION

This section describes three sampling methods for benthic macroinvertebrates[1] (benthos). Resulting samples characterize community composition, and can be used in bioassessments that evaluate water quality. Complementary methods for describing physical habitat conditions (depth, velocity and substrate) are also described because this information is often required for bioassessment.

The modules in this section can be applied in most wadeable streams with flowing water. Directions for splitting a sample of material collected in the field to reduce sample size for carrying back to a lab and a standard key for identifying benthos to the 27 groupings used for coarse level taxonomy surveys are also provided in this section as Appendix 1 and 2).

S2.M1: Rapid Macroinvertebrate Collection

This module describes a rapid sampling technique for determining if a site contains large-bodied benthic macroinvertebrates (benthos) that are known to be sensitive to most impacts (based on benthos tolerances to organic pollution[2]; e.g. Hilsenhoff 1987). Resulting data can be used in reconnaissance surveys as a coarse indicator of water quality conditions.

S2.M2: Stationary Kick Survey for Macroinvertebrates

This module describes a stationary kick technique for evaluating the relative abundance of taxonomic groups of benthos from within riffle habitats. This method is designed to minimize habitat effects between sites. This approach can be used to provide a more comprehensive list of taxa than S2.M1, Rapid Macroinvertebrate Collections. If estimating relative abundance of taxa in **both** riffle **and** pool habitats of a site is critical to the study design, then the methods in S2.M3, Transect Travelling Kick and Sweep Survey for Macroinvertebrates, should be used.

S2.M3: Transect Travelling Kick and Sweep Survey for Macroinvertebrates

Sampling techniques for determining relative abundance estimates for benthos in the riffle and pool habitats of a site are described. This approach can be used to estimate composition in a meander sequence by generating a composite sample of pools and riffles. This is the standard sampling procedure for the Ontario Benthos Biomonitoring Network and includes a benthic survey and field tally sheet.

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[1] Benthic macroinvertebrates are animals without backbones that live on the bottom of lakes, rivers, and streams and are visible with the naked eye. They are generally sedentary, exhibit variations in tolerances to ambient water and environmental quality, and are easy to collect.

[2] Low densities of pollution-sensitive taxa (e.g. mayflies, stoneflies and caddisflies) and an over-abundance of pollution tolerant taxa (e.g. midges, sow bugs and snails) imply a nutrient enriched site.

LITERATURE CITED

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist. 20:31-39.

Appendix 1

Bucket Method for Splitting a Sample

Once sampling has been completed, if many more than the required number of animals have been collected, a random portion of the sample can be poured back into the stream to avoid removal of an unnecessarily high number of animals. A method for randomly splitting a sample is given below; for simplicity, the example illustrates how to split a sample into equal halves, but the technique can be modified to allow splitting into different proportions (e.g. quarters or thirds).

Bucket Method for randomly splitting a sample into two equal halves (refer to diagram below):

1. Randomize the sample in the bucket.
2. Place a divider in front of you.
3. Pour half of the randomized sample into bucket (now the sample is split into two buckets). Place one bucket on the left, and one bucket on the right side of the dividing line (positions A and B in Figure A1).
4. Randomize samples in buckets A and B and pour-off samples (as in step 3); this results in buckets at positions C and D, and E and F, respectively (each contains approximately 1/4th of the original sample).
5. Pour-off contents of buckets at positions C, E, F, and D, (as in step 3), into buckets at positions 1 and 2; this has the effect of splitting the sample down to eighths (4/8ths of the sample on each side of the divider), and then re-combining into one sample on each side of the divider. These final two samples are approximately random halves of the original sample.

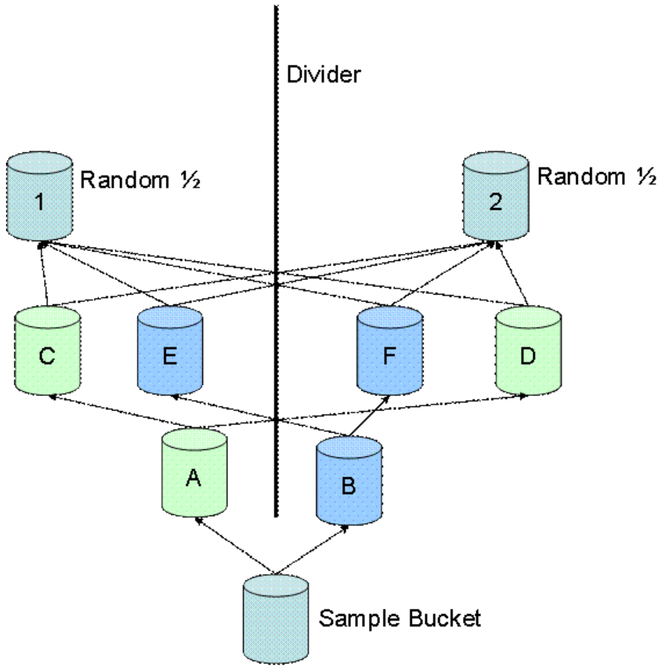


Figure 1a. Visualization of the splitting technique for a benthic sample.

Appendix 2

Appendix 2: Guide to Coarse-level Benthic-invertebrate Identification

In this section we describe the diagnostic features that distinguish the 27 taxa groups (a mixture of Classes, Orders, sub-Orders, and Families) that comprise the minimum taxonomic precision for the Ontario Stream Assessment Protocol and Ontario Benthos Biomonitoring Network.

Hydrozoa (Hydra)
Platyhelminthes (Flatworms)
Nemata (Roundworms)
Oligochaeta (Aquatic Earthworms)
Hirudinea (Leeches)
Isopoda (Sowbugs)
Amphipoda (Scuds)
Decapoda (Crayfish)
Acari (Aquatic Mites)
Ephemeroptera (Mayflies)
Anisoptera (Dragonflies)
Zygoptera (Damselflies)
Plecoptera (Stoneflies)
Hemiptera (True Bugs)
Megaloptera (Fishflies)
Trichoptera (Caddisflies)
Lepidoptera (Aquatic Moths)
Coleoptera (Beetles)
Chironomidae (Midges)
Tabanidae (Horse Flies)
Culicidae (Mosquitoes)
Ceratopogonidae (No-see-ums)
Tipulidae (Crane Flies)
Simuliidae (Black Flies)
Misc. Dipterans (Other True Flies)
Gastropoda (Snails)
Bivalvia (Clams)

This appendix is intended as a refresher for certified practitioners, particularly to remind OSAP members of the diagnostic characters commonly used in taxonomic diagnoses. When identification challenges arise, consult published keys, such as:

McCafferty, W.P. 1998. Aquatic Entomology: The Fisherman’s and Ecologists’ Illustrated Guide to Insects and their Relatives. Toronto, Ontario: Jones and Bartlett Publishers.

Merritt, R. W., Cummins, K. W., & Berg, M. B. (Eds) 2008. An Introduction to the Aquatic Insects of North America. Dubuque, Iowa: Kendall/Hunt Publishing Co.

Peckarsky, B. L., Fraissinet, P. R., Penton, M. A., & Conklin, D. J. 1990. Freshwater Macroinvertebrates of Northeastern North America . Ithaca, New York: Cornell University Press.

Smith, D. G. 2001. Pennak's Freshwater Invertebrates of the United States: Porifera to Crustacea. New York, New York: John Wiley & Sons, Inc.

Voshell, J. R. 2002. A Guide to Common Freshwater Invertebrates of North America. Granville, Ohio: McDonald & Woodward Publishing.

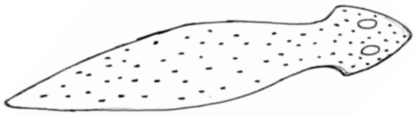
Figure A2 The 27 taxa group minimum taxonomic resolution (a mix of Classes, Orders, sub-Orders, and Families).

Hydrozoa (Hydras)

- Tube with tentacles
- Asexual reproduction by budding
- Inconspicuous, 2 - 25 mm long
- Variable colouration: often clear to whitish
- Sessile

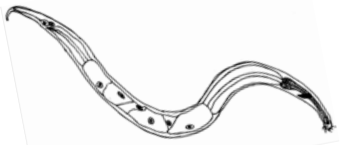
Platyhelminthes (Flatworms)

- Very flat ‘worms’, heads with eyespots
- Ventral mouth; may have pharynx
- 5 - 20 mm long, usually dark in colour: mottled grayish-brown to black dorsally
- Non-swimmers; creep slowly on bottom of sorting tray



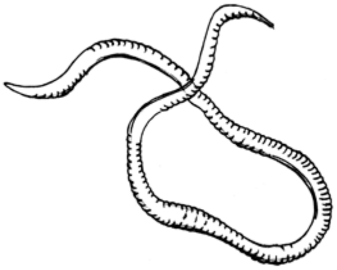
Nemata (Roundworms/Threadworms)

- Un-segmented, frequently clear
- Head usually tapered, tail pointed
- Often <1 cm long
- Rapid, whip-like movements



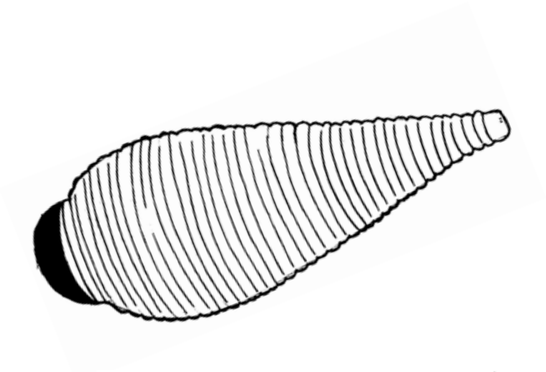
Oligochaeta (Aquatic Earthworms)

- Bundles of hairs on each segment behind the first
- Segmented bodies are round, soft, muscular and elongate. ~ 1 - 30 mm long, often pinkish
- Look like earthworms
- May crawl along bottom of tray but often coiled up
- No suckers or eyes



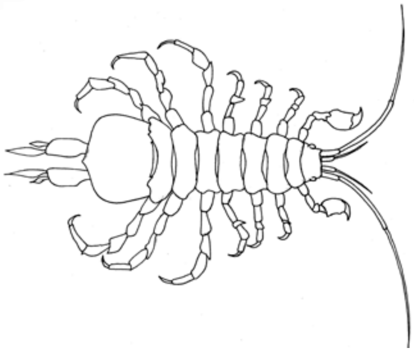
Hirudinea (Leeches)

- Suckers at both ends, move by inching along or swimming
- 34 annulated segments, no chaetae
- ~5 mm - 30 cm long
- Head often with several pairs of eyes
- Colour varies, brown, olive and black common; typically patterned dorsally



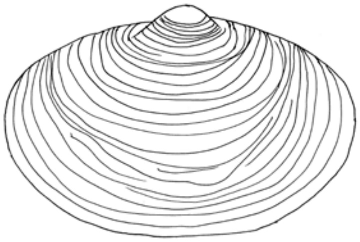
Isopoda (Sowbugs)

- 5 - 20 mm long; mini armadillos
- Dorso-ventrally compressed; 7 pairs of legs, adapted for crawling (first pair sub-chelate, others with simple claws)
- 1st antennae longer than 2nd
- Usually gray in colour
- Often associated with organic matter
- Uropods bifid



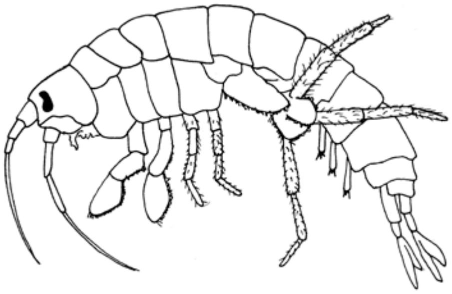
Bivalvia (Clams and Mussels)

- Hard oval shell hinged in two halves
- 2 - 250 mm; colour variable
- Found in bottom of tray in sand or gravel
- Watch for (and don't count) empty shells

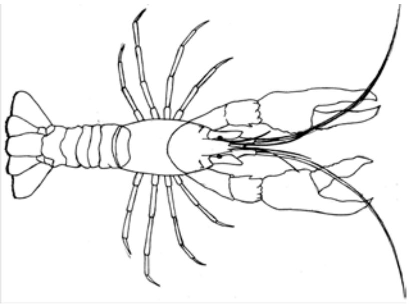


Amphipoda (Scuds)

- Laterally compressed
- 2 long antennae of approx. equal length
- 7 pairs of walking legs
- 6-segmented abdomen
- 5 - 20 mm long, colour variable
- Usually a translucent grey or light brown
- Catch with small piece of screen



Decapoda (Crayfish)

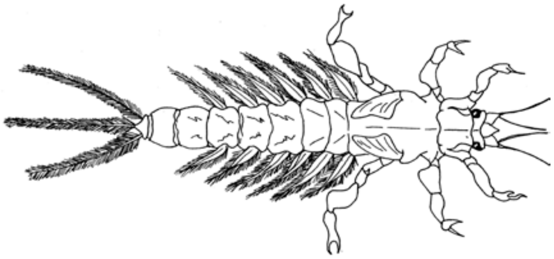


- Look like small lobsters; front half of body cylindrical, rear half dorso-ventrally flattened
- 5 pairs of walking legs: first 3 pairs chelate (claws of forelegs enlarged)
- Hard-shelled, eyes on stalks
- Broad telson used in backward-swimming escape
- 1 - 15 cm long, often green, brown, blue

Acari (Aquatic Mites)

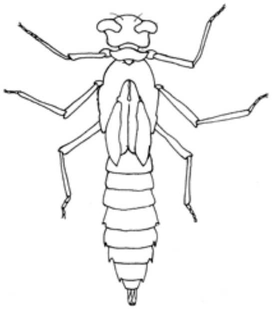
- Adults with 4 pairs of segmented legs (larvae with 3)
- Body a sphere without visible segments
- Anterior finger-like pedipalps; simple eyespots; no antennae
- Often brightly coloured (red, green, blue, brown)
- Look like small (1 - 7 mm) spiders
- Uncoordinated, scrambling swimming motion

Ephemeroptera (Mayflies)



- Usually 3-tailed (sometimes 2-tailed)
- Single tarsal claw
- Gills held dorso-laterally on abdomen
- 3 - 30 mm long (not including tails)
- Swim using dorso-ventral undulations

Anisoptera (Dragonflies)



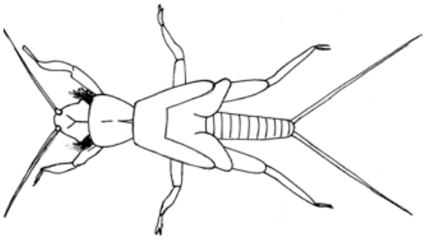
- Modified labium for catching prey
- Larger and heavier-bodied than mayflies; no visible external gills;
- Big head and eyes
- 15 - 45 mm; drab colours, often green to greenish brown
- Often flattened; jet propulsion

Zygoptera (Damselflies)

- Bodies more tubular, thinner than dragonflies
- 3 gills at terminus of abdomen
- Same modified raptorial labium as dragonflies
- 10 - 25 mm long, drab cryptic colours

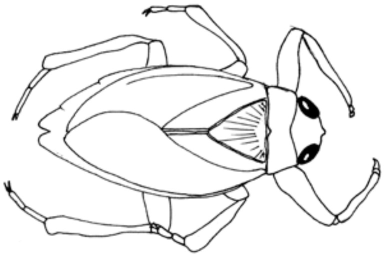
Plecoptera (Stoneflies)

- 2 tails
- Gills may be abdominal, thoracic, and on the ventral head or neck region (gills never insert dorso-laterally on abdomen)
- Tarsi with 2 claws
  5 - 50 mm, yellowish, brown or blackish



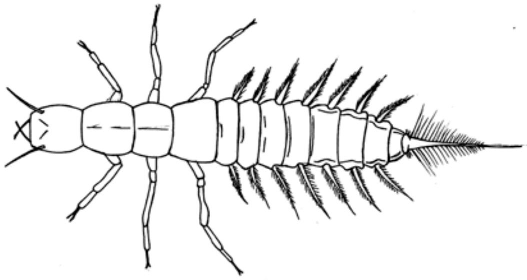
Hemiptera (True Bugs)

- 15-40 mm
- Sucking mouth parts (beak)
- No gills
- 2 claws on at least some legs
- Base of forewings leathery, otherwise membranous wings
- Often two pair of membranous wings
- Often with well-developed breathing appendages



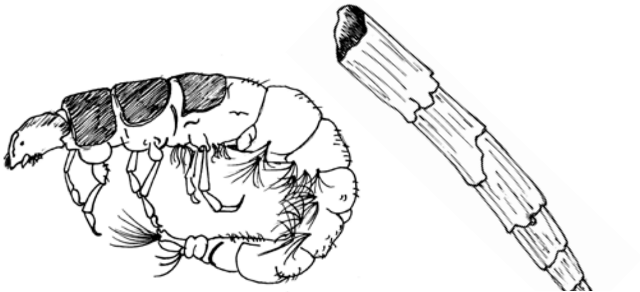
Megaloptera (Fishflies, Alderflies, Dobsonflies)

- Large: 25 - 90 mm long
- Lateral abdominal gill filaments
- Well-developed mandibles
- Either with anal prolegs or a long terminal filament



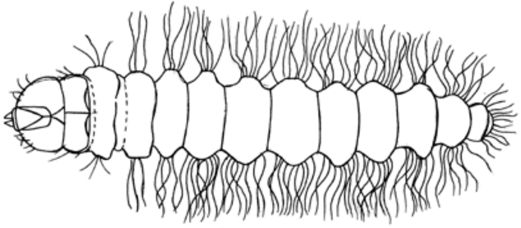
Trichoptera (Caddisflies)

- Anal prolegs with hooks
- Often with portable case or fixed-retreat
- Dorsal thoracic plates variously sclerotized
- 2-50 mm long, head and thorax compressed into anterior portion of body



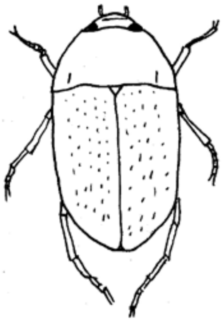
Lepidoptera (Aquatic Moths)

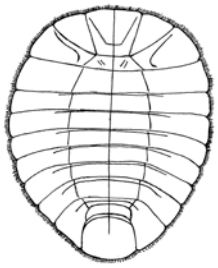
- Head with ring of ocelli
- 3 pairs of short, segmented, thoracic legs
- Ventral, abdominal prolegs
- 10 - 25 mm, crawl like a caterpillar



Coleoptera (Beetles)

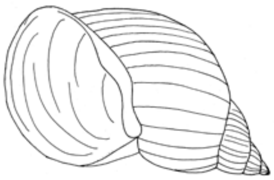
- 2 - 40 mm
- 3 pairs of thoracic legs
- Adults: Fore-wing modified as elytra, and extends posteriorly to cover all or most of the body
- Antennae with 11 or fewer segments
- Larvae: Sclerotized head with mandibles, maxillae, labium and 2- or 3-segmented antennae; May have un-segmented terminal abdominal appendages





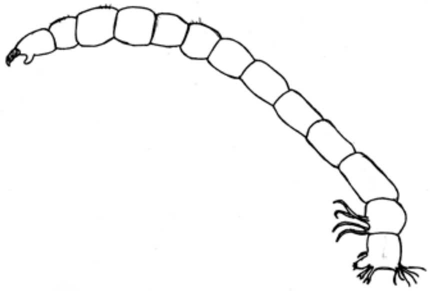
Gastropoda (Snails and Limpets)

- 2 - 70 mm
- Hard spiral or cap-shaped shell
- Bodies with prominent head and tentacles
- May have operculum



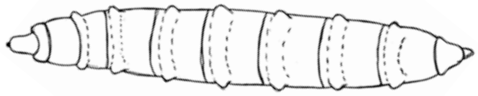
Chironomidae (Midges)

- 2 - 20 mm long, red, white, olive or yellowish
- Well developed, sclerotized head with eyes
- Anterior and posterior parapods with hooks
- Characteristic shape like letter “J”
- May be in a tube made of fine dirt particles
- Often caught in surface film



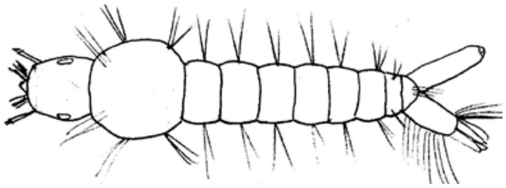
Tabanidae (Horse Flies, Deer Flies)

- 3 or 4 pairs of creeping welts with hooks on each of the first 7 abdominal segments
- Pointed at both ends, leathery texture
- Head retracted into thorax
- 15 - 40 mm



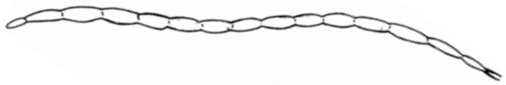
Culicidae (Mosquitoes)

- 3-15 mm
- Fused thoracic segments are wider than abdomen
- Brushes of hairs at front of head and sides of mouth
- Posterior respiratory siphon



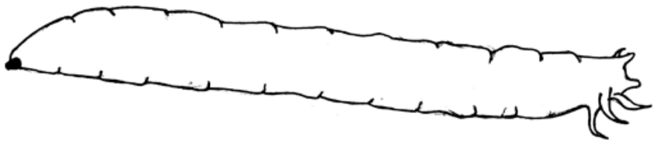
Ceratopogonidae (No-see-ums, Biting Midges)

- Very slender, pointed at both ends, segmented; small pointed sclerotized head
- No abdominal appendages but may be a tuft of terminal abdominal hairs
- 3 - 15 mm; skin smooth shiny and creamy white
- Remain stiff when picked up with forceps
- Move by “whipping”



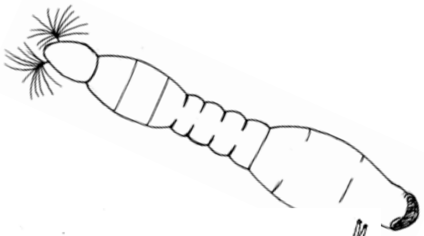
Tipulidae (Crane Flies)

- 10 - 50 mm, white, yellowish or brown
- Reduced head is retracted into thorax
- Membranous body; may have creeping welts
- Posterior respiratory disc with lobes



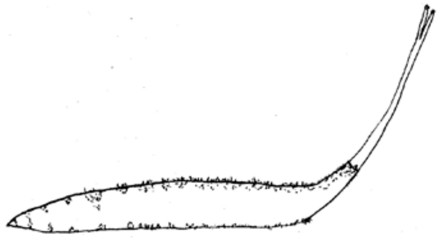
Simuliidae (Black Flies)

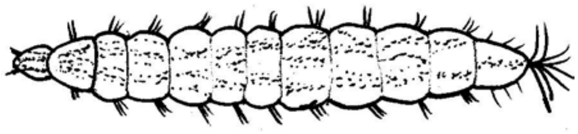
- Often with labral fans
- Like flattened maggot with one end 1/3 fatter
- Sessile with posterior attachment organ
- Move with looping (inch-worm) movements
- 3 - 15 mm, brown or greyish brown



Miscellaneous Diptera (Other True Flies)

- Adults with single pair of wings
- May have parapods, pseudopodia, creeping welts or other appendages, but no jointed thoracic legs
- Often maggot-like; head may be retracted into thorax





ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2, MODULE 1

Rapid Macroinvertebrate Collections[1]

TABLE OF CONTENTS

APPENDICES

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[1] Author: L. W. Stanfield and C. Jones

1.0 INTRODUCTION

This module describes a rapid assessment technique for determining if a site contains sensitive large-bodied benthic macroinvertebrates (benthos). Results from these surveys can be used in reconnaissance surveys as a coarse indicator of water quality conditions, based on Hilsenhoff's (1987) invertebrate tolerances to organic pollution[2]. The procedures are comparable to those described in the Watershed Report Card (2000).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and data collection can be completed in 10 minutes.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment is required:

1. Benthic Macroinvertebrate Sample Forms (preferably on waterproof paper)
2. Pencils
3. Forceps
4. Sampling net (e.g., D-net, kick-net (see S2.M2, Stationary Kick Survey for Macroinvertebrates, large aquarium net, etc.)
5. Magnifying glass
6. White sorting tray and kitchen sieve
7. Metre Stick (wooden)
8. Waders

Crews should adhere to safety precautions and requirements set forth by their employers / managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone, etc.)

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[2] In most stony streams, low densities of pollution-sensitive taxa (e.g., mayflies, stoneflies and caddisflies) and an overabundance of pollution tolerant taxa (e.g., midges, sow bugs and snails) imply a nutrient enriched site.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. Additional information required depends on the objectives of the study and resources available. If the objective of the study is to assess differences among sites, surveys should be conducted over reasonably short periods of time and within similar physiographic and climatic zones. Benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards. Begin the survey at the downstream (bottom) end of the site and if additional sampling is required, select subsequent collection areas that are upstream.

3.1 Locating the Collection Area

At each site, samples will be collected from a riffle. In most stream types, riffles occur at crossovers and it is in these areas that sensitive taxa should be present. Under low flow conditions, riffles are areas of relatively fast, turbulent flow, where the water's surface is typically broken and has an obvious slope.

3.2 Documenting Collection Area Habitat Conditions

Record the 'Stream Name', 'Stream Code', 'Site Code', 'Sample #', 'Collection Area' (i.e., 1 or 2), 'Habitat Sampled', and 'Date' on the Benthic Tally Sheet (see Appendix 1). Samples are consecutively numbered within a calendar year. Mark an 'X' in the box titled 'Rapid Survey'.

On the Benthic Tally Sheet measure and record the following:

- Maximum water depth ('Water Depth' (mm)'):; at the maximum depth within the collection area, place the ruler so that the thin side is facing into the current, ensuring that the ruler is straight and that it does not dig into the substrate. Measure the height of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler). Water depth measurements can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

- 'Hydraulic Head (mm)' is measured at the same location as the maximum water depth; place the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 1). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 1). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked 'Hydraulic Head (mm)' on the Benthic Tally Sheet. 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). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

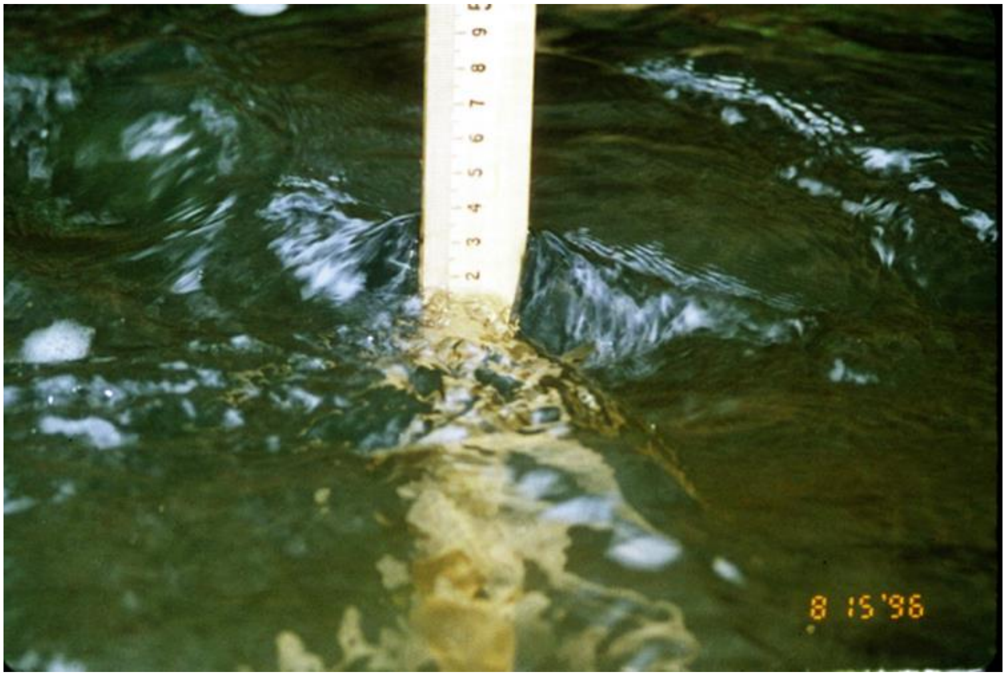


Figure 1: A Point Measurement of Hydraulic Head.

The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

3.3 Evaluating Invertebrate Communities

To determine the sampling procedures, assess which bed type most appropriately describes the riffle:

- **Cobble areas** have at least 10 particles with a median axis > 100 mm within the riffle
- **Sand and gravel areas** have less than 10 particles with a median axis > 100 mm

3.3.1 Sampling Procedures for Cobble Areas

In the riffle area, randomly select a cobble particle (> 100 mm) and scan for benthos. Identify all animals using either the Benthic Tally Sheet as reference or the Guide to Coarse-level Benthic-invertebrate Identification, S2.Appendix 2 (Jones *et al.* 2007). Record the approximate number of organisms as per Section 3.3.3 Data Recording. Measure and record the median axis of the particle in the substrate box on the Benthic Tally Sheet (Appendix 1). Repeat this across the entire riffle until 10 particles have been scanned for benthos and the particle size measured.

Measure and record 'Stream Width (m)' which is the wetted width of the stream to the nearest tenth of a metre. Be sure to subtract the width of islands and include undercuts in the total wetted width.

3.3.2 Sampling Procedures for Sand and Gravel Areas

Place a kick-net or a D-net on the substrate and while standing upstream, kick the substrate over an area of approximately 1 m^2, for 20 seconds to dislodge invertebrates. If a smaller net is used (i.e., large aquarium net), kick the substrate for 20 seconds to dislodge invertebrates while sweeping the net in the water column to capture benthos and materials as they drift downstream. Pick up the net and transfer the contents into a flat white-bottomed tray for sorting. Identify all animals using either the Benthic Tally Sheet as reference or the Guide to Coarse-level Benthic-invertebrate Identification, S2.Appendix 2 (Jones *et al.* 2007). Record the number of organisms as per Section 3.3.3 Data Recording.

Identify the 'Net Type' used by checking the appropriate choice on the field form and also indicate the 'Mesh Size'.

After the identification of benthos is complete, randomly select 10 particles from within the area sampled. Record the size according to the classifications in Table 1, or if the median axis of the particle is between 2 mm and 1000 mm, record the actual measurement.

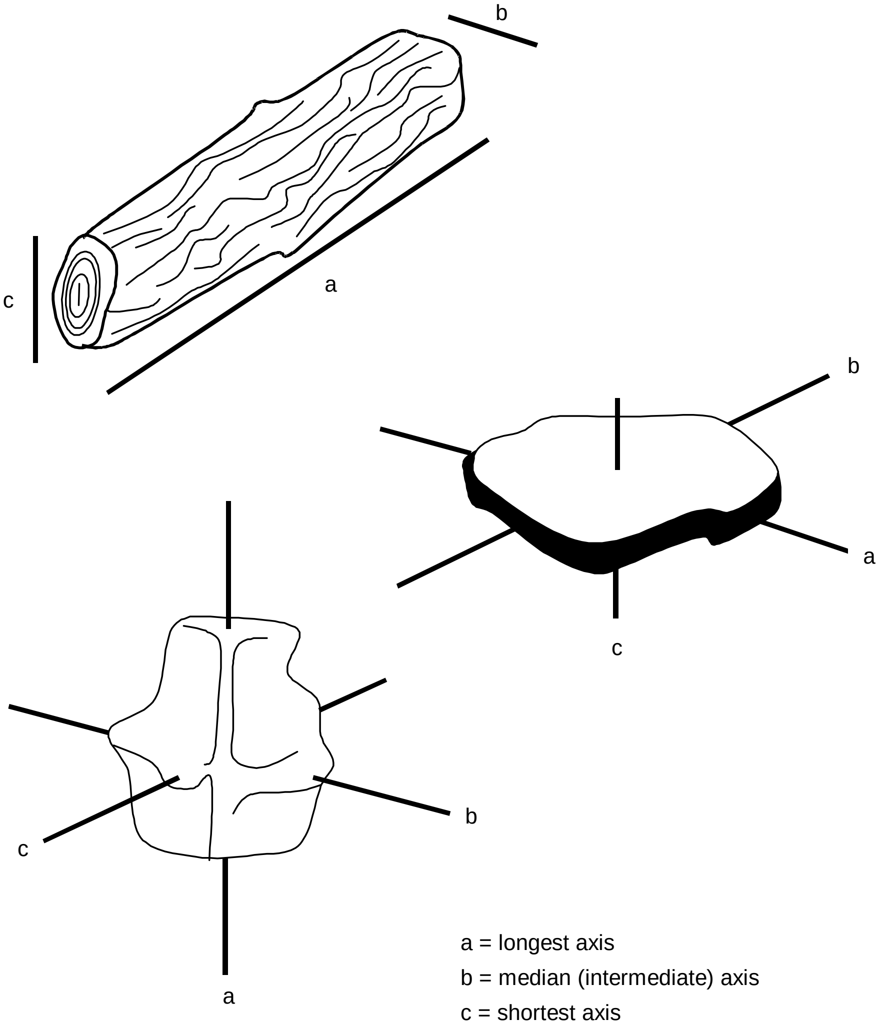


Figure 2: Measuring along the Median Axis of Objects.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

Table 1 - Substrate Descriptions and Size Categories

Material	Description	Size to be Recorded
‘Unconsolidated Clay’	Very hard packed when dry and sticky when wet	‘0.01’
‘Consolidated Clay’	Hard even when wet, slippery, grey in colour, often laminated	‘0.011’
‘Silt’	Feels soft like a powder or flour	‘0.05’
‘Sand’	Gritty, sizes >0.05 and < 2 mm	‘0.10’
‘Bedrock’	Exposed bedrock	‘1111’
Measured particles	Between 2 mm and 1000 mm.	Median axis
‘Large Boulders’	> 1000 mm but not attached to bedrock	‘1001’

Note that large material (i.e., greater than 1000 mm wide) such as concrete slabs, etc., are classified as ‘Large Boulders’. To ensure the accuracy of data entry, place a ‘0’ in front of all decimal points (i.e., ‘0.01’). **Be sure to measure all particles in your random sub-sample that are close to 2 mm in diameter to avoid misclassifying small particles.**

Measure and record ‘Stream Width (m)’ which is the wetted width of the stream (i.e., subtract the width of islands and include undercuts), to the nearest tenth of a metre.

3.3.3 Data Recording

This method is intended to classify the relative abundance of each taxa group. As such, crews can either count and record using the dot tally method for each taxa group where numbers are low; or when abundances are high the numbers can be estimated. Typically, dot tally is used for rare taxa, and estimates of abundance are used for more common taxa. For example, a rock is assessed and found to have 2 mayflies, 4 caddisflies and has many blackflies (estimated at between 100-200 animals. The surveyors would record 2, 4, and 150 respectively on the Benthic Tally Sheet for this subsample. At the completion of the subsample, add all the tallies and record this in the summary box for each taxonomic group (see Appendix 1).

Conducting a Dot Tally (‘Box Ten’)

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren’t mistaken for photocopy imperfections.

3.3.4 Criteria for Additional Sampling

If the samples from the first collection area indicate potentially impaired water quality (e.g., low numbers or absence of stoneflies, mayflies or caddisflies), move to another riffle in the site and continue sampling to confirm the results. Record the data from the second collection area on a new field form. Identify these as ‘Collection Area’ ‘1’ or ‘2’, as appropriate. Note that if sampling is repeated at the site throughout the year, record the ‘Sample #’ sequentially.

3.4 Tips for Applying this Module

Mayfly gills insert dorso-laterally on the abdomen; stoneflies have less obvious gills which are located on other parts of the body (e.g., thorax, underside of abdomen, underside of the head).

Check casings for the presence of caddisflies. Count only caddisflies, not empty cases.

Learn to characterize the organisms by their mode of movement: swimming, crawling or flexing, as this can help identify many of the taxa.

If a net is used to collect macroinvertebrates, there must be sufficient flow to enable dislodged animals to be carried into the net for capture. The net should be rinsed well between samples to prevent transfer of animals from one sample to another.

4.0 DATA MANAGEMENT

Upon returning from the field;
1. Create backups of all data (field forms, photos, benthic data), and store in a place separate from the originals.

2. Enter the data into an appropriate digital storage system (e.g., FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The genesis of the rapid macroinvertebrate survey was conversations held in workshops to develop a Watershed Report Card operating manual for use by citizen scientists, which were followed up with input from Bruce Kilgour and Ron Reid.

6.0 LITERATURE CITED

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist. 20:31-39.

Jones, C., K.M. Somers, B. Craig, and T. Reynoldson. 2007. Ontario Benthos Biomonitoring Network Protocol Manual. Ontario Ministry of the Environment, Dorset, Ontario

Watershed Report Card. 2000. Watershed Report Card: Manuals for Community Involvement in Watershed Management. Watershed Report Card Inc., Port Elgin, ON.

Appendix 1

Example Benthic Tally Sheet

Benthic Tally Sheet

Mandatory Fields In Grey
Must be filled out for processing

Date (yyyy-mm-dd): 2010-08-15

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3COW

Sample: 01

Collection Area: 01

Survey Type: ☒ Rapid ☐ Stationary Kick

Habitat Sampled: ☐ Riffle ☒ Pool

Stream Width (m): 1.3

Water Depth ~~(mm)~~ Hydraulic Head (mm): 120 | 55

Sampling Time (sec): 20

Unknown Species:

Comments:

Net Type: ☐ Square ☐ Surber ☐ D-net

Mesh Size (microns): ☒ 251-500 ☐ 501-1000

Sample Preserved? ☐ Yes ☐ No

No. of Vials:

Sorting Method: ☒ Unsorted ☐ Marchant Box ☐ Splitter

Sample Size: ☐ mL ☐ g

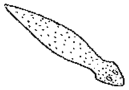
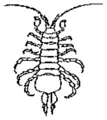
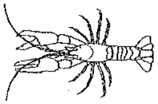
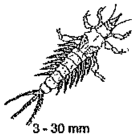
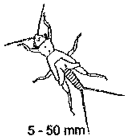
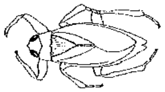
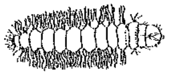
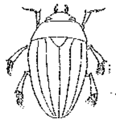
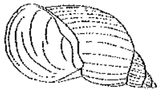
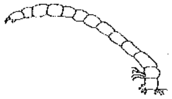
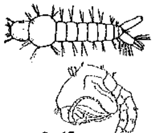
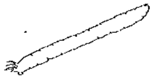
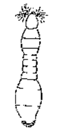
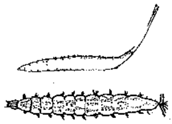
Total Vol/Wt:

Vol/Wt not Picked:

Identification: ☒ in Field ☐ in Lab ☐ Microscope ☐ no Microscope

Median sizes of 10 substrate particles randomly chosen from collection area (mm).

17	25	3	35	6
0.10	12	18	0.01	10

 2 - 25 mm **Hydrozoa** (Hydra) • 01	 5 - 20 mm **Platyhelminthes** (Flatworms)	 1 - 10 mm **Nemata** (Roundworms/Threadworms)	 1 - 30 mm **Oligochaeta** (Aquatic Earthworms)	 5 - 300 mm **Hirudinea** (Leeches)	 5 - 200 mm **Isopoda** (Aquatic Sowbugs) • 01	 2 - 250 mm **Bivalvia** (Clams) • • 02	 5 - 20 mm **Amphipoda** (Scuds)	 10 - 150 mm **Decapoda** (Crayfish)
 1 - 7 mm **Acari** (Aquatic Mites)	 3 - 30 mm **Ephemeroptera** (Mayflies) ☒ ••: 13	 15 - 45 mm **Anisoptera** (Dragonflies)	 10 - 25 mm **Zygoptera** (Damselflies)	 5 - 50 mm **Plecoptera** (Stoneflies)	 15 - 40 mm **Hemiptera** (True Bugs)	 25 - 90 mm **Megaloptera** (Fishflies)	 2 - 50 mm **Trichoptera** (Caddisflies)	 10 - 25 mm **Lepidoptera** (Aquatic Moths)
 2 - 40 mm **Coleoptera** (Beetles)	 2 - 70 mm **Gastropoda** (Snails)	 2 - 20 mm **Chironomidae** (Midges) ~ 50	 15 - 40 mm **Tabanidae** (Horse & Deer Flies)	 2 - 15 mm **Culicidae** (Mosquitos)	 3 - 15 mm **Ceratopogonidae** (No-see-ums)	 10 - 50 mm **Tipulidae** (Crane Flies)	 3 - 15 mm **Simuliidae** (Black Flies) ~ 50	 **Misc. Diptera** (Misc. True Flies)

Dot Tally (track total no. sampled): 117

Crew Leader (init. & last name): R YAN

Crew Init.: SK

Recorder Init.: SS

Verified: SK

Corrected: SS

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2, MODULE 2

Stationary Kick Survey for Macroinvertebrates[1]

TABLE OF CONTENTS

APPENDICES

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[1] Authors: Stanfield, L. W. and B. Kilgour

1.0 INTRODUCTION

This module describes a stationary kick technique for estimating the relative abundance of benthic invertebrate (benthos) taxa from riffle habitats. Results from these surveys can be used in bioassessments or as indicators of water quality conditions. This sampling method is more quantitative than that of S2.M1 - Rapid Macroinvertebrate Collections. If estimating relative abundance of taxa in the riffle **and** pool habitats of a site is critical to the study design, use S2.M3 - Transect Travelling Kick and Sweep Survey for Macroinvertebrates.

Several options are provided for sample processing; sub-sampling procedures, processing location, detail of identification etc. These options allow practitioners to tailor their collection and processing methods to suit their expertise, resources and study design (Stanfield 2003, Jones *et al.* 2007).

This technique requires that there be sufficient flow to enable dislodged animals to be carried into the net for capture.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and data collection can be completed in 15 minutes. The time required for sample processing is quite variable.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment is required:

1. Benthic Macroinvertebrate Sample Forms (preferably on waterproof paper)
2. Pencils
3. Net – constructed out of 60 x 110 cm – 1000 µm window screening stapled to two pieces of wood (doweling or hockey stick) to make a 60 x 100 cm net
4. Metre stick (wooden)
5. Nalgene™ squirt bottle and soft brush
6. Fine tweezers (2 pairs)
7. Eye droppers (at least 2, a variety of sizes is preferable)
8. White sorting trays (2)
9. Plastic spoon (tea- or table-spoon, either size)

10. Pail or deep tray (2 L capacity)
11. Sample bottles (1 L)
12. Watch, with seconds indicator
13. Preservative solution for specimens (i.e. alcohol)
14. Labels or permanent marker
15. Weigh scale or measuring cup.
16. Waders
17. Buckets
18. Splitting devices (multiple buckets or containers with a wedge/plate insert)

Additional equipment for sample processing includes:

1. Microscope or magnifying glass
2. Marchant Box (optional)
3. Sorting trays or Petri dishes

Crews should adhere to safety precautions and requirements set forth by their employers/ managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc).

Optional equipment includes a sample splitter, a device (e.g. a multi-probe) for measuring water quality variables (e.g. dissolved oxygen, pH, conductivity, and dissolved organic carbon) etc.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and S1.M2 - Screening Level Site Documentation, or S1.M3 - Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available. Benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards. Begin the survey at the downstream (bottom) end of the site and continue upstream.

3.1 Locating the Collection Areas

In most stream types, riffles occur at crossovers. Under low flow conditions, riffles are areas with relatively fast, turbulent flow, where the water's surface is typically broken and has an obvious slope.

Since most sites will contain multiple riffles, two riffle areas should be selected as follows:

- riffles at crossovers
- where depth, velocity and substrate permit easy sample collection

Once the riffles have been selected, the collection area is placed close to the center (both laterally and longitudinally) of each riffle, avoiding areas that contain large material, such as large logs or rocks, that would interfere with sample collection.

If there is no discernible riffle, collect the samples at the crossovers.

The following procedures (i.e. Sections 3.2 to 3.7) must be repeated at each riffle collection area.

3.2 Documenting Collection Area Habitat Conditions

Record the ‘Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample #’, ‘Collection Area’ (i.e. 1 or2), ‘Habitat Sampled’, and ‘Date’ on the Benthic Tally Sheet (see Appendix 1). Samples are consecutively numbered within a calendar year. Mark an ‘X’ in the box titled ‘Stationary Kick and Sweep’, identify the ‘Net Type’ by checking ‘Square’, and the ‘Mesh Size’ by checking the ‘501-1000 µm’ mesh size box.

On the Benthic Tally Sheet measure and record the following:

Maximum water depth (‘Water Depth’ (mm)); at the maximum depth within the collection area, place the ruler so that the thin side is facing into the current, ensuring that the ruler is straight and that it does not dig into the substrate. Measure the height of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler). Water depth measurements can be either recorded as observed (i.e. 18 mm) or can be rounded to the nearest 5 mm (i.e. 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

‘Hydraulic Head (mm)’ is measured at the same location as the maximum water depth; at this location, place the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 1). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 1). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked ’Hydraulic Head (mm)’ on the Benthic Tally Sheet. 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). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

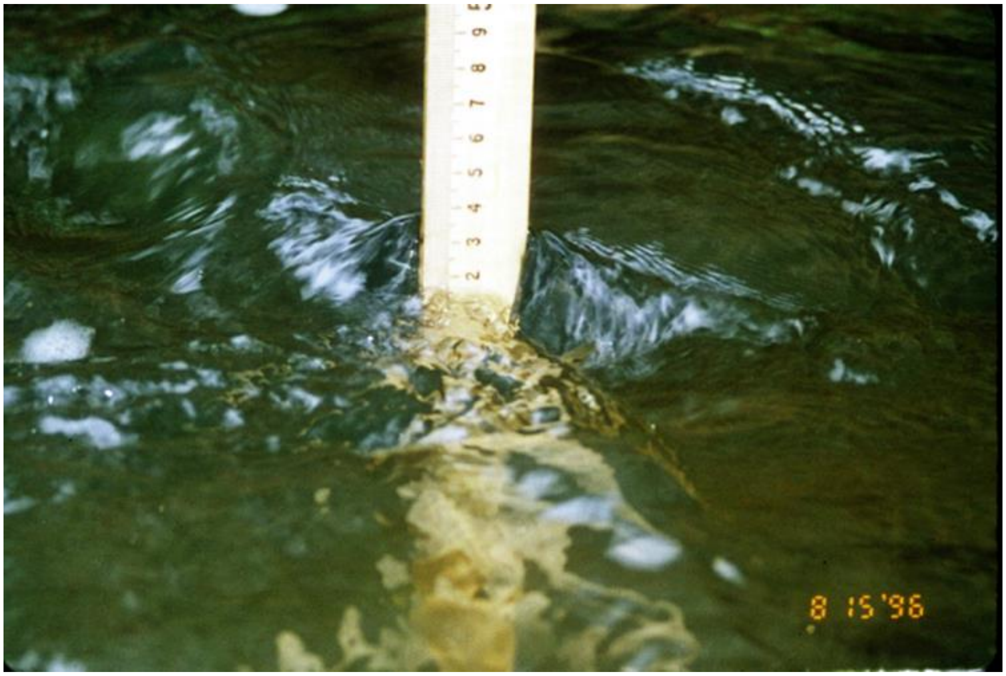


Figure 1: A Point Measurement of Hydraulic Head.
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

3.3 Obtaining the Invertebrate Sample

Place the sampling net on the stream bottom so that gaps are minimized and orient the net at a slight incline (i.e. approximately 70º from the stream bottom) (Figure 2). The second person kicks the substrate to a depth of ~5 cm for **one minute** over an area of approximately **1 m^2**. After kicking, pick up the largest particles in the collection area, hold them in front of the sampling net and rub them to dislodge any visible invertebrates (Figure 2). Do this for one minute.

Pick up the bottom of the net so that the current keeps the material on the sampling net. Bring the two poles together to form a cradle and carry the net to shore. Place a finger between the two poles and pinch the net at both ends. Splash the material on the net to the bottom of the cradle and empty the contents of the sampling net into a bucket. Use a soft brush or other device to remove the benthos. Ensure that no animals remain on the sampling net by rinsing it (Figure 3). Large organic debris (leaves, macrophytes, etc.) may be rinsed, inspected and discarded after removing any macroinvertebrates, adding these to the bucket.

Figure 2: Orientation of the Net and Collection of Benthos from Large Particles.

Figure 3: Sample Collection and Processing (in the field).

3.4 Preparing the Sample for Processing

Weigh or measure the total sample and record as ‘Total‘, under ‘Sample Size (ml or gm)’. Since this measure is used to determine the relative portion of the sample that was identified, the water can be decanted or included in the weight/volume measurement depending on the option selected for processing the benthos sample (i.e. preserved or live). However, it is critical that the sample be measured in the same state (e.g. water decanted versus water not decanted), prior to and after processing.

After weighing or measuring the total sample, if clearly more than 500 animals were collected, randomly split the sample using the methods outlined in S2.Appendix 1: Bucket Method for Splitting a Sample. The volume or weight of the portion discarded should be recorded on the back of the Benthic Tally Sheet, so that the total 'Portion Not Picked' can be determined later.

3.5 Processing the Sample

There are a number of options available for processing the benthos sample. The study design will dictate which of the following options are selected:

- preserved or live
- laboratory or field picking
- Marchant box or spoon sub-sampling
- use of a microscope or no use of a microscope
- taxonomic level desired
- specimen archiving or discarding

3.5.1.1 Live or Preserved

If the sample is to be preserved, it should be transferred to a labelled container and enough preserving solution should be added to cover the animals. Seal the jar tightly and swirl gently to ensure all the sample gets mixed with the preserving solution. Each jar is labelled with a stream name, site code, the collection area number, the number of sample jars taken, the date, and the type of preserving solution used (usually alcohol). Place a label both on the lid of the jar and inside the jar (i.e. ideally on waterproof paper, with pencil). If the sample will be processed live, add water and keep the sample cool until it is processed. Live samples should be processed within 48 hours.

3.5.1.2 Picking the Sample

If a Marchant box (i.e. Marchant 1989) is being used and the sample has been preserved, rinse the sample with water and transfer to the box and see further directions in box below. Otherwise, gently stir the collected material and take a random sub-sample by collecting one spoonful of material. Put the sub-sample into a sorting tray. Add clean water to the tray.

Marchant Box Method

The standard sub-sampling box is a modified Marchant design consisting of an approximately 27 x 27 x 15 cm box that is divided into 100 cells and has a water tight lid. Wash the sample from the sieve into the Marchant Box and fill with water to a depth just below the height of the walls dividing the cells. Water depth is important. In the case of live samples, water deeper than the dividing walls will allow animals to swim between the cells once the contents have been randomized. Less water will make it difficult to distribute the sample among the 100 cells. Close and fasten the lid. Invert and gently mix the sample with side-to-side rocking motions. Right the box quickly and set on a level surface to let contents settle into cells. Using random numbers for the 10 columns and 10 rows, randomly select one or more cells and transfer contents to a suitable container or Petri dish using a pipette (or turkey baster), vacuum pump or aspirator and suction flask, or similar method.

The cell-extraction method used for Marchant sub-sampling strongly influences sample-processing time. Consider the costs of more sophisticated equipment such as aspirators, pumps, suction flasks, and tubing in relation to the improved efficiency resulting from their use. Using an aspirator and suction flask may be the best balance between minimal cost and extraction efficiency.

Pick out organisms one-at-a-time using either fine tweezers or an eyedropper. Identify each organism to the taxonomic level desired using either the Benthic Tally Sheet for reference, the Guide to Coarse-level Benthic-invertebrate Identification, S2.Appendix 2 (Jones *et al.* 2007), or other published keys. Record the abundance on the Benthic Tally Sheet or a customized tally sheet[2].

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

If the sample will be processed live, add water and keep the sample cool until it is processed.

Live samples should be processed within 48 hours. If samples are to be archived, place the identified organisms into one or more sample jars that contain 70% alcohol. The sub-sample is considered adequately ‘picked’ when no more animals are found in one to three minutes.

Animals that cannot be identified should not be included in the tally. They should be set aside and identified by an expert. To be counted, a specimen must have enough intact body parts to permit its identification and it must have a head. Larval husks and empty shells and cases are not counted.

Continue processing sub-samples until 100 animals have been picked or the whole sample has been searched. **Pick the entire sub-sample that contains the 100th animal;** this ensures that the samples are not biased towards larger animals.

Example: One spoonful of material provided 50 organisms. A second spoonful provided 62 organisms. The sampling can be terminated after the second spoonful has been processed because more than 100 organisms were found in the two complete sub-samples.

On the tally sheet, check the box for either ‘Field’ or ‘Lab’ depending on the location where benthics are identified. Convert the dot tally to a total number for each type of organism in the appropriate boxes on the data form. This ensures accurate conversion of the data and speeds data entry.

3.6 Determining the Percent of Sample Processed

Once sorting is completed, measure (weight or volume) the remains of the kick sample and record this measurement in the ’Portion Not Picked:’ box if the sample was not split. If the sample was split, the ‘Portion Not Picked’ will be the total of the weight or volume of the remaining kick sample in addition to the weight or volume of the portion that was discarded (i.e. recorded on the back of the tally sheet).

Example: 1000 ml of kick sample (and water) was measured. More than 500 organisms were observed, so the sample was split and 500 ml of kick sample (and water) was discarded in the stream. After 112 organisms were identified, 100 ml of sample (and water) remains. The ‘Portion Not Picked’ equals 600 ml (500 ml +100 ml).

This information is used to estimate invertebrate abundance in the sampling area[3].

---

[2] If identification below Order level is desired, a customized tally sheet will need to be developed.

[3] # macroinvertebrates/m^2= # organisms counted *100/ %sample processed

3.7 Recording Substrate Size and Stream Width

After the identification of benthos is complete, randomly select 10 particles from within the area sampled. Record the size according to the classifications in Table 1, or if the median axis of the particle is between 2 mm and 1000 mm, record the actual measurement.

Note that large material (i.e. greater than 1000 mm wide) such as concrete slabs, etc., are classified as 'Large Boulders'. To ensure the accuracy of data entered, insert a '0' in front of all decimal points (i.e. '0.01'). **Be sure to measure all particles that are close to 2 mm in diameter to avoid misclassifying small particles.** Measure and record 'Stream Width (m)' which is the wetted width of the stream (i.e. subtract the width of islands and include undercuts), to the nearest tenth of a metre.

Table 1 - Substrate Descriptions and Size Categories

Material	Description	Size to be Recorded
'Unconsolidated Clay'	Very hard packed when dry and sticky when wet	'0.01'
'Consolidated Clay'	Hard even when wet, slippery, gray in colour, often laminated	'0.011'
'Silt'	Feels soft like a powder or flour	'0.05'
'Sand'	Gritty, sizes >0.05 and < 2 mm	'0.10'
'Bedrock'	Exposed bedrock	'1111'
Measured particles	Between 2 mm and 1000 mm.	Median axis
'Large Boulders'	> 1000 mm but not attached to bedrock	'1001'

Measure and record the wetted width of the stream (i.e. subtract the width of islands and include undercut(s), to the nearest tenth of a metre under 'Stream Width' (m)

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 4). Rocks will often lie with the median axis at right angles to the flow.

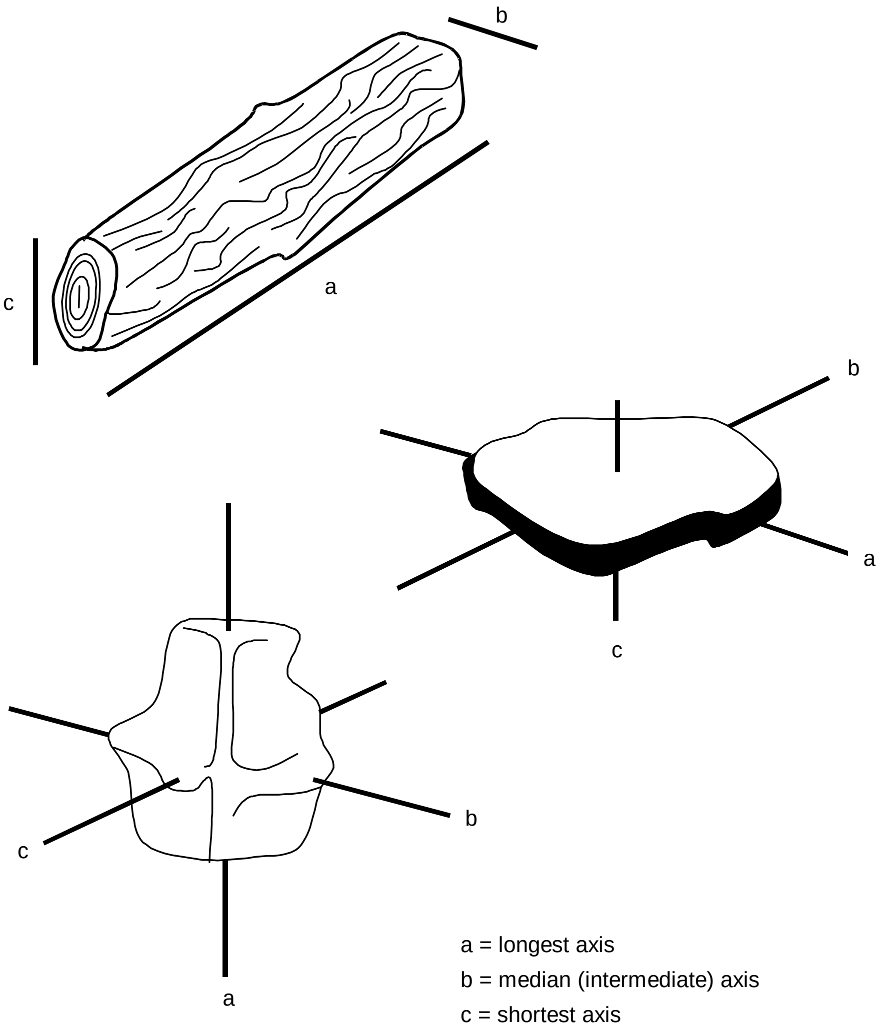


Figure 4: Measuring along the Median Axis of Objects.

3.8 Tips for Applying this Module

Mayfly gills insert dorso-laterally on the abdomen; stoneflies have less obvious gills which are located on other parts of the body (e.g. thorax, underside of abdomen, underside of the head).

Check casings for the presence of caddisflies. Count only caddisflies, not empty cases.

Learn to characterize the organisms by their mode of movement: swimming, crawling or flexing, as this can help identify many of the taxa.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create backups of all data (field forms, photos, benthic data), and store in a place separate from the originals.

2. Enter the data into an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The stationary kick and sweep methodology was reviewed by Keith Somers and Ron Hall and later by Chris Jones.

6.0 LITERATURE CITED

Jones, C., K.M. Somers, B. Craig, and T. Reynoldson. 2007. Ontario Benthos Biomonitoring Network Protocol Manual. Ontario Ministry of Environment, Dorset, Ontario.

Marchant, R. 1989. A subsampler for samples of benthic invertebrates. Bulletin of the Australian Society of Limnology 12: 49-52.

Stanfield, L. W. (Ed.). 2003. Guidelines for Designing and Interpreting Stream Surveys: A Compendium Manual to the Ontario Stream Assessment Protocol. Version 1.1 Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton.

Appendix 1

Example Benthic Tally Sheet

Benthic Tally Sheet

Mandatory Fields In Grey
Must be filled out for processing

Date (yyyy-mm-dd): 2010-08-12

Stream Name: WILMOT CREEK

Stream Code: WM1
Site Code: 3CDW
Sample: 01
Collection Area: 01

Survey Type ☐ Rapid ☒ Stationary Kick

Habitat Sampled ☒ Riffle ☐ Pool

Stream Width (m)	Water Depth (mm)	Hydraulic Head (mm)	Sampling Time (sec)
1.2	120	55	120

Unknown Species

Comments: GRAVEL RIFFLE

Net Type
☐ Square
☐ Surber
☒ D-net

Mesh Size (microns)
☒ 251-500
☐ 501-1000

Sample Preserved? ☒ Yes ☐ No

No. of Vials: 01

Sorting Method
☒ Unsorted
☐ Marchant Box
☐ Splitter

Sample Size ☐ mL ☒ g

Total Vol/Wt: 240

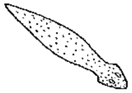
Vol/Wt not Picked: 180

Identification
☒ in Field
☐ in Lab
☐ Microscope
☐ no Microscope

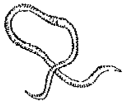
Median sizes of 10 substrate particles randomly chosen from collection area (mm).

17	25	5	55	4
0.10	12	18	0.01	16


2 - 25 mm
Hydrozoa
(Hydra)
· 01


5 - 20 mm
Platyhelminthes
(Flatworms)
☒☒· 21


1 - 10 mm
Nemata
(Roundworms/Threadworms)

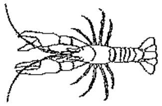

1 - 30 mm
Oligochaeta
(Aquatic Earthworms)


5 - 300 mm
Hirudinea
(Leeches)

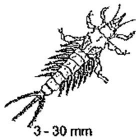

5 - 200 mm
Isopoda
(Aquatic Sowbugs)
· 01


2 - 250 mm
Bivalvia
(Clams)
·· 02


5 - 20 mm
Amphipoda
(Scuds)
·· 02

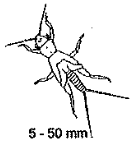

10 - 150 mm
Decapoda
(Crayfish)

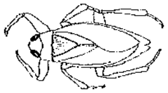

1 - 7 mm
Acari
(Aquatic Mites)


3 - 30 mm
Ephemeroptera
(Mayflies)
☒ ·:· 13

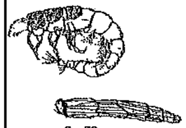

15 - 45 mm
Anisoptera
(Dragonflies)
:· 3

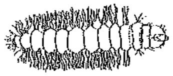

10 - 25 mm
Zygoptera
(Damselflies)
·· 2

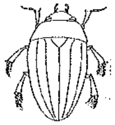

5 - 50 mm
Plecoptera
(Stoneflies)

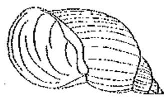

15 - 40 mm
Hemiptera
(True Bugs)

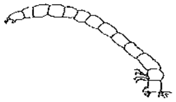

25 - 90 mm
Megaloptera
(Fishflies)


2 - 50 mm
Trichoptera
(Caddisflies)
☒☒ ☒ 29

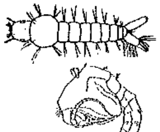

10 - 25 mm
Lepidoptera
(Aquatic Moths)


2 - 40 mm
Coleoptera
(Beetles)

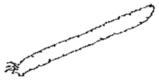

2 - 70 mm
Gastropoda
(Snails)
·· 2

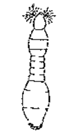

2 - 20 mm
Chironomidae
(Midges)
☒☒ ☒ 30

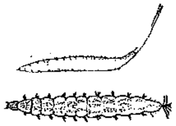

15 - 40 mm
Tabanidae
(Horse & Deer Flies)


2 - 15 mm
Culicidae
(Mosquitos)


3 - 15 mm
Ceratopogonidae
(No-see-ums)


10 - 50 mm
Tipulidae
(Crane Flies)


3 - 15 mm
Simuliidae
(Black Flies)


Misc. Diptera
(Misc. True Flies)

Dot Tally (track total no. sampled) ☒☒☒☒☒☒☒☒☒☒ ⁛

Crew Leader (init. & last name): R YAN

Crew Init.	Recorder Init.	Entered	Verified	Corrected
KS	KS	SS	KS	SS

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2, MODULE 3

Transect Travelling Kick and Sweep Survey for Macroinvertebrates[1]

TABLE OF CONTENTS

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[1] Authors: C. Jones and L.W. Stanfield

1.0 INTRODUCTION

This module describes techniques for sampling benthic macroinvertebrates (benthos) in the riffle and pool habitats of a site. Results s can be as indicators of biodiversity or water quality conditions. This module is applied within the Ontario Benthos Biomonitoring Network (OBBN) (Jones *et al.* 2007) and as such includes measures of site conditions and local habitat that aid in the research to understand and quantify biocriteria for Ontario streams.
This methodology is designed to be used on any wadeable habitat within a stream, but to standardize approaches we suggest it be applied on either riffles or pools. These two habitats provide good contrast in flow and sediment composition that result in different benthic communities and are hypothesized to respond differently to stressors.

Several options are provided for sample processing; sub-sampling procedures, processing location, detail of identification etc. These options allow practitioners to tailor their collection and processing methods to suit their expertise, resources and study design (Stanfield 2003, Jones *et al.* 2007).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and sample collection can be completed in 15- 30 minutes. The time required for sample processing will vary with the study design for sample identification.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check
- Sampling/collection permits

The following equipment is required:

1. Benthic Macroinvertebrate Sample Forms, on waterproof paper
2. Stopwatch
3. Waders
4. Metre Stick (wooden)
5. Measuring tape
6. Pencils
7. D-Net (500 µm mesh, 25-40 cm net opening width)
8. Squirt bottle and a fine brush
9. Sample bottles (1 L)
10. Labels or permanent marker
11. Buckets
12. Preservative solution for specimens

Equipment for processing the sample includes:

13. Sorting trays or Petri dishes
14. Fine tweezers (2 pairs)
15. Plastic spoon (teaspoon or tablespoon)
16. Equipment for splitting samples (e.g. multiple buckets or Marchant Box)
17. Specimen bottles or vials
18. Microscope
19. Sieve (500 µm)

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and S1.M2 - Screening Level Site Documentation. Additional information required depends on the objectives of the study and resources available. Benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards. Begin the survey at the downstream (bottom) end of the site and proceed upstream.

Ideally, all practitioners would apply this module in support of the OBBN research, collecting all aspects of this module within the desired time windows (spring and fall) . However, depending on study designs, users may choose to apply the module at other times or to apply only parts of the module. It is recommended that no less than the information shown on the tally sheet be collected at every sample area. Data that is repeated on both the ‘benthic tally sheet’ and the ‘benthic survey sheet’ need only be recorded in one place. This information is shown on both field sheets to optimize options for field collections and to enable one tally sheet to be used for all benthic sampling modules.

Be sure to fill out the form headers on all field sheets with the ‘Stream Name’, ‘Stream Code’, ‘Site Code’ and ‘Sample’ Number as per S1.M2.

3.1 Locating the Collection Areas

To collect data to the OBBN standard (Jones *et al*. 2007) select three collection areas; two in riffles and one in a pool. In most stream types, riffles occur at crossovers. Under low flow conditions, riffles are areas of relatively fast, turbulent flow, where the water’s surface is typically broken and has an obvious slope. Under low flow conditions, pools are areas of relatively slow flow and have no obvious slope in the water’s surface.

Since most sites will contain multiple pools and riffles, collection areas should be selected as follows:

- riffles that are located at crossovers

- where depth, velocity and substrate permit safe sample collection

In atypical streams, where riffles and pools either cannot be easily distinguished, or do not occur at normal locations in the meander sequence, select ‘pool’ and ‘riffle’ sampling locations that are relatively slow and deep and relatively fast and shallow, respectively.

3.2 Recording the Maximum Depth, Hydraulic Head and Wetted Width

Before kicking and sweeping in each collection area, measure and record the maximum water depth, hydraulic head, and wetted width. These measurements will be recorded on either the Benthic Survey Sheet (e.g. Appendix 1) or the Benthic Tally Sheet (e.g. Appendix 2),.

3.2.1 Measuring Maximum Water Depth

At the maximum depth in the collection area, place the ruler so that the thin side is facing into the current, ensuring that the ruler is straight and that it does not dig into the substrate. Measure the depth of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler). Water depth measurements can be either recorded as observed where they can be accurately determined (i.e. 18 mm) or can be rounded to the nearest 5 mm (i.e. 20 mm) where there is pulsing or soft substrate, whichever is easier for the crews.

3.2.2 Measuring Hydraulic Head

‘Hydraulic Head (mm)’ is measured at the same location as the maximum water depth; at this location, place the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 1). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 1). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked ’Hydraulic Head (mm)’ on the field data forms. 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). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

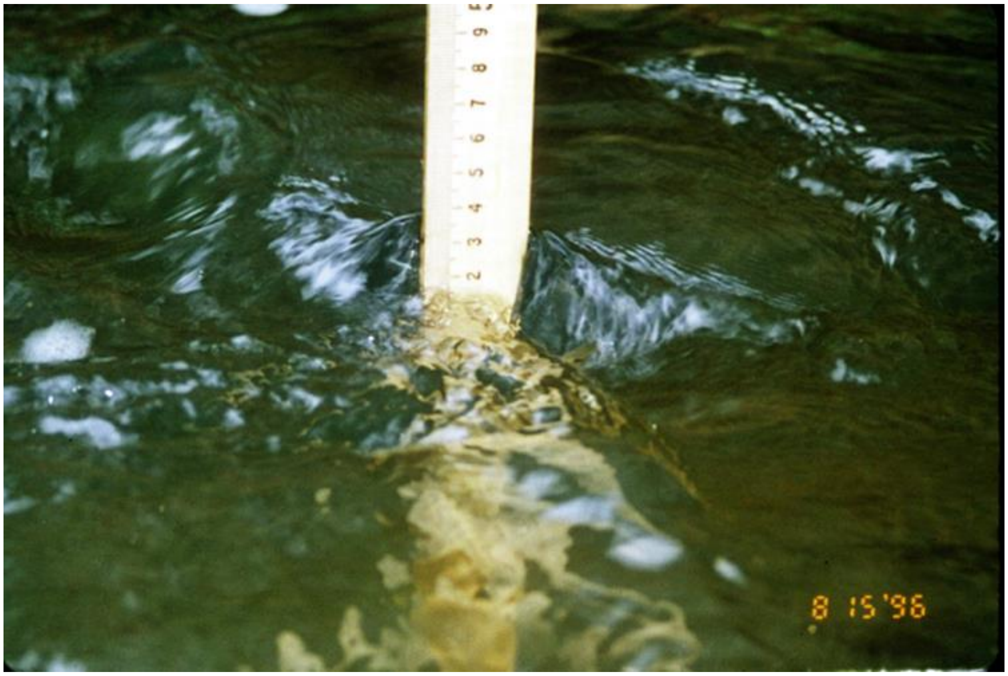

Figure 1: Measuring Hydraulic Head.
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

3.2.3 Measuring Wetted Width

Measure and the wetted width at each collection area (subtract the width of islands and include undercuts). Record 'wetted width' to the nearest tenth of a metre.

3.3 Collecting the Invertebrate Sample

Invertebrate densities vary depending on habitat and food availability. The intention of this module is to:

- sample enough habitat to obtain at least 100 organisms
- to minimize disturbances to the stream
- minimize effort/cost
- and ensure effort per unit of sampling is comparable

To accommodate these objectives a tiered approach is offered. In areas where abundance of benthos is unknown or known to be low, sample a minimum of 10 linear metres of stream in approximately 3 minutes along each collection area (transect). This will generally provide 100 animals or more. If stream width at the collection area is less than 10 m, multiple transects should be sampled such that the total distance sampled is at least 10 m (i.e. a distance greater than 10 m may be attained as transects must be sampled in their entirety).

In areas where benthos are known to be abundant and the stream width is between 4 and 10 m wide, sampling a single transect is likely to be sufficient. If the stream width greater than 15 m and benthos are known to be abundant, sampling along the transect can be adjusted such that about 10 m is covered, sampling all habitats with equal effort. If this approach is applied, record the actual width of stream sampled in the comments field of the Benthic Survey Sheet. Note that regardless of which approach is applied all of the habitats across the width of the stream should be sampled (except where safety is a concern) equally. Transects are established perpendicular to the main concentration of flow (i.e. thalweg).

Begin sampling at the farthest downstream collection area (transect). Prior to sampling, place a bucket at the water's edge. Start the timer and begin at the water's edge, vigorously kicking the substrate to disturb it to a depth of ~5 cm. Continue this process along the transect to the opposite bank. Use the timer to guide sampling to ensure that approximately 3 minutes of effort is applied proportionately to all habitats and record the actual time spent sampling. Sweep the D-net both vertically and horizontally through the water column, keeping the net downstream and close to the area being disturbed so that dislodged invertebrates will be carried into the net. A good sweeping motion is particularly important in areas of slow current to ensure animals are collected in the net. If only one person is sampling, the net is held downstream as the sampler progresses along the transect kicking the substrate (sampler typically moves sideways along the transect facing downstream).

If the sampling net fills (i.e. when material begins to bypass the net), stop sampling (also stop the stopwatch), mark the location, sieve the sample in the net, empty the net contents into a bucket and return to continue sampling the transect (restart stopwatch). Transfer all collected material to a labelled container, ensuring that all invertebrates are removed from the D-net (use a water bottle to wash down the sides and if necessary remove any remaining animals by hand). Add water if the collection is to be live processed, and keep the sample cool.

Repeat this process for subsequent upstream collection areas.

3.4 Documenting Sampling Effort

Record the 'Sampling Time' (i.e. the cumulative time spent kicking and sweeping only) and the 'Sampling Distance' (i.e. the total distance sampled while kicking and sweeping) on the Benthic Survey Sheet.

3.5 Sample Sorting and Preserving

3.5.1 Preparing the Sample for Processing

Rinse off and discard wood, rocks, leaves and other large materials; release any animals that are not of interest to the benthic macroinvertebrate survey (e.g. fish) that were caught in the net. Sieve collected materials through 500 µm mesh to remove fine particulate matter (which clouds sorting trays and makes sorting much more difficult). If clearly more than 500 animals were collected, the sample can be randomly split using the methods outlined in S2.Appendix 1:

Bucket Method for Splitting a Sample. The volume or weight of the portion discarded should be noted in the ‘Comments’ on the field form so that the portion of the sample picked can be estimated.

3.5.2 Processing the Sample

There are a number of options available for processing the benthos sample. The study design will dictate which of the following options are selected. Preferred options for the OBBN are identified with a “P”

- preserved (P) or live
- laboratory (P) or field picking
- Marchant box (P) or bucket sub-sampling
- use of a microscope (P) or no use of a microscope
- taxonomic precision: detailed (species/lowest taxonomic level achievable) (P); family level; 27-group level as shown on tally sheet
- specimen archiving (P) or discarding

3.5.2.1 Live or Preserved

If the sieved sample is to be preserved, it should be transferred to a labelled container and preserving solution should be added as per the type of solution used. Seal the jar tightly and swirl gently to ensure all the sample gets mixed with the preserving solution. Each jar is labelled with the stream name, site code, sample number, collection area, the number of sample jars taken, the date, and the type of preserving solution used (usually alcohol). Place a label both on the lid of the jar and inside the jar (i.e. ideally on waterproof paper, with pencil). If the sample will be processed live, add water and keep the sample cool until it is processed. Live samples should be processed within 48 hours.

3.5.2.2 Picking the Sample

If a subsampling device similar to that designed by Marchant (i.e. Marchant 1989) is to be used, rinse the sample with water and transfer to the “box”. Otherwise, gently stir the collected material and take a random portion of material. Use a device that enables collection of material from the bottom of the container. Put this sub-sample into a sorting tray or into a Petri dish if a microscope is being used. Add clean water to the tray.

Preserving a Sample

With advances in genetic technology and information, it is now possible to identify many benthic species based on genetics (DNA barcoding). The following process is recommended to both preserve the sample should DNA analysis be undertaken in future and to reduce the shrinking of the organism to enable identification based on morphology. The sample should be as clean as possible to minimize false DNA information being attached to organisms.

To fix the organism and its DNA, the initial preservation should be into 95% ethanol. The sample should be stored in either hard plastic or glass for approximately one week. Make sure that the total volume of the combined tissues does not exceed 10% of the liquid volume. To minimize shrinking of organisms from dehydration, samples can be transferred to 80% alcohol after several days or one week.

Make sure that the bottle is labelled with all the pertinent key identifiers for each vial, including: Stream Code, Site Code, Sample, Date, and Collection area. If you must place a label inside the container, do not use plastic paper or “Rite in the Rain”, as these contain chemicals that interfere with DNA storage and extraction. Store the sample bottle at room temperature.

Marchant Box Method

The preferred sub-sampling device is a modified Marchant design consisting of a tight sealing box that is divided into 100 cells. A size of approximately 27 x 27 x 15 cm works well. Wash the sample from the sieve into the Marchant Box and fill with water to a depth just below the height of the walls dividing the cells. Water depth is important. In the case of live samples, water deeper than the dividing walls will allow animals to swim between the cells once the contents have been randomized. Less water will make it difficult to distribute the sample among the 100 cells. Close and fasten the lid. Invert and gently mix the sample with side-to-side rocking motions. Right the box quickly and set on a level surface to let contents settle into cells. Using random numbers for the 10 columns and 10 rows, randomly select one or more cells and transfer contents to a suitable container for sorting/identification using a pipette (or turkey baster), vacuum pump or aspirator and suction flask, or similar method.

The cell-extraction method used for Marchant sub-sampling strongly influences sample-processing time. Consider the costs of more sophisticated equipment such as aspirators, pumps, suction flasks, and tubing in relation to the improved efficiency resulting from their use. Using an aspirator and suction flask may be the best balance between minimal cost and extraction efficiency.

Under a microscope or from an open pan, pick out organisms using either fine tweezers or an eyedropper. Identify each organism to the taxonomic level desired using diagnostic characteristics (see S2.Appendix 2: Guide to Coarse-level Benthic-invertebrate Identification or published keys (e.g. Voshell 2002). Record the abundance on the Benthic Tally Sheet or a customized tally sheet[2]. If samples are to be archived, place the identified organisms into one or more sample jars containing preservative (generally 70% alcohol). Search each sub-sample thoroughly. To gain confidence in knowing "when to stop" have a colleague check the sample. They should not be able to find an organism within a minute of searching.

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

Animals that cannot be identified should not be included in the tally. They should be set aside and identified by an expert. To be counted, a specimen must have enough intact body parts to permit its identification and it must have a head. In biomonitoring surveys, larval husks and empty shells and cases are not counted.

Continue processing sub-samples until 100 animals have been picked or the whole sample has been picked. **Pick the entire sub-sample that contains the 100th animal**. This ensures that the samples are not biased toward larger animals.

Example: One spoonful of material provided 50 organisms. A second spoonful provided 62 organisms. The sampling can be terminated after the second spoonful has been processed because greater than 100 organisms was obtained in the two complete sub-samples.

If identification is carried out on preserved samples, the taxonomist will record the organisms present on a tally sheet to the level of taxonomy specified by the project objectives. Record the number of each type of organism in the appropriate boxes on the data form.

3.6 Determining the Percent of Sample Processed

Weigh or measure the total sample and record as 'Total Vol/Wt' under 'Sample Size', also indicate the units used for sample size (e.g. ml or gm). Since this measure is used to determine the relative portion of the sample that was identified, the water can be decanted or included in the weight/volume measurement depending on the option selected for processing the benthos sample (i.e. preserved or live). However, it is critical that the sample be measured in the same state (e.g. water decanted versus water not decanted), prior to and after processing.

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[2] A customized tally sheet will reflect the level of precision employed in the study and the expected taxa that will be found in a sample. Leave space to add new taxa.

Once sorting is completed, measure (weight or volume) the remaining sample and record this measurement in the 'Vol/Wt Not Picked' box if the sample was not split. If the sample was split, the 'Portion Not Picked' will be the total of the weight or volume of the remaining kick sample in addition to the weight or volume of the portion that was discarded (i.e. recorded in comments on the Benthic Tally Sheet).

Example: 1000 ml of kick sample (and water) was measured. More than 500 organisms were observed, so the sample was split and 500 ml of kick sample (and water) was discarded in the stream. After 112 organisms were identified, 100 ml of sample (and water) remains. The 'Portion Not Picked' equals 600 ml (500 ml +100 ml).

This information is used to estimate invertebrate abundance in the sampling area. On the Benthic Tally Sheet, check the box for 'Field' or 'Lab' depending on the location where benthos are identified, and indicate whether a microscope was used to aid in identification. Also indicate whether the sample was preserved and the number of vials the sample was archived in.

3.7 Documenting potential sources of variance to benthic communities from local sources

The attributes described in this section are mandatory for OBBN contributors and should also be considered beneficial to other practitioners as a means of describing factors that could also affect benthic community metrics of a sample site. Record these data one the 'Benthic Survey Sheet' (see Appendix I for an example).

3.7.1 Visual based Substrate Samples

Traditionally, stream surveyors recorded the dominant and subdominant substrate composition visually. These data provide a means of assessing conditions across a larger study area and at present it is not well understand whether these measures provide greater explanatory power to recent measures that utilize a pebble count (see Section 4.2 below). Therefore, practitioners are asked to record both for now.

Record the dominant and second dominant substrate types in the 'Substrate' section. Dominant substrate types can be determined by visual estimation, the rapid assessment methodology (S4.M8), or the substrate portion of S4.M2. Substrate categories can be viewed in Table 1.

Table 1 - Substrate Class Categories

Class	Description
1	Clay
2	Silt (floury, <0.06 mm)
3	Sand (grainy, 0.06 – 2 mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 – 250 mm)
6	Boulder (>250mm)
7	Bedrock

3.7.2 Point Particle Substrate Measurement

For each collection area, randomly select and measure 10 substrate particles. A substrate particle should be selected by looking away and extending an index finger until a substrate particle is touched. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Benthic Survey Sheet; otherwise record the appropriate substrate size code found in Table 2. Measure the particle along its median axis (Figure 1); for very large particles measurements may be taken in the stream. Remove any undecomposed organic material (e.g. leaves, sticks), before making substrate measurements. Decomposed organic material should be classified as silt.

Median Axis
There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

Table 2: Substrate Descriptions and Size Categories.

Material	Description	Size to be Recorded
‘Unconsolidated Clay’	Very hard packed when dry and sticky when wet	‘0.01’
‘Consolidated Clay’	Hard even when wet, slippery, gray in colour, often laminated	‘0.011’
‘Silt’	Feels soft like a powder or flour	‘0.05’
‘Sand’	Gritty, sizes >0.05 and < 2 mm	‘0.10’
‘Bedrock’	Exposed bedrock	‘1111’
Measured particles	Between 2 mm and 1000 mm.	Median axis
‘Large Boulders’	> 1000 mm but not attached to bedrock	‘1001’

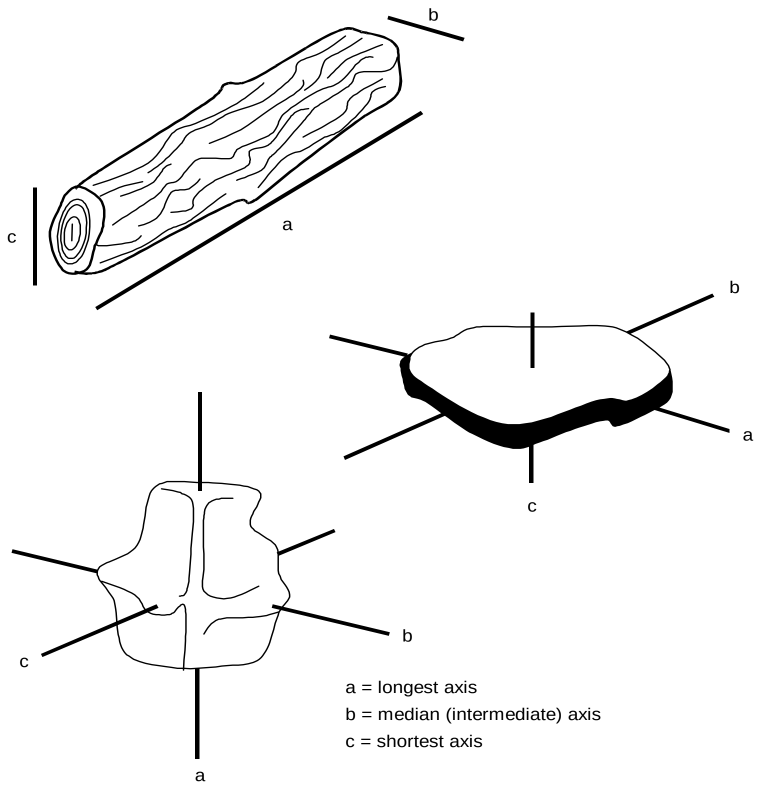

Figure 1: Measuring the Median Axis Cover and Substrate.

3.7.3 Aquatic Macrophytes and Algae

For each collection area, record the types of aquatic macrophytes and algae present. Classify each as; 0 (Absent), 1 (Present) or 2 (Abundant). For definitions see Table 3.

3.7.4 Measuring Bankfull Width

Record ‘Bankfull Width’ to the nearest tenth of a metre. If unfamiliar with bankfull indicators refer to S4.M3.

3.7.5 Riparian Vegetation Community

Observe the riparian vegetation community in zones 1.5-10 meters, 10-30 meters and 30-100 meters from the stream sampling reach. Indicate the dominant community in each zone for both the left and right banks in the ‘Riparian Vegetation Community’ section. Refer to Table 4 for community type descriptions.

Table 3 - Aquatic Macrophytes and Algae

Aquatic Vegetation Type	Description
Macrophytes	aquatic plants with obvious stems, leaves and roots
'Emergent'	rooted in substrate but part of plant extends above the water surface (e.g. cattails)
'Rooted Floating'	rooted in the substrate with floating leaves (e.g. water lilies)
'Submergent'	rooted in substrate and grow completely below surface of the water (e.g. milfoil)
'Free Floating'	float on the water surface or in the water column and are not rooted to the substrate (e.g. duckweed)
Algae	aquatic organisms containing chlorophyll and distinguished from plants by the absence of true roots, stems, and leaves
'Floating'	algae floating on the water surface or in the water column
'Filamentous'	green algae having a hair-like growth form (cells arranged in long filaments); slimy to the touch
'Attached'	algae attached to substrate (other than filamentous algae) (e.g. Chara); may form a slime or crust

3.7.6 Measuring Canopy Cover

Visually estimate the percent tree canopy shading the wetted area of the sampling reach (all three collection areas) or measure canopy cover using an appropriate instrument (e.g. densiometer). Record the '% Canopy Cover' as; 0-24%, 25-49%, 50-74% or 75-100%.

3.7.7 River Characterization

Indicate whether the stream has permanent or intermittent flow. If the flow permanence is unknown, check '*Unknown*'. Identifying the flow status of a stream can be challenging and can be determined if the stream has been classified by the local Ministry of Natural Resources office or Conservation Authority. Another option is to apply the Stream Permanency Handbook for South-central Ontario (Bergman, Irwin and Boos 2005) in unclassified areas.

3.7.8 Reference Sites

Indicate whether the site is a candidate reference site (i.e. it reflects least disturbed conditions in the sampled stream's ecoregion). If the site is a candidate reference site and the sampling is being conducted as part of the OBBN, collected invertebrate samples should be identified as precisely as possible (at least to the family level), preserve them and carry out appropriate quality assurance checks on the identifications and enumerations. Send the preserved sample to the OBBN Coordinator[3] for genus/species level identification.

Table 4 - Types of Vegetative Communities

Vegetative Community	Description
'None'	Over 75% of the ground surface is not vegetated.
'Lawn'	Grasses that are kept immature due to mowing.
'Cropped Land'	Planted in agricultural crops in most years; plants typically arranged in rows (machine-planted); may be tilled periodically.
'Meadow'	< 25% tree/shrub cover; characterized by grasses and forbs allowed to reach a mature state
'Scrubland'	> 25% and < 60% trees or shrubs interspersed with grasses and sedges (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height).
'Forest'	> 60% of the canopy is covered by the crowns of trees.
Wetland	Areas that are seasonally or permanently flooded and support vegetation adapted to the wet conditions.

4.0 TIPS FOR APPLYING THIS MODULE

Check snail, clam and caddisfly casings for the presence of animals. Count only animals, not empty cases.

Learn to characterize the organisms by their mode of movement: (swimming, crawling or flexing) and the morphological characteristics of each taxa that are diagnostic of the taxonomic membership.

5.0 DATA MANAGEMENT

Upon returning from the field;

1. Create backups of all data (field forms, photos, benthic data), and store in a place separate from the originals.

2. Enter the data directly into the OBBN database, or store data in an in-house database and arrange for bulk data upload to the OBBN database. Data can also be entered into FWIS where taxa identification remains at the 28 group level.
By storing the data digitally in a central database it can be shared with a large number of users province-wide.

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[3] Send samples to the attention of the OBBN Coordinator at: Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, P0A 1E0

6.0 ACKNOWLEDGEMENTS

Ongoing revisions to the traveling kick and sweep module continues to benefit from members of the Ontario Benthic Biomonitoring Network.

7.0 LITERATURE CITED

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Appendix 1

Example Benthic Survey Sheet

Benthic Survey Sheet

Mandatory Fields In Grey
Must be filled out for processing

Stream Code: WMI
Site Code: 3CDW
Sample: 01
Date (mm-dd): 2010 08 21
Time (24hr): 13:12

NOTE:
For all measurements, right and left banks defined facing upstream.

Stream Name: WILMOT CREEK

Water Quality

Water Temp (°C): 19.6
Conductivity (uS/cm): 364
pH: 7.2
DO (mg/L): 9.4
Alkalinity (mg/L as CaCO3): 6.2

Substrate

Enter dominant substrate class and second dominant class for each sub-sample.

	Collect. Area 1	Collect. Area 2	Collect. Area 3
Dominant	4	3	4
2nd Dominant	2	2	3

Class	Description
1	Clay (hard pan)
2	Silt (floury, <0.06 mm particle diameter)
3	Sand (grainy, 0.06 - 2mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (>250 mm)
7	Bed Rock

Bankfull Width (m): 6.7

Gear Type
☐ Poled Seine ☐ Ponar
☒ D-Net ☐ Ekman
☐ Surber ☐ Other :

Collection Method
☐ Rapid Survey
☐ Stationary Kick Survey
☒ Transect Kick & Sweep
☐ Grab

MeshSize (microns)
☐ 250 ☐ 600
☒ 500 ☐ 1000
(Select the box that most closely represents the mesh size used.)

% Canopy Cover
☐ 0 - 24 ☒ 50 - 74
☐ 25 - 49 ☐ 75 - 100
If instrument used, record type:

River Characterization
☒ Perennial
☐ Intermittent
☐ Unknown

Candidate Reference Site? (ie. minimally impacted)
☐ Yes
☒ No

Comments: DATA TO BE PROVIDED TO OBBN

Crew Leader (initial & last name): A ROSS

Aquatic Macrophytes & Algae

Enter appropriate abundance class for each type and sub-sample.

Pebble sizes (mm) use sizes from table 1

3.0	10	67	250	25
0.05	0.10	0.10	7	37

Macrophytes	Collect. Area 1	Collect. Area 2	Collect. Area 3
Emergent	2	0	2
Rooted Floating	0	0	0
Submergent	0	0	1
Free Floating	0	0	0

Algae	Collect. Area 1	Collect. Area 2	Collect. Area 3
Floating Algae	0	0	0
Filamentous	1	1	1
Attached Algae	0	1	0

Class	Description
0	Absent
1	Present
2	Abundant

Riparian Vegetation Community

Only check one box for each bank and zone.

Dominant Vegetation Type

	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands
1.5-10m	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐	☐
10-30m	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐
30-100m	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐

	Pool or Riffle (P/R)	Sampling Dist.(m)	Sampling Time (min : sec)	Max. Depth (mm)	Hydraulic Head (mm)	Wetted Width (m)	Grabs/ Area
Collection Area 1:	R	3.5	3:01	37	15	3.5	1
Collection Area 2:	P	3.2	3:10	120	0	3.7	1
Collection Area 3:	R	3.7	2:56	43	10	3.4	2

Enter a P or an R to indicate whether the collection was a riffle or pool.

1, 2, or 3 grabs can be collected within each collection area.

Crew Names: J. BYE

Recorder Init.	Entered	Verified	Corrected
JB	2010/10/10 AC	2010/10/11 JB	2010/10/12 JB

Appendix 2

Example Benthic Tally Sheet

Benthic Tally Sheet

Mandatory Fields in Grey
Must be filled out for processing

Date (yyyy-mm-dd): 2010-08-21

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3CDW

Sample: 01

Collection Area: 01

Survey Type ☐ Rapid ☐ Stationary Kick

Habitat Sampled ☒ Riffle ☐ Pool

Stream Width (m): 3.5

Water Depth (mm): 37

Hydraulic Head (mm): 15

Sampling Time (sec): 181

Unknown Species

Comments: SAMPLE TO BE IDENTIFIED TO GENUS IN LAB LATER IN THE YEAR. SAMPLE PICKED LIVE.

Net Type
☐ Square
☐ Surber
☒ D-net

Mesh Size (microns)
☒ 251-500
☐ 501-1000

Sample Preserved? ☒ Yes ☐ No

No. of Vials: 01

Sorting Method
☒ Unsorted
☐ Marchant Box
☐ Splitter

Sample Size ☐ mL ☒ g

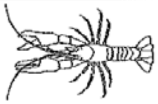
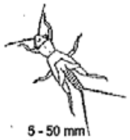
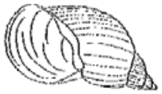
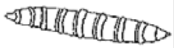
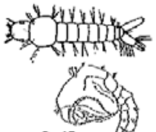
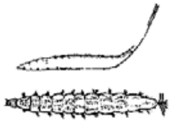
Total Vol/Wt: 1050

Vol/Wt not Picked: 400

Identification
☐ In Field
☒ in Lab
☒ Microscope
☐ no Microscope

Median sizes of 10 substrate particles randomly chosen from collection area (mm).

3	18	21	61	19
0.01	0.10			

 2 - 25 mm **Hydrozoa** (Hydra)	 5 - 20 mm **Platyhelminthes** (Flatworms)	 1 - 10 mm **Nemata** (Roundworms/Threadworms) 1	 1 - 30 mm **Oligochaeta** (Aquatic Earthworms)	 5 - 300 mm **Hirudinea** (Leeches)	 5 - 200 mm **Isopoda** (Aquatic Sowbugs) 4	 2 - 250 mm **Bivalvia** (Clams) 3	 5 - 20 mm **Amphipoda** (Scuds) 4	 10 - 150 mm **Decapoda** (Crayfish)
 1 - 7 mm **Acari** (Aquatic Mites) 3	 3 - 30 mm **Ephemeroptera** (Mayflies) ☒ ☒ 25	 15 - 45 mm **Anisoptera** (Dragonflies) 2	 10 - 25 mm **Zygoptera** (Damselflies)	 5 - 50 mm **Plecoptera** (Stoneflies) ☒ ☒ 22	 15 - 40 mm **Hemiptera** (True Bugs) 2	 25 - 90 mm **Megaloptera** (Fishflies) 4	 2 - 50 mm **Trichoptera** (Caddisflies) ☒ ☒ ☒ 30	 10 - 25 mm **Lepidoptera** (Aquatic Moths)
 2 - 40 mm **Coleoptera** (Beetles) ☒ 13	 2 - 70 mm **Gastropoda** (Snails)	 2 - 20 mm **Chironomidae** (Midges) ☒ 19	 15 - 40 mm **Tabanidae** (Horse & Deer Flies) 4	 2 - 15 mm **Culicidae** (Mosquitos)	 3 - 15 mm **Ceratopogonidae** (No-see-ums) 5	 10 - 50 mm **Tipulidae** (Crane Flies) 2	 3 - 15 mm **Simuliidae** (Black Flies)	 **Misc. Diptera** (Misc. True Flies) 4

Dot Tally (track total no. sampled) ☒ ☒ ☒ ☒
☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒

Crew Leader (init. & last name): R YAN

Crew Init.	Recorder Init.	Entered	Verified	Corrected
KS	SS	KS	SB	KS

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 3

Fish Community Assessment

TABLE OF CONTENTS

Module Code	Title	Type
S3.M1	Fish Community Sampling using Screening, Standard and Multiple Pass Electrofishing Techniques	Screening Surveys, Assessment Surveys and Diagnostic Surveys for some variables
S3.M2	Fish Community Sampling using Seining Techniques	Screening Surveys, Assessment Surveys and Diagnostic Surveys for some variables

APPENDIX

1.0 INTRODUCTION

The modules in this section provide standard methodologies for assessing fish communities in wadeable streams. Depending on the technique used and the level of effort applied, the data generated can be used to assess the presence or absence of target species, assess the overall fish community and calculate various metrics (e.g. Catch-per-unit effort (CPUE), Biomass-per-unit effort (BPUE), species richness etc.), or determine population estimates. Providing standard methodologies that vary in the accuracy of the data collected and that can target a variety of habitats offers flexibility for users to accommodate different study designs.

A summary of the procedures, the effort required implementing them, and the accuracy of the data collected for each is provided below. Additional details are provided in the introduction section of each module.

Accepted standard protocols in this section include:

S3.M1: Fish Community Sampling using Screening, Standard and Multiple Pass Electrofishing Techniques

In this module, three standard approaches (screening, single pass standard and multiple pass removal) are described that vary in the amount of sampling effort required. Since the approaches are very similar, they are described in one module.

The standard approaches are recommended for use in wadeable, hard-bottomed streams. Each approach requires that all habitats within the site boundaries are sampled. For maximum efficiency, water levels should be near baseflow conditions. Winter sampling poses additional problems such as ice build-up on equipment.

This module complements the Ontario Ministry of Natural Resources (OMNR) Backpack (Class II) electrofishing course and the provincial electrofishing policy (Electrofishing Equipment and Operating Guidelines and Procedures, OMNR Official Procedure Manual FI.3.01.01). Surveyors must meet all of the guidelines and safety requirements applicable to their office when conducting electrofishing surveys.

S3.M2: Fish Community Sampling using Seining Techniques

This module describes how to use and document fish surveys conducted with a seine net. Seining is a widely used technique to collect information on stream fish communities and assess populations in specific habitat types. It is popular because it is non-lethal, can be performed relatively quickly using inexpensive equipment and requires minimal training. The method can be applied individually or as a supplemental methodology to electrofishing to ensure all habitat types in a site are effectively sampled.

Appendix 1

OMNR Fish Species Codes and Common Names

ONTARIO MINISTRY OF NATURAL RESOURCES FISH SPECIES CODES & COMMON NAMES[1]

000.Unknown (UNKN)..........

PETROMYZONTIDAE - Lampreys - (LAMPR) - 010
016. Chestnut Lamprey (ChLam) . *Ichthyomyzon castaneus*
012. Northern Brook Lamprey (NBLam)*Ichthyomyzon fossor*
013. Silver Lamprey (SiLam)..........*Ichthyomyzon unicuspis*
011. American Brook Lamprey (ABLam)*Lethenteron appendix*
014. Sea Lamprey (SeLam) ....*Petromyzon marinus*
015. (IchSp) ....*Ichthyomyzon* sp.

POLYODONTIDAE - Paddlefishes - (PADDL) - 020
021. Paddlefish (Paddl)..........*Polyodon spathula*

ACIPENSERIDAE - Sturgeons - (STURG) - 030
031. Lake Sturgeon (LaStu) ....*Acipenser fulvescens*

AMIIDAE - Bowfins - (BOWFI) - 050
051. Bowfin (Bowfi)..........*Amia calva*

LEPISOSTEIDAE - Gars - (GARS) - 040
042. Spotted Gar (SpGar) ....*Lepisosteus oculatus*
041. Longnose Gar (LnGar) ....*Lepisosteus osseus*
044. Florida Gar (FlGar)............ *Lepisosteus platyrhinchus*
043. (LptSp).......... *Lepisosteus* sp.

ANGUILLIDAE - Freshwater Eels - (EELS) - 250
251. American Eel (AmEel)..........*Anguilla rostrata*

CLUPEIDAE - Herrings - (HERRI) - 060
061. Alewife (Alewi) ....*Alosa pseudoharengus*
062. American Shad (AmSha)..........*Alosa sapidissima*
063. Gizzard Shad (GiSha) ....*Dorosoma cepedianum*
064. (AloSp).......... *Alosa* sp.

HIODONTIDAE - Mooneyes - (MOONE) - 150
151. Goldeye (Golde)..........*Hiodon alosoides*
152. Mooneye (Moone)..........*Hiodon tergisus*

SALMONIDAE ....salmon, trout, whitefishes, grayling
400. (Hy400)..........hybrids

SALMONINAE - Salmon, Trout subfamily - (SA_TR) - 070
071. Pink Salmon (PiSal) ....*Oncorhynchus gorbuscha*
072. Chum Salmon (CmSal) ....*Oncorhynchus keta*
073. Coho Salmon (CoSal) .... *Oncorhynchus kisutch*
076. Rainbow Trout (RaTro) ....*Oncorhynchus mykiss*
074. Sockeye Salmon (SoSal) .... *Oncorhynchus nerka*
075. Chinook Salmon (ChSal). *Oncorhynchus tshawytscha*
077. Atlantic Salmon (AtSal) .... *Salmo salar*
078. Brown Trout (BwTro)..........*Salmo trutta*
079. Arctic Char (ArCha)..........*Salvelinus alpinus*
080. Brook Trout (BkTro) ....*Salvelinus fontinalis*
083. Aurora Trout (AuTro)......... *S. fontinalis timagamiensis*
081. Lake Trout(LaTro)……………….*Salvelinus namaycush*
082. Splake (Splak)................*S. fontinalis x S. namaycush*
422. Tiger Trout ....*Salmo trutta* X *Salvelineus fontinalis*
084. (OncSp) ....*Oncorhynchus* sp.
085. (SalSp).......... *Salmo* sp.
086. (SlvSp) .... *Salvelinus* sp.
420. (Hy420)………………………..Salmon & Trout hybrids

COREGONINAE - Whitefish subfamily - (WHITE) - 090
093. Cisco (Lake Herring)((LaHer) ....*Coregonus artedi*
091. Lake Whitefish (LaWhi) ....*Coregonus clupeaformis*
094. Bloater (Bloat).......... *Coregonus hoyi*
095. Deepwater Cisco (DwCis) .... *Coregonus johannae*
096. Kiyi (Kiyi)..........*Coregonus kiyi*
097. Blackfin Cisco (BfCis)................*Coregonus nigripinnis*
099. Shortnose Cisco (SnCis) ....*Coregonus reighardi*
100. Shortjaw Cisco (SjCis) .... *Coregonus zenithicus*
101. Pygmy Whitefish (PyWhi).............*Prosopium coulterii*
102. Round Whitefish (RoWhi)..... *Prosopium cylindraceum*
103. Chub (Chub)…….. (Cisco species other than *C. artedi*)
106. (CorSp)…………………………………..*Coregonus* sp.
107. (ProSp) .... *Prosopium* sp.
450. (Hy450)………………………………Whitefish hybrids

THYMALLINAE - Grayling subfamily - (GRAYL) - 110
111. Arctic Grayling (ArGra)..........*Thymallus arcticus*

OSMERIDAE - Smelts - (SMELT) - 120
121. Rainbow Smelt (RaSme)..........*Osmerus mordax*

ESOCIDAE - Pikes and Mudminnows - (PIKES) - 130
133. Grass Pickerel (GrPic) *Esox americanus vermiculatus*
131. Northern Pike (NoPik) .... *Esox lucius*
132. Muskellunge (Muske) .... *Esox masquinongy*
135. Chain Pickerel (ChPic) .... *Esox niger*
134. (EsoSp).......... *Esox* sp.
500. (Hy500)……………………………………..Pike hybrids
501. (Hy501) ..*Esox lucius x Esox americanus vermiculatus*
502. Norlunge (Hy502).....*Esox lucius x Esox masquinongy*

Mudminnows - (MUDMI) - 140
141. Central Mudminnow (CeMud) .... *Umbra limi*

CYPRINIDAE - Carps and Minnows - (Ca_MI) - 180
216. Central Stoneroller (CeSto) .. *Campostoma anomalum*
181. Goldfish (Goldf) .... *Carassius auratus*
184. Redside Dace (RsDac)............*Clinostomus elongatus*
185. Lake Chub (LaChu) ....*Couesius plumbeus*
219. Grass Carp (GrCar)............ *Ctenopharyngodon idella*
203. Spotfin Shiner (SfShi) ....*Cyprinella spiloptera*
186. Common Carp (CoCar) .... *Cyprinus carpio*
187. Gravel Chub (GrChu) ....*Erimystax x-punctata*
188. Cutlip Minnow (ClMin) ....*Exoglossum maxillingua*
189. Brassy Minnow (BrMin) ....*Hybognathus hankinsoni*
190. Eastern Silvery Minnow (ESMin) . *Hybognathus regius*
217. Striped Shiner (StShi)............. *Luxilus chrysocephalus*
198. Common Shiner (CoShi).......... *Luxilus cornutus*
205. Redfin Shiner (ReShi)..........*Lythrurus umbratilis*
191. Silver Chub (SiChu)............. *Macrhybopsis storeriana*
214. Northern Pearl Dace (PeDac).. *Margariscus nachtriebi*
192. Hornyhead Chub (HdChu) ....*Nocomis biguttatus*
193. River Chub (RiChu) .... *Nocomis micropogon*
194. Golden Shiner (GoShi) .... *Notemigonus crysoleucas*
195. Pugnose Shiner (PnShi) ....*Notropis anogenus*
196. Emerald Shiner (Emshi)............ *Notropis atherinoides*
197. Bridle Shiner (BrShi)..........*Notropis bifrenatus*
218. Ghost Shiner (GhShi) .... *Notropis buchanani*
199. Blackchin Shiner (BcShi) ....*Notropis heterodon*
200. Blacknose Shiner (BnShi)............ *Notropis heterolepis*
201. Spottail Shiner (SpShi) .... *Notropis hudsonius*
215. Silver Shiner (SiShi) .... *Notropis photogenis*
202. Rosyface Shiner (RoShi) .... *Notropis rubellus*
204. Sand Shiner (SaShi).......... *Notropis stramineus*
206. Mimic Shiner (MiShi) ....*Notropis volucellus*
207. Pugnose Minnow (PnMin).........*Opsopoeodus emiliae*
182. Northern Redbelly Dace (NRDac).......*Chrosomus eos*
183. Finescale Dace (FsDac) .... *Chrosomus neogaeus*
208. Bluntnose Minnow (BnMin)...........*Pimephales notatus*
209. Fathead Minnow (FhMin)...........*Pimephales promelas*
210. Blacknose Dace (BnDac)............*Rhinichthys atratulus*
211. Longnose Dace (LnDac).........*Rhinichthys cataractae*
220. Rudd (Rudd)..........*Scardinius erythrophthalmus*
212. Creek Chub (CrChu)............*Semotilus atromaculatus*
213. Fallfish (Fallf)..........*Semotilus corporalis*
222. (HygSp)..........*Hybognathus* sp.
228. (HybSp) .... *Hybopsis* sp.
229. (LuxSp)..........*Luxilus* sp.
223. (NocSp) .... *Nocomis* sp.
224. (NotSp)..........*Notropis* sp.
221. (PhoSp)..........*Chrosomus* sp.
225. (PimSp) ....*Pimephales* sp.
226. (RhiSp)..........*Rhinichthys* sp.
227. (SemSp) .... *Semotilus* sp.
600. (Hy600)…………………………………Minnow hybrids
601. (Hy601)…………*Carassius auratus x Cyprinus carpio*
602. (Hy602) .... *Chrosomus* hybrids
603. (Hy603) ....*Chrosomus eos x Chrosomus neogaeus*
604. (Hy604) ....*Chrosomus eos x Margariscus nachtriebi*
605. (Hy605)*Chrosomus neogaeus x Margariscus nachtriebi*
610. (Hy610) .... *Notropis* hybrids
611. (Hy611) ....*Luxilus cornutus x Notropis rubellus*
612. (Hy612) ...*Luxilus cornutus x Semotilus atromaculatus*
620. (Hy620) .. *Pimephales promelas x Pimephales notatus*

CATOSTOMIDAE - Suckers - (SUCKE) - 160
162. Longnose Sucker (LnSuc) .....*Catostomus catostomus*
163. White Sucker (WhSuc) ....*Catostomus commersonii*
161. Quillback (Quill) .... *Carpiodes cyprinus*
164. Lake Chubsucker (LaChs)................*Erimyzon sucetta*
165. Northern Hog Sucker (NHSuc) . *Hypentelium nigricans*
166. Bigmouth Buffalo (BmBuf) ....*Ictiobus cyprinellus*
174. Black Buffalo (BlBuf)..........*Ictiobus niger*
167. Spotted Sucker (SpSuc) ....*Minytrema melanops*
168. Silver Redhorse (SiRed)...........*Moxostoma anisurum*
173. River Redhorse (RiRed) ....*Moxostoma carinatum*
169. Black Redhorse (BlRed) .... *Moxostoma duquesnei*
170. Golden Redhorse (GoRed)..... *Moxostoma erythrurum*
171. Shorthead Redhorse(ShRed) *Moxostoma macrolepidotum*
172. Greater Redhorse (GrRed). *Moxostoma valenciennesi*
176. (CatSp).......... *Catostomus* sp.
177. (MoxSp)..........*Moxostoma* sp.
178. (ItbSp) ....*Ictiobus* sp.
550. (Hy550)…………………………………..Sucker hybrids
551. (Hy551) .... *Ictiobus* hybrids

ICTALURIDAE - Bullhead Catfishes - (CATFI) - 230
231. Black Bullhead (BlBul).......... *Ameiurus melas*
232. Yellow Bullhead (YeBul) ....*Ameiurus natalis*
233. Brown Bullhead (BrBul) ....*Ameiurus nebulosus*
234. Channel Catfish (ChCat)...............*Ictalurus punctatus*
235. Stonecat (Stone) ....*Noturus flavus*
236. Tadpole Madtom (TaMad) ....*Noturus gyrinus*
237. Brindled Madtom (BrMad)..........*Noturus miurus*
238. Margined Madtom (MaMad) ....*Noturus insignis*
244. Northern Madtom (NoMad)........... *Noturus stigmosus*
239. Flathead Catfish (FhCat) ....*Pylodictis olivaris*
241. (IctSp)..........*Ictalurus* sp.
242. (NtuSp)..........*Noturus* sp.
243. (AmeSp)..........*Ameiurus* sp.
650. (Hy650)………………………..Bullhead Catfish hybrids
651. (Hy651) ....*Ameiurus melas x Ameiurus nebulosus*

PERCOPSIDAE - Trout-perches - (TROUT) - 290
291. Trout-perch (TrPer).............*Percopsis omiscomaycus*

GADIDAE - Cods - (CODS) - 270
271. Burbot (Burbo)..........*Lota lota*

FUNDULIDAE – Topminnows/Killifishes - (KILLI) - 260
261. Banded Killifish (BaKil)................*Fundulus diaphanus*
262. Blackstripe Topminnow (BsTop) ...... *Fundulus notatus*

ATHERINIDAE - Silversides - (SILVE) - 360
361. Brook Silverside (BrSil)..............*Labidesthes sicculus*

GASTEROSTEIDAE - Sticklebacks - (STICK) - 280
284. Fourspine Stickleback (FoSti) ....*Apeltes quadracus*
281. Brook Stickleback (BrSti) .... *Culaea inconstans*
282. Threespine Stickleback (ThSti)*Gasterosteus aculeatus*
283. Ninespine Stickleback (NiSti).........*Pungitius pungitius*

COTTIDAE - Sculpins - (SCULP) - 380
381. Mottled Sculpin (MoScu)..........*Cottus bairdii*
382. Slimy Sculpin (SlScu)..........*Cottus cognatus*
383. Spoonhead Sculpin (ShScu)..........*Cottus ricei*
384. Deepwater Sculpin(DwScu)*Myoxocephalus thompsonii*
387. Fourhorn Sculpin (FhScu)*Myoxocephalus quadricornis*
385. (CotSp).......... .*Cottus* sp.
386. (MyoSp).......... .*Myoxocephalus* sp.
800. (Hy800)…………………………………Sculpin hybrids
801. (Hy801)..................... *Cottus bairdi x Cottus cognatus*

CYCLOPTERIDAE - Lumpfishes - (LUMPS) - 390
391. Lumpfish (Lumpf).......... *Cyclopterus lumpus*

MORONIDAE - Temperate Basses - (BASSE) - 300
301. White Perch (WhPer)..........*Morone americana*
302. White Bass (WhBas).......... *Morone chrysops*
303. (MorSp)..........*Morone* sp.

CENTRARCHIDAE - Sunfishes - (SUNFI) - 310
311. Rock Bass (RoBass)..........*Ambloplites rupestris*
312. Green Sunfish (GrSun) .... *Lepomis cyanellus*
313. Pumpkinseed (Pumpk)..........*Lepomis gibbosus*
323. Warmouth (Warmo) ....*Lepomis gulosus*
324. Orangespotted Sunfish (OsSun) ....*Lepomis humilis*
314. Bluegill (Blueg)..........*Lepomis macrochirus*
315. Northern Sunfish (LeSun) ....*Lepomis peltastes*
316. Smallmouth Bass (SmBas) ....*Micropterus dolomieu*
317. Largemouth Bass (LmBas) ......*Micropterus salmoides*
318. White Crappie (WhCra).......... *Pomoxis annularis*
319. Black Crappie (BlCra) ....*Pomoxis nigromaculatus*
320. (LepSp).......... *Lepomis* sp.
321. (MicSp) .... *Micropterus* sp.
322. (PomSp) ....*Pomoxis* sp.
700. (Hy700)…………………………………Sunfish hybrids
701. (Hy701)..........*Lepomis* hybrids
702. (Hy702)......*Lepomis gibbosus x Lepomis macrochirus*
703. (Hy703).......... *Lepomis cyanellus x Lepomis gibbosus*
704. (Hy704).......... *Lepomis cyanellus x Lepomis peltastes*
705. (Hy705)..... *Lepomis cyanellus x Lepomis macrochirus*
706. (Hy706) *Pomoxis annularis x Pomoxis nigromaculatus*

PERCIDAE – Perch and Darter Family - (PERCH) - 330
335. Eastern Sand Darter (ESDar) ...*Ammocrypta pellucida*
336. Greenside Darter (GsDar)......*Etheostoma blennioides*
337. Rainbow Darter (RaDar) .... *Etheostoma caeruleum*
338. Iowa Darter (IoDar) .... *Etheostoma exile*
339. Fantail Darter (FtDar)................ *Etheostoma flabellare*
340. Least Darter (LeDar)............. *Etheostoma microperca*
341. Johnny Darter (JoDar) ....*Etheostoma nigrum*
346. Tessellated Darter (TeDar) .... *Etheostoma olmstedi*
350. Ruffe (Ruffe).......... *Gymnocephalus cernua*
331. Yellow Perch (YePer).......... *Perca flavescens*
342. Logperch (Logpe) ....*Percina caprodes*
343. Channel Darter (ChDar).......... *Percina copelandi*
344. Blackside Darter (BsDar) .... *Percina maculata*
345. River Darter (RiDar)..........*Percina shumardi*
332. Sauger (Sauge) .... *Sander canadensis*
333. Blue Pike (BlPik)..................... *Sander vitreus glaucus*
334. Walleye (yellow pickerel) (Walle) ....*Sander vitreus*
351. Johnny/Tesselated darter (Hy351) *Etheostoma nigrum/ Etheostoma olmstedi*
347. (SanSp) .... *Sander* sp.
348. (EthSp) ....*Etheostoma* sp.
349. (PerSp) ....*Percina* sp.
750. (Hy750)……………………………………Perch hybrids
751. (Hy751)..............*Sander canadensis x Sander vitreus*

SCIAENIDAE – Drum Family - (DRUMS) - 370
371. Freshwater Drum (FwDru) .... *Aplodinotus grunniens*

GOBIIDAE - Gobies - (GOBIE) - 365
366. Round Goby (RoGob).........*Neogobius melanostomus*
367. Freshwater Tubenose Goby (TnGob) .... *Proterorhinus semilunaris*

PLEURONECTIDAE - Righteye Flounders -
396. European Flounder (EuFlo).............*Platichthys flesus*

ONTFISH.DOC, April 29, 2013

[1] Formatted by Karen Ditz, Ichthyology and Herpetology, Royal Ontario Museum, May 1994. Reformatted and modified (name changes according to Page, L.M., H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, N.E. Mandrak, R.L. Mayden, and J.S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 34, Bethesda, Maryland. 243 p.) by Melanie Croft-White, 2013.

Adapted from:

D. P. Dodge, G. A. Goodchild, J. C. Tilt, and D. C. Waldriff. 1984. MNR's Manual of Instructions - Aquatic Habitat Inventory Surveys.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 3: MODULE 1

Fish Community Sampling Using Screening, Standard and Multiple Pass Electrofishing Techniques[1]

TABLE OF CONTENTS

APPENDICES

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[1] Author: L. W. Stanfield

1.0 INTRODUCTION

This module describes how to conduct electrofishing surveys. Electrofishing is a common technique used to collect information on stream fish communities or populations. It is popular because it is non-lethal, can be performed relatively quickly, can be applied in a standardized way, and most fish are vulnerable to the gear.

In this module, three standard approaches are described that vary in the amount of sampling effort required. Since the approaches are very similar, they are described in one module. A brief overview of the three approaches is provided to assist in the selection of the appropriate method. Procedural differences are outlined in Section 3.1, Differences in Sampling Approaches.

The standard approaches are recommended for use in wadeable, hard-bottomed streams. Each approach requires that all habitats within the site boundaries are sampled. Water levels should be near baseflow conditions for maximum efficiency. Winter sampling poses additional problems such as ice build-up on equipment.

The completion of S1.M1- Defining Site Boundaries and Key Identifiers and S1.M2 - Screening Level Site Documentation or S1.M3 - Assessment Procedures for Site Feature Documentation, are mandatory when using this module. This module should also be done in conjunction with S1.M6 - Tracked Species in order to record incidental observations of invasive, sensitive and indicator species.

This module complements the Ontario Ministry of Natural Resources (OMNR) Backpack (Class II) electrofishing course and the provincial electrofishing policy (Electrofishing Equipment and Operating Guidelines and Procedures, OMNR Official Procedure Manual FI.3.01.01). Surveyors must meet all of the guidelines and safety requirements applicable to their office when conducting electrofishing surveys.

Screening Survey:

This approach is used to generate a list of the common fish species at a site. This approach characterizes fish communities at the site provided all habitats are sampled. It also provides a qualitative assessment of species abundance at a site.

This approach does not provide quantitative estimates of population abundance and should not be used when a comprehensive species list is required. In light of the low sampling effort, there is a high probability that rare species will not be captured. The screening survey methodology is not recommended for ‘trend through time’ surveys.

Standard Single Pass Survey:

This approach can be used to produce a comprehensive fish species list for a site. It will characterize the fish community and provide a qualitative assessment of species abundance at the site.

In some situations, this approach can also be used to determine salmonine biomass and/or population size. The biomass/population size must be previously calibrated, using the Multiple Pass Survey. Sixty percent of the population must be captured in the Standard Single Pass Survey. This approach has been shown to be effective in determining salmonine biomass in waters with high conductivity using well trained crews (Jones and Stockwell 1995). If these conditions cannot be met, the multiple pass survey is recommended for determination of salmonine biomass/populations.

Multiple Pass Survey:

Standard three-pass removal surveys (e.g., Zippen 1958) are used to estimate population size of individual fish species at a site. These surveys produce lower variances in catches than single pass surveys. This provides the ability to detect differences in catches over time or between sites. Assumptions of this approach and ways to address them are:

1. Emigration from and immigration to the site must be negligible. Block (barrier) nets placed at the top and bottom of the site will ensure this condition is met.

2. The probability of capture during a pass is the same for each fish. Applying appropriate sampling effort (see Section 3.2, Electrofishing Survey Methods) and sampling all habitats within a site will help. Attempt to capture all fish observed with equal intensity, regardless of species or size.

3. The probability of capture remains constant between passes. Using the same effort (measured as shocker seconds) and crew on each pass will ensure that this condition is met.

This approach maximizes the probability of obtaining declining catches with each pass. Population estimates can then be calculated for all species and age groups. This approach also offers the greatest probability of capturing all species within a site. When catches do not decline (due to lower catchability rates for some species, Mahon 1980), catch per unit effort can be derived.

Use of Block (Barrier) Nets

Blocknets must be used during Multiple Pass Surveys and may be used for Single Pass Surveys. To install blocknets, pound T-bars or poles into the stream bottom at the top and bottom of the site. Place the net on the upstream side of the poles and tie it well above the water level. The net should be anchored to the stream bottom with materials heavy enough to prevent it from being lifted as debris collects in the net (and increases the drag). Surveyors should ensure that there are no escape routes. Minimize disturbance by not walking into the sample site except where necessary. Do not take any boulders for anchoring the net from within the site.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two to five people. The number varies depending on the technique used, the size of the stream and the abundance of fish that will be sampled.

Pre-field activities should include:

- Obtaining a "Licence to Collect Fish for Scientific Purposes" from OMNRF (see OSAP General Introduction for additional details).
- Obtain any other authorizations that may be required (e.g. *Endangered Species Act, 2007* (ESA) and/or *Species at Risk Act*). (see OSAP General Introduction for additional details).
- Landowner contact
- Documentation of site access and appropriate stream identifiers (see S1,M2 and S1.M3)
- Equipment check

The following equipment is required[2]:

1. Fish Sampling form(s) on waterproof paper (if possible)
2. Pencils
3. Backpack electrofisher
4. Charged batteries or gasoline, as appropriate

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[2] It is recommended that crews take backup equipment as this type of survey often results in frequent breakdowns, especially with batteries, electrofishers, nets, and weighing scales.

5. Anode pole
6. Electrofishing nets (2 or 3)
7. Chest waders for all crew members
8. Polarized glasses and hats for all crew members
9. Electrofishing gloves for all crew members
10. Aquarium dip nets (2-4)
11. Buckets for holding fish (6-10)
12. Bowl of sufficient size for weighing fish
13. Weighing scales (different capacities)
14. Plastic Volumetric container (doubles for weighing fish and volume displacement)
15. Measuring board
16. Sampling box with Whirl-Pak® bags
17. Collection labels
18. Preserving solution for specimens
19. Fish identification keys
20. Tape measure

Additional equipment for multiple pass surveys includes:

21. Seine or small mesh gill nets
22. Sufficient number of poles (T-bars) to span the stream with approximately 1 m spacing between poles
23. Pole driver or sledge hammer
24. Materials to anchor the bottom of the net to the stream bottom to prevent fish escape[3]

Optional items include cellular/satellite phone, spare anode ring and/or pole, tool kit with wrench and screw drivers, spare gloves and chest waders, wader repair kit, two to three buckets with screened sides for flow-through circulation or portable power source with water pump and hoses to circulate water and fish immobilizing agents.

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

Define and document the site boundaries and location following the procedures described in S1.M1, Site Identification and Documentation.

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[3] Boulders from outside the site or from the floodplain are the easiest to use for this task, but crews need to have alternatives for streams where these materials are not available.

3.1 Differences in Sampling Approaches

The main differences in the three sampling approaches are summarized in Table 1. Effort expended by field crews during a sampling pass greatly influences the outcome of the survey. Table 1 provides the basic sampling intensity guidelines for the three different protocols.

Table 1 - Sampling Techniques for Screening, Single Pass and Multiple Pass Electrofishing Surveys

Approach	Intensity	Effort	Blocknets	Survey Technique	Release of Fish
Screening	Single pass Low (2-5 sec/m^2)	20 to 30 min	Not used	Emphasis on coverage of all habitats	into site
Single Pass	Single pass High (7-15 sec/m^2)	45 min to 2 hrs	Optional	*Attempt to capture all fish observed and 60-70 % of entire population	into site
Multiple Pass	Multiple pass Moderate (5-10 sec/m^2)	3 to 8 hrs	Top and bottom	Attempt to capture 50-60 % of fish each pass	outside site

* In waters with low conductivity, it is unknown if this level of intensity/effort is sufficient to meet this criteria.

3.2 Electrofishing Survey Methods

Prior to starting the survey, enter the water 5 to 10 m downstream of the bottom of the site, adjust the settings on the electrofisher and test the electrofisher to ensure that it is working properly. Move to the bottom of the site. Zero the timer on the electrofisher, record the start time, shocker setting and begin sampling.

The anode operator usually carries the bucket with the fish while the netter(s) position themselves in escape routes, usually on either side of the anode. The amount of time spent in each habitat should be adjusted to optimize catche, however surveyors should ensure that shallower, less complex habitats are also sampled (see Figure 1).

Extra time should be spent sampling areas of instream cover (e.g., undercut banks, macrophyte beds, unembedded large rocks, and woody material) as these areas likely harbour fish.

Use only enough current to immobilize the fish. All fish should be netted and retained. Minimize the disturbance to instream habitat while electrofishing.

If a species protected under the ESA[4] is caught incidentally, it should immediately be returned to the waters from which it was caught and released in a manner that causes the least harm to the fish (unless otherwise authorized through a permit issued under the ESA or acting in accordance with conditions on a Licence to Collect Fish for Scientific Purposes). Incidental catches of all species at risk, including those listed as special concern, should be reported to the Natural Heritage Information Centre (NHIC)[5].

Standardization of Electrofishing Catches to Effort

In a study carried out on Wilmot Creek east of Toronto, Stanfield *et al.* (2012) found that an effort of 5 s/m^2 yielded an average catch that was 78 % of surveys conducted at the same sites at an effort of 15 s/m^2. Further, an asymptotic model effectively described the catch-effort relationship for salmonids, sculpins, dace and darters. Analysis demonstrated how travel time affects the trade-off between sampling many sites at low intensity or fewer sites at higher intensity. For developed areas where access is relatively easy and sites are wadeable the optimum electrofishing effort intensity is approximately 5 s/m^2. This optimum intensity will shift depending on the catchability of the taxa and large changes in the study's between-site travel time to site area ratio. These findings have been incorporated into standardization formulas within the Flowing Waters Information System to provide a means for practitioners to compare observed and standardized catches for the target taxa in this study. Extrapolation to other taxa not studied here is up to the discretion of project managers and should be tested in the future.

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[4] Species listed as extirpated, endangered or threatened on the Species at Risk in Ontario List (SARO List) are protected under the ESA. Refer to Ontario Regulation 230/08 for the SARO List.

[5] Report a SAR occurrence by calling (705) 755-2159 or visiting the NHIC website (https://www.ontario.ca/page/natural-heritage-information-centre).

The following techniques are useful when sampling different habitat types.

Technique 1: In very fast water (i.e., chutes), place the nets at obvious escape routes, making sure they touch the stream bottom. Then, place the anode approximately 1 to 1.5 m upstream of the nets. Turn the power on and draw the anode to the nets. Check the nets for fish. Repeat this process across the fast water.

Technique 2: In deep pools and log jams, experiment with different techniques to pull the fish towards the netter(s) (i.e., place anode ring on bottom of stream and pull up and towards the netter(s), or place the anode as far forward as safely possible and draw back).

Technique 3: In areas that have relatively uniform depth and substrate (e.g., shallow riffles and flats), and sufficient flow to draw the fish to the nets, begin sampling at one side and move across the stream at right angles to the flow. Move the anode in a regular pattern to cover all of the stream bottom within 1 m of the sampler (i.e. ).

Technique 4: To capture lamprey in silty backwater habitats, try pulsing the electrofisher (i.e., turning power on and off in rapid succession).

For multiple pass surveys, release all processed fish downstream of the site after they have been processed. Leave sufficient time between passes for the stream to stabilize (approximately one hour). The interval between passes can be used to enumerate and identify captured fish.

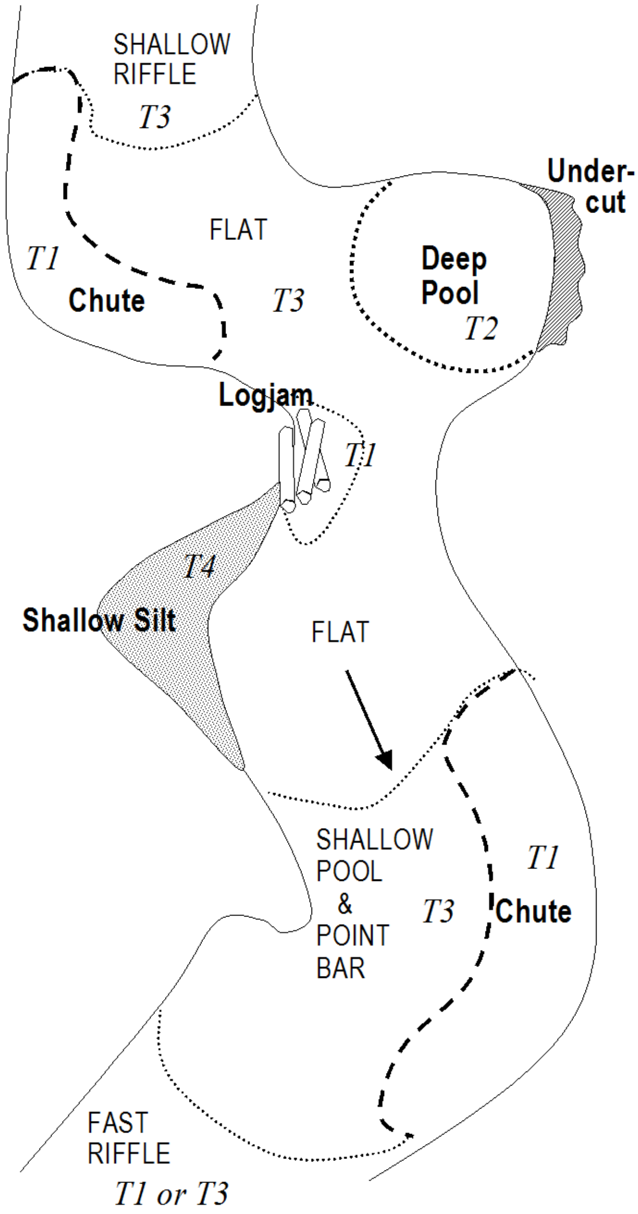

Figure 1: Suggested Electrofishing Techniques for Various Habitats. The letter 'T' and following number refers to the techniques described in Section 3.2, Electrofishing Survey Methods.

3.3 Processing Fish

To maintain temperature and oxygen levels, all fish should be kept in a flow-through holding tank downstream of the site. The catch should be periodically emptied into this holding tank.

Alternatively, the fish could be held in a container placed in a shaded area and the water changed regularly until the pass is complete.

When species identification is obvious, sort all fish into bins according to species (otherwise sort to the lowest taxonomic level possible[6]). It may be prudent to divide the catches of species into size groupings (e.g. young-of-year, yearlings, etc.)[7].

Process the fish according to the objectives of the project, recording data to the lowest level of taxonomic resolution feasible given the crews training and expertise. Note that biomass estimates are generated for all fish with associated weight data. Density estimates are generated using all fish from the individual records that do not have the "bulk" box marked off and all bulk fish. In effect, marking the bulk logical field indicates that this fish should not be counted twice in any summary queries. Therefore it is important to make sure this box is marked when a fish is included in both the individual and bulk sides of the field sheet. Three options are described below:

1. At minimum, count and record the number of fish in each grouping/species, and take a bulk weight (nearest gm) to provide information on fish biomass. Measure the length of the largest and smallest fish of each game fish species and any other species that is being targeted in the survey. Record this information in the individual fish data section, making sure to mark off the box titled "bulk" if the weight of the fish is included in the bulk weight measurement. The size range provides information on the life stages of fishes inhabiting a site (see example Appendix 1).

2. Where a survey focuses on particular target species or life stages, and time does not allow for measuring length and weight of all individuals, randomly select a sample of each species (typically up to 20 specimens) and measure individual length and weight of each fish. Where only a length frequency histogram is desired or target fish are too small to be weighed, record the individual total length only along with an x in the "bulk" box. These fish will be counted and bulk weighed. All remaining fish should be counted and weighed in bulk by group/species (see Appendix 2).

3. For detailed fish population assessments, count and record the number of each grouping/species, and take individual length and weight measurements from all fish. Where time is limiting or weigh scales are not available, individual length measurements

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[6] In Ontario, the Ministry of Natural Resources and Forestry (OMNRF), Department of Fisheries and Oceans and the Royal Ontario Museum (ROM) have developed an OSAP fish identification certification program. The program certifies individuals in fish identification at different levels of expertise. The ROM also offers fish identification workshops.

[7] 'Group number' codes are user defined and may be assigned as dictated by study design.

are often sufficient. Good relationships between length and weight for most sport fish species are available, so where lengths are available, weights can be derived.

For all fish that cannot be positively identified to species, preserve a subsample for laboratory verification. Voucher specimens of known or suspected aquatic invasive species should also be retained, preserved and reported to the Ministry of Natural Resources Invading Species Awareness Program[8].

3.4 Preserving Sampled Fish

Where species identification is uncertain or study design dictates that preservation or validation of species identification is necessary, there are several options for preserving specimens. The approach used will be dictated by whether the fish are to be: retained for identification based on morphological characteristics (Option 1); retained for potential future research using DNA bar-coding (Option 2); or live released (Option 3).

DNA bar-coding is a rapidly evolving technique that offers the potential to be able to identify organisms based on DNA sequences. Using an approach that offers the potential for DNA bar-coding does not guarantee resources will be available to conduct immediate analysis, but allows for the archiving of specimens for potential future analyses and research projects.

If a decision is made to retain specimens for preservation, fish should be euthanized as per organizational guidelines. Storage of all preserved specimens must be arranged by the organization that collected the sample (or requested it be retained) as no central repository is currently in place.

Regardless of the procedure followed, preserve the organisms in groups according to the lowest taxonomic resolution possible and follow the guidelines below for labelling the sample. Never preserve more fish than are necessary for the study purpose.

Option 1: Preservation for Morphological Identification (no DNA analysis)
Where no requirement for genetic validation is expected and surveyors wish to minimize shrinking of fish to make morphological examinations easier, each family group sample should be fixed in 10% buffered formalin to prevent tissue decomposition. These fish can be placed in separate Whirl-Pak® bags, jars or high quality re-sealable bags (doubled). Specimens should be fully immersed in the fixative for a minimum of two days for small fish and seven days for large fish.   Fish larger than 15 cm should be slit along the side below the lateral line to facilitate

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[8] Contact the Invading Species Hotline (1-800-563-7711) or website (www.invadingspecies.com) to report an occurrence. To request a copy of the *Ontario Field Guide to Aquatic Invasive Species (3rd ed.)* call 705-755-1960.

fixation. After fixation, specimens should be thoroughly rinsed with water and transferred to 70-75% ethyl alcohol for long-term storage.

Option 2: Preservation for Future DNA bar-coding and Morphological Identification
Where a desire to both preserve the sample for potential DNA bar-coding and identify the specimen based on morphological characteristics exists, specimens should be preserved in ethanol. This method will reduce the shrinking of the organism to enable identification based on morphology. The sample should be as clean as possible to minimize false DNA information being attached to organisms.

To fix the organism and its DNA the initial preservation should be into 95% ethanol. The sample should be stored in either hard plastic or glass for approximately one week. Make sure that the total volume of the combined tissues does not exceed 10% of the liquid volume. Transfer the sample to 80% alcohol to minimize shrinking.

Another option is to remove a small piece of fin that can be stored in a glass or hard plastic vile as a means of validating the specimen using DNA bar-coding. The fin can either be stored in 95% ethanol or it can be allowed to “dry”. If samples are to be preserved dry, pat the fin dry before putting it in the vile to remove liquids that promote decay. It is not recommended that fins from more than one fish be placed in a single jar if the “dry” fin approach is used as the fins tend to stick to each other and/or break into pieces.

Option 3: Live Release
Depending on the study and the conditions associated with a collection permit, all fish may need to be live released. In these instances high quality photographs of fish for which identification is uncertain should be taken. Photos should document the key morphological features that allow one species to be distinguished from another. Note, if a fish is believed to represent a range expansion for that species, or is of other special interest, the surveyor should consider taking a fin sample as described above for potential DNA bar-coding.

3.4.1 Labelling

For each container of preserved fish, record the following onto a label that is either placed inside the jar, for non-DNA samples, or is attached to the outside of the jar for all others[9]:

1. Site identification information (i.e., ‘Stream Name’, ‘Stream Code’, ‘Site Code’)
2. ‘Date’
3. ‘Bag No’ (number consecutively, i.e., ‘1’ of ‘5’)

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[9] Placing labels inside jars is appropriate if the material is guaranteed not to leach (e.g. do not use “write in the rain” or plastic labels) or if the samples are never to be analyzed for DNA.

4. ‘Batch #’ (the individual identification number used for this record on the fish sampling form)
5. ‘Type of Sample’ (i.e., whether it represents a random or specific sample)
6. ‘No Org’ (number of organisms in each container)
7. ‘Suspected Contents’ (the family or species code used to identify the fish catch (common name is fine)).
8. ‘Collector’ (the person who identified the sample).

Use waterproof paper and an HB pencil for labels. The information recorded should correspond to the information recorded in the Fish Sampling Form.

Example Fish Sample Label

Stream Name: WILMOT CREEK Stream Code: WM1 Site Code: 3CDW
Date: 97/08/10 Sample: 1 Run No: 1 Bag No: 1 of 5 Batch #: 1 of 4
Type of Sample: RANDOM No Org: 5
Suspected Contents: MOTTLED SCULPIN Collector: K. RYAN

3.5 Recording Data

Record the ‘Stream Name’, ‘Stream Code’, ‘Site Code’ and ‘Sample’ number on the Fish Sampling Form (see Appendix 1). Samples are consecutively numbered within a calendar year. Record the ‘Run’ number as applicable (e.g., Run 1 of 1). Record the ‘Licence to Collect Fish for Scientific Purposes' number under which the fish were collected in the ‘Science Collect. No.’ box.

Record all data pertaining to the sampling methods used and all survey results on the Fish Sampling Forms. The intent of the survey methods data is to document the factors in each survey that might influence catch. Record the type of electrofisher used and the settings (voltage, frequency and pulse width). Record any deviations from the recommended techniques in the appropriate boxes.

- ‘Inexperienced Sampler’ indicates that at least one of the crew members did not meet Class 2 certification according to the OMNR electrofishing policy
- ‘Imprecise Weigh Scale Used’ indicates that the unit used did not have a least 0.5 g accuracy
- ‘All Habitats Not Sampled’ indicates that some habitat could not be sampled
- ‘Upstream Blocknet Used’ indicates that a net was used in a single pass survey to reduce escapement from the site.

Record the time that the crew began electrofishing (‘Start Time’) and the time that they finished (‘Stop Time’) using the 24-hour clock. Calculate the duration in minutes and record this under ‘Elapsed Time’. Also record the electrofishing seconds (‘Shocker Sec’) from the electrofishing unit, the names of the ‘Shocker’ and ‘Netters’, and the number of pages (‘Page __ of __’) associated with the sample. If more than one page is required, record the site identification data and the date on each page.

Data for individual fish (‘Individual fish data’) and bulk samples (‘Bulk fish data’) are recorded as follows:

Individual fish data:

- ‘Id #’, a unique number that is consecutively recorded (beginning at 1) for each fish[10]
- ‘Species’, a unique number that refers to each species or family of fish (a list of Ontario fish species codes is provided in Appendix 2 and has been updated to include all hybrids and uncommon species).

The first time that the species code is used, record the common name or an acceptable acronym[11] (as listed in Appendix 2) in the ‘Remarks’ column. This will provide a backup in case the wrong number was recorded or the number is illegible. There are also columns to record whether the individual fish weight was included in a bulk sample (‘B’), whether scales (‘S’) or otoliths (‘O’) were taken and if the sample was preserved (‘P’). Record any other information on the fish including diseases or malformities in the ‘Remarks’ column.

Bulk fish data:

- ’Batch #’, sequentially identify each bulk sample
- ‘Species or Family’, code for unidentifiable groups
- ‘Number of fish’, number of individuals counted
- ‘Bulk Weight (gm.)’, bulk weight to the nearest gram
- ‘# Pres.’, number preserved
- ‘Bag #’, allows more than one bag to be recorded per batch (i.e., bags 4 and 5)

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[10] If desired, fish from different portions of the site may be separated by recording individual numbers 100, 101, etc. for fish captured in the first portion and 200, 201, etc. for the next portion.

[11] For common species, surveyors often use short forms that include distinct letters from the species name, e.g., Rainbow Trout RaTro, Mottled Sculpin MoScu, etc. Acronyms have been developed for all fish species codes (see Appendix 2).

Finally, record the name of the person who identified the fish in the field ‘Field Id. Name’. If several people were involved, record the person who was responsible for quality control.

If no fish are caught at the site, even though the equipment is functional, mark a ‘1’ in the ‘No Catch’ box to ensure this important information is not mistaken for an omission by the field crews.

Bulk Weights

Bulk weights are obtained by sorting fish into similar species or groups and weighing them as a group. Count the number of fish in the bulk sample. Net all of the fish and allow the water to drain. Place all of the fish into a tared weighing bin and record the bulk weight of the sample to the nearest gram. The weighing bin should contain enough water to cover the fish, this will reduce handling stress.

3.6 Recording the Area Sampled

Site area must be measured so effort and catch can be estimated per unit area (m^2). If Point Transect Sampling for Channel Structure, Substrate and Bank Conditions (S4.M2) is being conducted at this site in the same year, then site length and widths will be available and new measurements are not necessary (place an ’X’ in the box titled ‘Channel Morphology Data Available’).

If this data is not available, or the entire site cannot be sampled for some reason, an estimate of sample area is required. Chain the midstream length of the site sampled. Measure 10 wetted stream widths (must subtract the width of islands and include undercuts) at approximately even distances along the length of the site. Record the results of these measurements under ‘Length’ (m.)’ and Stream Width (‘Widths (m.)’) on the Fish Sampling Form.

3.7 Fish Species Confirmation

Preserved fish need to be identified by a knowledgeable/certified individual. Contact the ROM or OMNR Fisheries Policy Section for a list of certified taxonomists. Provide a photocopy of the original Fish Sampling Form so the contents can be recorded on the form, either under the bulk fish data or on the back of the form (see example in Appendix 1). Record the name of the taxonomist and their level of certification (if applicable) on the form under ‘Lab Identification’.

The following protocol is suggested for correcting bulk sample identifications:

1. If a bag contains a mixture of two or more species of the same genus, rerecord the data for that sample to the genus level (e.g., if the bag contains Longnose and Blacknose Dace, record as *Rhinichthys* sp. - code ‘226’).

2. If a bag contains several species of different genera, rerecord the data to the lowest taxonomic level that appropriately describes the sample (e.g., Northern Redbelly Dace, Creek Chub and Bluntnose Minnow would be recorded as minnow family – code ‘180’).

3. Record a weight and count for the appropriate code. For Lab Identification Results, add the new species and counts, but leave the weight box empty.

The weight and count data should be accurate to the level of identification. Crews should staple a copy of the sheet used for lab identification to the original field sheet, changing codes on the field sheets as necessary. In Examples C and D in Appendix 1, the Species or Family number for the Bulk Sample 1 (Bag # 1) would be changed from 380 (sculpins) to 381 (Mottled Sculpin) to reflect the lab identification results.

3.8 Tips for Applying this Module

Avoid overcrowding fish in buckets to reduce mortality from stress and lack of oxygen.

Routinely change the water in all buckets.

Allow sufficient time for anaesthetized fish to recover before releasing them.

Expect to find unfamiliar species at a site. Although mortality should be minimized, preserve representative fish so that identifications can be confirmed.

Laminate and tape the species codes to the back of the clipboard.

While electrofishing, it is important to maintain a high level of interest and alertness among crew members to ensure that effort remains constant. This is usually accomplished by constant verbal communication amongst crew members.

Use Mandrak and Crossman (1992) as a guide to species distribution within the study area and preserve new species that are caught as voucher specimens.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g., FWIS, or the MOE Portal), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca\fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to share provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 LITERATURE CITED

Jones, M.L. and J.D. Stockwell. 1995. A rapid assessment procedure for enumeration of Salmonine populations in streams. North American Journal of Fisheries Management 15:551-562.

Mahon, R. 1980. Accuracy of catch-effort methods for estimating fish density and biomass in streams. Environmental Biology of Fishes. 5:343-360.

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Stanfield, L. W., N. Lester and I. Petreman. 2013. Optimal effort intensity in backpack electrofishing surveys. North American Journal of Fisheries Management. 33: 277-286.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.

6.0 ACKNOWLEDGEMENTS

The electrofishing module benefitted from early reviews by Scott Gibson, Emily Joyce and Mike Stoneman. Repeatability measures were tested on Wilmot Creek as part of the Wilmot Creek Project.

Appendix 1

Example Fish Sampling Forms

Example A:

Note that the field identification was carried out by a Certificate Level 2, therefore each of these taxa could be identified to species. No new taxa were identified for this watershed, therefore no fish were preserved. One netter was inexperienced (was not certified with the appropriate number of hours of experience). No channel morphology data was collected in the same year, therefore site length and width data was collected.

Fish Sampling

Mandatory Fields In Grey
Must be filled out for processing

Stream Name: WILMOT CREEK

Date (yyyy-mm-dd): 2010-07-21

Stream Code: WM1

Sample: 01

Run No.: 01 of 01

Start Time (24hr): 10:30

Stop Time (24hr): 11:45

Elapsed Min.: 75

Shocker Sec.: 2755

Site Code: 3COW

Science Collect. No.: 9678903

Model No.: 12-B

Anod. Voltage: 1 300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☐ Yes ☒ No

If no, measure the station length and 10 widths.

Length (m): 45.5

Widths (m)

1	5.6	6	5.0
2	5.8	7	5.4
3	6.0	8	5.7
4	4.8	9	6.7
5	4.5	10	8.0

Individual Fish ☒ Total Length ☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B / O	P / S	Sp Name/Remarks
1	076	120	15	☐ ☐	☐ ☐	RAINBOW TROUT
2	076	96	9	☐ ☐	☐ ☐	"
3	078	55	5	☐ ☐	☐ ☐	BROWN TROUT
4	078	102	10	☐ ☐	☐ ☐	"
5	210	22	8	☐ ☐	☐ ☐	BLACKNOSE DACE
6	210	28	9	☐ ☐	☐ ☐	"
7	212	56	7	☐ ☐	☐ ☐	CREEK CHUB
8	212	62	8	☐ ☐	☐ ☐	"
9	163	126	45	☐ ☐	☐ ☐	WHITE SUCKER
10	163	158	50	☐ ☐	☐ ☐	"
11	209	22	4	☐ ☐	☐ ☐	FATHEAD MINNOW
12	209	34	7	☐ ☐	☐ ☐	"
13	198	12	3	☐ ☐	☐ ☐	COMMON SHINER
14	198	18	7	☐ ☐	☐ ☐	"
15				☐ ☐	☐ ☐	
16				☐ ☐	☐ ☐	
17				☐ ☐	☐ ☐	
18				☐ ☐	☐ ☐	
19				☐ ☐	☐ ☐	
20				☐ ☐	☐ ☐	

Comments: FIRST TIME NETTING FOR CB -

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Deviations *(Check all that apply)*
☒ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	0	20	24	0	—	RAINBOW TROUT
2	078	0	2	4	0	—	BROWN TROUT
3	210	0	7	20	0	—	BLACKNOSE DACE
4	212	0	4	30	0	—	CREEK CHUB
5	163	0	3	150	0	—	WHITE SUCKER
6	209	0	2	12	0	—	FATHEAD MINNOW
7	198	0	2	9	0	—	COMMON SHINER
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: EL CB

Recorder: E.L

Field ID (init. & last name): S TRUTTA

Cert. Level: 2

Lab ID (init. & last name): —

Cert. Level: —

Entered/ Scanned: 2010/10/10 EL

Verified: 2010/10/20 CB

Corrected: 2010/10/22 ST

Example B:

Note that the field identification was carried out by a Certificate Level 1, and the taxa captured were identifiable to species at this level. No new taxa were identified for this watershed, therefore no fish were preserved. Channel morphology data was collected in the same year, therefore no site length or width data was collected.

Fish Sampling

Mandatory Fields In Grey
Must be filled out for processing

Stream Name: WILMOT CREEK

Date (yyyy-mm-dd): 2010-06-21

Stream Code: WM1

Sample: 01

Run No.: 01 of 01

Site Code: 3CDW

Science Collect. No.: 967890З

Start Time (24hr): 10:30

Stop Time (24hr): 11:45

Elapsed Min.: 75

Shocker Sec.: 2755

Model No.: 12-B

Anod. Voltage: 1 300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☒ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): .

Widths (m)

1	.
2	.
3	.
4	.
5	.
6	.
7	.
8	.
9	.
10	.

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B O	P S	Sp Name/Remarks
1	076	115	40	☐ ☐	☐ ☐	RAINBOW TROUT
2	076	78	7	☐ ☐	☐ ☐	"
3	076	75	6	☐ ☐	☐ ☐	"
4	076	253	475	☐ ☐	☐ ☐	"
5	076	215	376	☐ ☐	☐ ☐	"
6	076	130	85	☐ ☐	☐ ☐	"
7	076	70	6	☐ ☐	☐ ☐	"
8	076	68	3	☐ ☐	☐ ☐	"
9	076	60	2	☐ ☐	☐ ☐	"
10	078	210	301	☐ ☐	☐ ☐	BROWN TROUT
11	078	95	17	☐ ☐	☐ ☐	"
12	078	195	270	☐ ☐	☐ ☐	"
13	078	65	3	☐ ☐	☐ ☐	"
14	163	153	42	☐ ☐	☐ ☐	WHITE SUCKER
15	163	122	31	☐ ☐	☐ ☐	"
16	163	201	77	☐ ☐	☐ ☐	"
17				☐ ☐	☐ ☐	
18				☐ ☐	☐ ☐	
19				☐ ☐	☐ ☐	
20				☐ ☐	☐ ☐	

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: EL, CB

Recorder: CB

Field ID (init. & last name): S TRUTTA

Cert. Level: 1

Lab ID (init. & last name):

Cert. Level:

Entered/ Scanned: 2010/11/11 ER

Verified: 2010/11/12 CB

Corrected: 2010/11/13 ST

Example C:

This field record shows a combination of individual and bulk data. Note that the field identification was carried out by a Certificate Level 1, therefore cyprinidae and sculpins were preserved. The crew separated *Rhynichthys* sp., as they were confident that this group was either Longnose or Blacknose Dace. Total lengths of young of year (< 100 mm) Rainbow and Brown Trout were bulk weighed and recorded as Group 1. Scale samples were taken from representative fish in the sample.

Fish Sampling

Mandatory Fields In Grey
Must be filled out for processing

Stream Name: WILMOT CREEK

Date (yyyy-mm-dd): 2010-07-06

Stream Code: WM1

Sample: 01

Run No.: 01 of 01

Start Time (24hr): 10:30

Stop Time (24hr): 11:45

Elapsed Min.: 75

Shocker Sec.: 2755

Site Code: 3CDW

Science Collect. No.: 9678903

Model No.: 12-B

Anod.Voltage: 1

300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☒ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): .

Widths (m)

1	.	6	.
2	.	7	.
3	.	8	.
4	.	9	.
5	.	10	.

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B	P	O	S	Sp Name/Remarks
1	076	115	40	☐	☐	☐	☒	RAINBOW TROUT
2	076	78	7	☐	☐	☐	☒	"
3	076	75	6	☐	☐	☐	☒	"
4	076	253	475	☐	☐	☐	☒	"
5	076	130	376	☐	☐	☐	☒	"
6	076	70	85	☐	☐	☐	☒	"
7	076	210	406	☐	☐	☐	☒	"
8	078	212	301	☐	☐	☐	☒	BROWN TROUT
9	078	195	270	☐	☐	☐	☒	"
10	078	65	—	☒	☐	☐	☐	"
11	077	130	35	☐	☐	☐	☒	NO CLIPS ATLANTIC SALMON
12	077	120	30	☐	☐	☐	☒	"
13	076	63	—	☒	☐	☐	☐	RAINBOW TROUT
14	076	65	—	☒	☐	☐	☐	"
15	380	25	3	☐	☐	☐	☐	SCULPIN
16	380	31	4	☐	☐	☐	☐	SCULPIN
17	226	62	5	☐	☐	☐	☐	RHYNICTHYS
18	226	48	3	☐	☐	☐	☐	"
19	180	78	5	☐	☐	☐	☐	CYPRINIDAE
20	180	62	3	☐	☐	☐	☐	"

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	1	10	24	0	-	RAINBOW TROUT
2	078	1	2	4	0	-	BROWN TROUT
3	380	0	30	102	6	1	SCULPIN
4	226	0	9	32	9	2	RHYNICTHYS
5	180	0	8	41	8	3	CYPRINIDAE
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name): S STRUTTA

Crew: CB EL

Recorder: EL

Field ID (init. & last name): S STRUTTA

Cert. Level: 1

Lab ID (init. & last name):

Cert. Level:

Entered/ Scanned: 2010/08/02 EL

Verified: 2010/08/04 CB

Corrected: 2010/09/12 CB

Example D:

Lab identification results are recorded on this field sheet. Note that the bag number must be recorded to enable summary reports to accurately record results to the most accurate level of identification. The summary report will be able to report that the bulk catch of sculpins were of one species e.g., Mottled Sculpin, as long as the bag number and number of fish are recorded.

Fish Sampling

Mandatory Fields In Grey
Must be filled out for processing

Stream Name: WILMOT CREEK

Date (yyyy-mm-dd): 201_-__-__

Stream Code: WM1

Sample: 01

Run No.: 01 of 01

Site Code: 3CDW

Science Collect. No.: 9678903

Start Time (24hr): 10:30

Stop Time (24hr): 11:45

Elapsed Min.: 75

Shocker Sec.: 2755

Model No.: 12-B

Anod. Voltage: 1

Voltage: 300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☒ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): .

Widths (m)

1	.	6	.
2	.	7	.
3	.	8	.
4	.	9	.
5	.	10	.

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B	P	O	S	Sp Name/Remarks
1	076	115	40	☐	☐	☐	☒	RAINBOW TROUT
2	076	78	7	☐	☐	☐	☒	"
3	076	75	6	☐	☐	☐	☒	"
4	076	253	475	☐	☐	☐	☒	"
5	076	130	376	☐	☐	☐	☒	"
6	076	70	85	☐	☐	☐	☒	"
7	076	201	406	☐	☐	☐	☒	"
8	078	212	301	☐	☐	☐	☒	BROWN TROUT
9	078	195	270	☐	☐	☐	☐	"
10	078	65	—	☒	☐	☐	☐	"
11	077	130	35	☐	☐	☐	☒	NO CLIPS ATLANTIC SALMON
12	077	120	30	☐	☐	☐	☒	"
13	076	65	—	☒	☐	☐	☒	RAINBOW TROUT
14	076	63	—	☒	☐	☐	☒	"
15	380	25	3	☐	☐	☐	☐	SCULPIN
16	380	31	4	☐	☐	☐	☐	"
17	226	62	5	☐	☐	☐	☐	RHYNICTHYS
18	226	48	3	☐	☐	☐	☐	"
19	180	78	5	☐	☐	☐	☐	CYPRINIDAE
20	180	62	3	☐	☐	☐	☐	CYPRINIDAE

Comments

ALL LAB RESULTS ENTERED IN DATABASE

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	1	10	24	0	—	RAINBOW TROUT
2	078	1	2	4	0	—	BROWN TROUT
3	380	0	30	102	6	1	SCULPIN
4	226	0	9	32	9	2	RHINICHTHYS
5	180	0	8	41	8	3	CYPRINIDAE
6	—	LAB IDENTIFICATION RESULTS —					
7	381	-	6	—	—	1	MOTTLED SCULPIN
8	210	-	7	—	—	2	BLACKNOSE DACE
9	211	-	2	—	—	2	LONGNOSE DACE
10	212	-	4	—	—	3	CREEK CHUB
11	198	-	2	—	—	3	COMMON SHINER
12	209	-	2	—	—	3	FATHEAD MINNOW
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: CB EL

Recorder: EL

Field ID (init. & last name): S TRUTTA

Cert. Level: 1

Lab ID (init. & last name): S GIBBS

Cert. Level: 2

Entered/Scanned: 2010/08/02 EL

Verified: 2010/09/01 CB

Corrected: 2010/09/03 CB

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 3: MODULE 2

Fish Community Sampling Using Seining Techniques[1]

TABLE OF CONTENTS

APPENDICES

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[1] Author: L. W. Stanfield, and S. Gibson

1.0 INTRODUCTION

This module describes how to use and document fish surveys conducted with a seine net. Seining is a widely used technique to collect information on stream fish communities and assess populations in specific habitat types. It is popular because it is non-lethal, can be performed relatively quickly using relatively inexpensive equipment and requires no specialized training. The method can be applied individually or as a supplemental methodology to electrofishing to ensure all habitat types in a site are effectively sampled.

This method is best applied in slower moving waters such as pools and slow runs and can be an effective technique to sample turbid waters where electrofishing surveys are less effective. In some areas it is also used in fast waters and in concert with electrofishing to increase catches in these hard to sample areas. Fortunately for fish surveys, seining tends to be most effective where electrofishing is least effective (that is deeper, slower, turbid waters) and is therefore the preferred sampling technique for these types of habitats. Seining on its own is not effective for species that are fast water or coarse substrate obligates, (e.g., Atlantic Salmon, sculpin). Seining can even in some instances capture burrowing species (e.g., lamprey) when the net dredges the stream bottom.

1.1 Sampling Considerations

The use of seining within a study will depend on the study objectives and the stream conditions. Seining can be effectively applied in any stream habitat that is less than the depth of the net (typically 1.5 m) and has conditions that enable the leadline to remain in close contact with the stream bed. It can be applied at any time of year, but is more effective under low flow conditions and at times when ice is not present in the river. The technique can be applied within specific habitats or across multiple habitats in order to assess an entire site.

For example, seining can be applied to:

- Supplement an electrofishing survey by sampling the areas that seining provides a more effective method for capturing fish (e.g., deep, slow moving or turbid habitats)
- Targeted sampling of specific habitats for individual species for which habitat requirements are well known and conducive to seining
- Generate estimates of abundance using depletion techniques
- Evaluate species presence and likely absence by conducting multiple seine hauls over extended distances of a stream segment (see Appendix 1)
- Study differences in sampling efficiencies between methods and to understand species habitat requirements.

This module is designed to standardize seining surveys by documenting both the effort applied and the habitat conditions surveyed and to provide a consistent means of recording catches. Standardizing the surveys regardless of the study design objectives will facilitate expanded use of the data and comparisons between catches. Specifically how this method will be incorporated within a study design is beyond the scope of the module, but some information has been extracted from Portt *et al.* (2008) to provide context on comparing catches between electrofishing and seining and the amount of habitat required to capture rare fish (Appendix 1).

2.0 PRE-FIELD ACTIVITIES

This module requires a minimum crew of two people but is most effective with crew sizes of four or five (e.g., two to pull the seine, one to lift the net off of snags and two to process fish). The number varies depending on the technique used, the size of the stream and the abundance of fish that will be sampled.

Pre-field activities should include:

- Obtaining a “Licence to Collect Fish for Scientific Purposes” from OMNRF (see OSAP General Introduction for details).
- Obtain any other permits or authorizations that may be required (e.g. *Endangered Species Act, 2007* (ESA) and/or *Species at Risk Act*). (see OSAP General Introduction for details).
- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The approaches used and study design considerations should be documented by filling out the meta-data module field sheet (S0.M1 - Study Design Metadata).

The following equipment is required:

1. Fish Sampling form(s) on waterproof paper (if possible)
2. Pencils
3. Seine net
4. Chest waders for all crew members
5. Polarized glasses and hats for all crew members
6. Aquarium dip nets (2-4)
7. Buckets for holding fish (6-10)
8. Bowl of sufficient size for weighing fish
9. Weighing scales (different capacities)

10. Plastic volumetric container (doubles as weigh scale bowl and volumetric measurer backup)
11. Measuring board
12. Sampling box with tools, duct tape, wader repair kit, goop etc.
13. Thick plastic bags or jars (e.g., Whirl-Pak®) for preserving fish
14. Preserving solution for specimens
15. Camera for verifying unknown fish
16. Collection labels
17. Fish identification keys
18. Tape measure
19. Wooden metre stick

Seine nets are available in many forms and lengths that affect their efficiency in specific streams. Surveyors should consider how differences in specific net types (mesh size, length/depth, bag presence, float types etc.), will affect catches. For example larger mesh sizes will have a lower probability of detecting young of year or very small fish.

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

Sampling must be conducted within the confines of a sample site as defined in S1.M1- Defining Site Boundaries and Key Identifiers. Each new seine haul conducted outside the boundaries of a site requires a new site code and sample number etc. This is essential to enable the quantification of and comparison of the spatial distribution of fish within and across streams. Record to the desired level of detail the Site Identification field sheet (see S1.M2 or S1.M3) for each sample site. All collection areas (habitat types) sampled within a single site receive the same site code and sequential numbers to identify each (e.g., collection area 1, 2 etc.). If multiple seine hauls are applied within a collection area, these are recorded as run 1, 2, 3 etc). See the example field sheet in Appendix 2.

Collection Area

Collection areas are defined by the area that is seined during a single haul. The area to be sampled is defined by a combination of hydraulic and substrate conditions and sampling factors such as the presence of wood, vegetation or other materials that dissect the effective sampling area. Catches from individual collection areas are sorted and processed separately, although habitat information need only be recorded once.

Surveyors will first, identify where seining is to be carried out within a site. Such locations will depend on study design and feasibility. Many sites will have areas that are not appropriate for seining due to the presence of log jams, boulders or large macrophyte beds etc. In some instances, Individual obstructions can be overcome by quickly lifting the net over the obstruction without the survey being compromised. If no suitable collection areas exist within a site, the unsampleable box should be marked on the Site Identification form, and the rationale and effected module code (S3.M2) should be recorded.

3.1 Seining Survey Methods

Regardless of the habitat being sampled a seine haul involves pulling a net from an origin so as to corral fish within a confined space and then bringing the net back to the shore to close the loop. The specific techniques applied to maximize effectiveness will vary with habitat conditions. Depending on the depth of water and velocity, surveyors can either loop the lead line around their ankle or bottom of their back leg boot or use a pole and tie the net to the bottom and loop it over the top to provide a fulcrum for pulling. In fast moving water, it can be easier and more effective to seine in a downstream direction. The leadline moves along the bottom and the float line stays in contact with the surface during the “haul”. Once the two surveyors meet, they draw the ends of the net together, and one surveyor gradually pulls both ends of the net simultaneously to make the loop smaller. Care must be taken to ensure that the leadline maintains constant contact with the substrate. As the net approaches the shore the leadline is pulled slightly more so that the fish become trapped within a “bag[2]”. Surveyors must take care to ensure that fish do not escape over the top of the net while pulling it in. The last step is to process the catch - how this is accomplished depends on both the numbers and species of fish caught and objectives of the survey. See details below.

For multiple pass surveys, release all processed fish downstream of the site after they have been processed and repeat the survey, making sure to differentiate the catch in each haul as run 1, 2, 3 etc.

3.1.1 Processing Station

Identify a flat, well-shaded location close to the stream to set up a processing station that is out of the collection area to be sampled. Partially fill all the buckets to be used to sort and process fish and make ready any other equipment that will be used (e.g., weigh scale or volumetric beakers, camera, etc.).

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[2] Seine nets can be purchased with or without a central bag. Bags are useful for concentrating fish when long hauls are used and flows are minimal, but crews must pull the net such that the bag is the last part of the net pulled from the water.

3.1.2 Establish a Sampling Strategy

Plan out the sampling strategy, ensuring a gentle or flat gradient with minimal roughness is located at the entry/exit point where the seine is to be retrieved. Ensure you have a strategy to deal with obstacles in the stream. If there is an additional crew member available, this person follows the seine to help free it from any obstructions. A pole is a useful item for lifting the seine over boulders in pools and can also be helpful when attached to each end to assist with pulling the net. If the seine has been carried or stored in a way so that there is a possibility of twists in the net, check to make sure it will feed out properly before starting the survey (see survey wrap-up).

3.1.3 Pull the Seine

Exactly how the seine will be hauled will vary depending on the habitat, flow conditions and crew preferences. The following general advice is provided to illustrate the range in ways the equipment can be applied in various habitats of a “typical stream site”.

With each technique once the loop is closed, one surveyor pulls both ends simultaneously towards shore, once on shore surveyors can pull the leadline at a slightly more rapid rate, thereby closing the bottom part of the net first and forcing the fish into the middle depths of the river within a “bag”. Work the net slowly and watch for wood, rocks, large fish or reptiles. If present, they can be removed once the loop is closed and before either the net or small fish are damaged. Once the seine is hauled to shore and the fish are trapped in the bag, remove any remaining vegetation, rocks etc., and prepare to transfer the catch.

Technique 1: This technique is only feasible when short bag-less and larger meshed seines are used (e.g., ¼ “). In most fast water habitat units, approach from the upstream side of the habitat, keeping the net above the water until both surveyors are in place. Then drop the net and the outside person will proceed downstream to the end of the habitat and move towards shore again. Once the outside person has reached shore the inside person closes the loop and the net is pulled in.

Technique 2: Where banks provide a habitat boundary a surveyor walks against the bank and the second person walks ahead so as to direct fish into the net rather than around it. Try to block escape routes and operate the haul so as to direct escaping fish into the net. Continue moving upstream until the habitat has been surveyed making sure the leadline remains in contact with the substrate. At the top of the feature in a shallow, lower velocity area, bring the two ends of the net together and pull in the seine (see below).

Technique 3: In deep pools and flats, the lead surveyor enters the water at a shallow location that is generally not expected to have fish. In general, the lead surveyor will start so as to close the most likely escape route first. In most situations the lead surveyor will start at the downstream end, moving across the stream to the edge of the collection area, moving upstream and then back across the stream to close the loop. The lead surveyor walks slowly around the perimeter of the collection area so as not to startle the fish. The second surveyor feeds the net and if necessary, helps lift the leadline over obstacles until the lead person reaches the start point again and the net is hauled to shore.

Technique 4: An alternative, labour intensive strategy, for targeting larger fish is to use two nets. One is placed in quieter water at the downstream end of a habitat unit and a second net is dragged through the upstream waters until the fish are trapped between the nets. Multiple surveyors hold the net so that mid channel sections do not move ahead of the peripheral ends. Additional surveyors can help “herd” fish to the downstream net and use dip nets to capture larger fish once corralled. In smaller streams, this technique can be applied to sample multiple habitat types in one sweep.

3.1.4 Transferring the catch

The nature of the catch will dictate how it will be transferred to sorting bins. For example if large fish are present, most situations will require their extraction first. Then depending on the catch, either net the fish from the bag, or place the entire bag in a sorting bucket to begin processing the catch. Before lifting the bag, remove all rocks, vegetation and sticks from the net and work the catch into a small “bag”. Ensuring both the leadline and floatline are held securely, pick the bag up and empty it into a container large enough to hold the sample without compromising oxygen levels in the water. After emptying the bag, perform a quick inspection of the net to ensure all fish have been removed. Begin sorting the catch.

If a species protected under the ESA[3] is caught incidentally, it should immediately be returned to the waters from which it was caught and released in a manner that causes the least harm to the fish (unless otherwise authorized through a permit issued under the ESA or acting in accordance with conditions on a Licence to Collect Fish for Scientific Purposes). Incidental catches of all species at risk, including those listed as special concern, should be reported to the local OMNRF District and the Natural Heritage Information Centre (NHIC)[4].

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[3] Species listed as extirpated, endangered or threatened on the Species at Risk in Ontario List (SARO List) are protected under the ESA. Refer to Ontario Regulation 230/08 for the SARO List.

[4] Report a SAR occurrence by calling (705) 755-2159 or visiting the NHIC website (https://www.ontario.ca/page/natural-heritage-information-centre).

3.2 Processing Fish

To maintain temperature and oxygen levels, the fish should be either held in a container placed in a shaded area and the water changed regularly or flow through bins should be used. When species identification is obvious, sort all fish into bins according to species (otherwise sort to the lowest taxonomic level possible[5]). It may be prudent to divide the catches of species into size groupings (e.g. young-of-year, yearlings, etc.) if identified as a need in the study design[6].

Many fisheries surveys summarize catches based on both numbers and weights of catches. If a weigh scale is not available for a survey, an alternative strategy is to measure the volume of water displaced by a catch and to use the correction formula described in the text box below to estimate the catch weight.

Record the volumes in the species name/remarks fields and convert them before data entry.

Record catches to the lowest level of taxonomic resolution feasible given the crews training and expertise. Process the fish according to the objectives of the project, following one of the several options described below:

1. At minimum, count and record the number of fish in each grouping/species, and take a bulk weight (nearest gm) to provide information on fish biomass. Measure the length of the largest and smallest fish of each game fish species and any other species that is being targeted in the survey. The size range provides information on the life stages of fishes inhabiting a site (see example Appendix 2). Record this information in the individual fish data section, making sure to mark off the box titled “bulk” if the weight of the fish is included in the bulk weight measurement[7].

2. Where a survey focuses on particular target species or life stages, and time does not allow for measuring length and weight of all individuals, randomly select a sample of each species (typically up to 20 specimens) and measure individual length and weight of each fish. Where only a length frequency histogram is desired or target fish are too small to be weighed, record the individual total length only along with an x in the “bulk” box. These fish will be counted and bulk weighed. All remaining fish should be counted and weighed in bulk by group/species (see Appendix 2).

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[5] OSAP fish identification certification program certifies individuals in fish identification at different levels of expertise. The ROM also offers fish identification workshops.

[6] ‘Group number’ codes are user defined and may be assigned as dictated by study design.

[7] Marking the bulk weight box on the “Individual fish tally sheet ensured that this fish will only be counted once in the summary query.

3. For detailed fish population assessments, count and record the number of each grouping/species, and take individual length and weight measurements from all fish. Where time is limiting or weigh scales are not available, individual length measurements are often sufficient. Good relationships between length and weight for most sport fish species are available, so where lengths are available, weights can be derived.

For all fish that cannot be positively identified to species, preserve a subsample for laboratory verification. Voucher specimens of known or suspected aquatic invasive species should also be retained, preserved and reported to the Ministry of Natural Resources Invading Species Awareness Program[8].

3.3 Preserving Sampled Fish

Where species identification is uncertain or study design dictates that preservation or validation of species identification is necessary, there are several options for preserving specimens. The approach used will be dictated by whether the fish are to be: retained for identification based on morphological characteristics (Option 1); retained for potential future research using DNA bar-coding (Option 2); or live released (Option 3).

DNA bar-coding is a rapidly evolving technique that offers the potential to be able to identify organisms based on DNA sequences. Using an approach that offers the potential for DNA bar-coding does not guarantee resources will be available to conduct immediate analysis, but allows for the archiving of specimens for potential future analyses and research projects.

If a decision is made to retain specimens for preservation, fish should be euthanized as per organizational guidelines. Storage of all preserved specimens must be arranged by the organization that collected the sample (or requested it be retained) as no central repository is currently in place.

Regardless of the procedure followed, preserve the organisms in groups according to the lowest taxonomic resolution possible and follow the guidelines below for labelling the sample. Never preserve more fish than are necessary.

*Option 1**:** Preservation for Morphological Identification (no DNA analysis)*

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[8] Contact the Invading Species Hotline (1-800-563-7711) or website (www.invadingspecies.com) to report an occurrence. To request a copy of the *Ontario Field Guide to Aquatic Invasive Species (3rd ed.)* call 705-755-1960.

Where no requirement for genetic validation is expected and surveyors wish to minimize shrinking of fish to make morphological examinations easier, each family group sample should be fixed in 10% buffered formalin to prevent tissue decomposition. These fish can be placed in separate Whirl-Pak® bags, jars or re-sealable bags (doubled). Specimens should be fully immersed in formalin for a minimum of three days (optimum fixation times are 1-2 weeks for fish less than 6 inches, and 2-4 weeks for fish larger than 6 inches). **After fixation, specimens should be thoroughly rinsed with water and transferred to 40% ethyl alcohol for preservation prior to identification and/or storage. Note that specimens fixed in formalin may not be suitable for future DNA analysis.**

Option 2: Preservation for Future DNA bar-coding and Morphological Identification
Where a desire to both preserve the sample for potential DNA bar-coding and identify the specimen based on morphological characteristics exists, specimens should be preserved in ethanol. This method will reduce the shrinking of the organism to enable identification based on morphology. The sample should be as clean as possible to minimize false DNA information being attached to organisms.

To fix the organism and its DNA the initial preservation should be into 95% ethanol. The sample should be stored in either hard plastic or glass for approximately one week. Make sure that the total volume of the combined tissues does not exceed 10% of the liquid volume. Transfer the sample to 80% alcohol to minimize shrinking.

Another option is to remove a small piece of fin that can be stored in a glass or hard plastic vile as a means of validating the specimen using DNA bar-coding. The fin can either be stored in 95% ethanol or it can be allowed to “dry”. If samples are to be preserved dry, pat the fin dry before putting it in the vile to remove liquids that promote decay. It is not recommended that fins from more than one fish be placed in a single jar if the “dry” fin approach is used as the fins tend to stick to each other and/or break into pieces.

Option 3: Live Release
Depending on the study and the conditions associated with a collection permit, all fish may need to be live released. In these instances high quality photographs of fish for which identification is uncertain should be taken. Photos should document the key morphological features that allow one species to be distinguished from another. Note, if a fish is believed to represent a range expansion for that species, or is of other special interest, the surveyor should consider taking a fin sample as described above for potential DNA bar-coding.

3.3.1 Labelling

For each container of preserved fish, record the following onto a label that is either placed inside the jar, for non-DNA samples, or is attached to the outside of the jar for all others[9]: Use waterproof paper and an HB pencil for labels.

1. Site identification information (i.e., ‘Stream Name’, ‘Stream Code’, ‘Site Code’)
2. ‘Date’
3. Collection area and Run number (which is synonymous with haul number)
4. ‘Batch #’ (the individual identification number used for this record)
5. ‘Bag No’ (number consecutively, e.g., ‘1’ of ‘5’), to accommodate larege catches
6. ‘Type of Sample’ (i.e., whether it represents a random or specific sample)
7. ‘No Org’ (number of organisms in each container)
8. ‘Suspected Contents’ (the family or species code used to identify the fish catch (common name is fine)).
9. ‘Collector’ (the person who identified the sample).

Example Fish Sample Label

Stream Name: WILMOT CREEK Stream Code: WM1 Site Code: 3CDW
Date: 97/08/10 Sample: 1 Coll No: 1 Batch #: 3 Run #: 1 Bag No: 1 of 1
Type of Sample: RANDOM No Organisms: 6
Suspected Contents: MOTTLED SCULPIN Collector: K. RYAN

Note: This example is for the bulk sample record of batch 3 in Appendix C.

3.4 Documenting the Area and Habitat Sampled

Because of the challenges in identifying habitat boundaries (see Stanfield and Jones 1998) crews are asked to record basic habitat information for each sample unit.

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[9] Placing labels inside jars is appropriate if the material is guaranteed not to leach (e.g. do not use “write in the rain” or plastic labels) or if the samples are never to be analyzed for DNA.

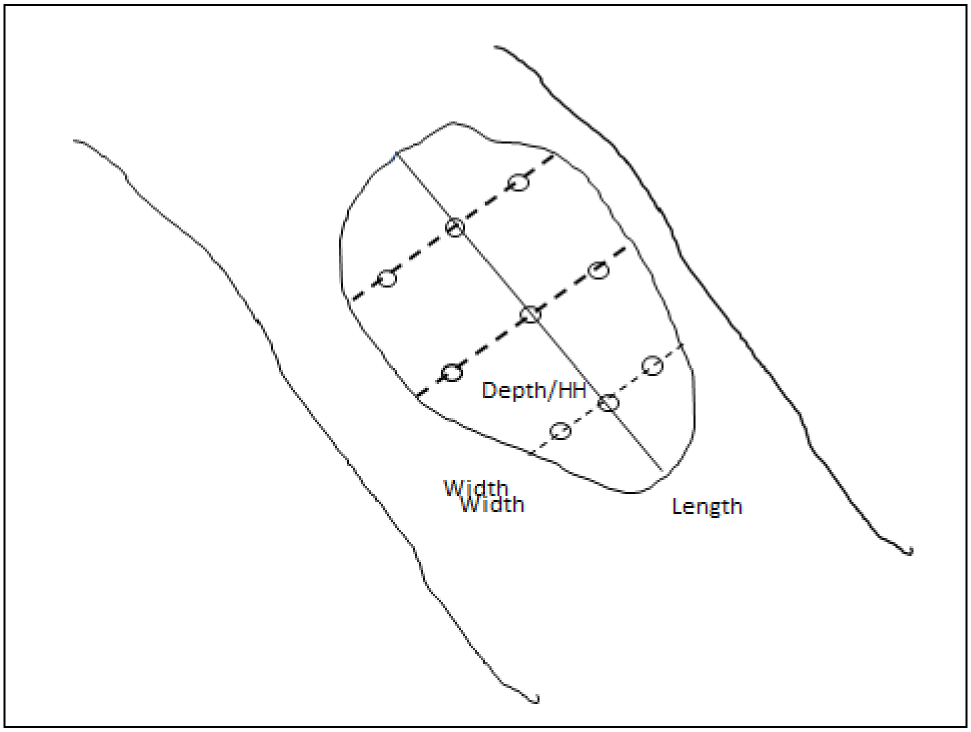

Figure 1: Example habitat measurement locations for an irregular shaped collection area.

The collection area must be measured so effort and catch can be estimated per unit area (m^2). Measure the length of the collection area down the midstream. Measure 3 wetted stream widths, (e.g. subtract the width of islands and include undercuts) at appropriate locations to be able to determine the mean width. At 9 approximately equally spaced locations and along visually located transects (3 per transect) record the depth and hydraulic head to the nearest 5 mm (see Figures 1 and 2). Record the results of these measurements under ‘collection Length (m.)’, Stream Width (‘Widths (m.)’), ‘Depth (mm) and HH on the Seine Sampling Form.

Depth and Hydraulic Head

Hydraulic head is measured by placing a wooden ruler on the stream bed so that it is vertical and the **wide side with the markings is on the downstream side of flows**). The ruler will create a barrier to flow. Measure the maximum height difference observed over a 3-5 second period between the front and back of the ruler (Figure 2). 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. Depth is measured by turning the ruler so that the thin edge is angled into the flow. Depth is read from the middle of the ruler to the nearest 5 mm.

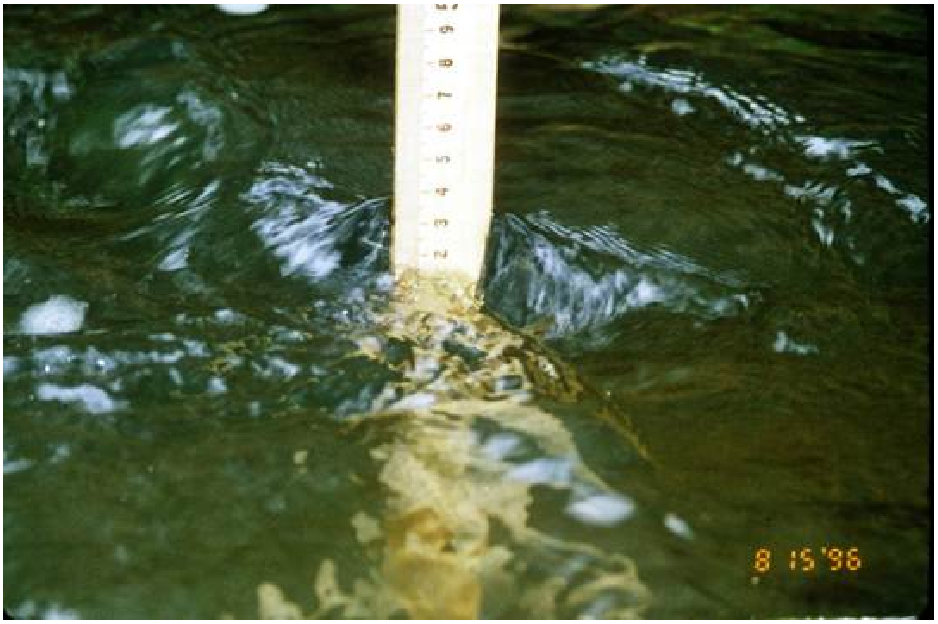

Figure 2: A 20 mm hydraulic head.

3.5 Recording Data

Record the ‘Stream Name’, ‘Stream Code’, ‘Site Code’ and ‘Sample’ number on the Fish Sampling Form (see Appendix 2). Samples are consecutively numbered within a calendar year. Record the ‘Collection Area’‘(1, 2, 3 etc.) and Run (replicate)’ number as applicable (e.g., Run 1 of 1). Record the ‘Licence to Collect Fish for Scientific Purposes' number under which the fish were collected in the ‘Science Collect No.’ box.

Record all mesh size of the seine and any deviations from the recommended techniques in the appropriate boxes.

- ‘Inexperienced Sampler’ indicates that at least one of the crew members has not performed this methodology at least 3 times before.

- ‘Imprecise Weigh Scale Used’ indicates that the unit used did not have a least 0.5 g accuracy
- ‘All Habitats Not Sampled’ indicates that some habitat could not be sampled within the collection area
- ‘Compromised survey indicates that the leadline was not in contact with the substrate for a period of time that likely resulted in the escape of some fishes.

Record the time that the crew began seining (‘Start Time’) and the time that they finished (‘Stop Time’) using the 24-hour clock. If more than one page is required, record the site identification data and the date on each page.

Data for individual fish (‘Individual fish data’) and bulk samples (‘Bulk fish data’) are recorded as follows:

<u>Individual fish data:</u>

- ‘Id #’, a unique number that is consecutively recorded (beginning at 1) for each fish
- ‘Species’, a unique number that refers to each species or family of fish (a list of Ontario fish species codes and common names is provided in S3 Introduction: Appendix 1)

The first time that the species code is used, record the common name or the acceptable acronym[10] (as listed in S3 Introduction: Appendix 1) in the ‘Remarks’ column. This will provide a backup in case the wrong species code is recorded or the number is illegible. There are also columns to record whether the individual fish weight is included in a bulk sample (‘B’), whether scales (‘S’) or otoliths (‘O’) are taken and if the sample is preserved (‘P’). Record any other information on the fish including diseases or malformities in the ‘Remarks’ column.

<u>Bulk fish data:</u>

- ’Batch #’, sequentially identify each bulk sample
- ‘Species or Family’, code for unidentifiable groups
- ‘Number of fish’, number of individuals counted
- ‘Bulk Weight (gm.)’, bulk weight to the nearest gram
- ‘# Pres.’, number preserved

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[10] For common species, surveyors often use short forms that include distinct letters from the species name, e.g., Rainbow Trout - RaTro, Mottled Sculpin - MoScu etc. The approved acronyms found in S3 Introduction: Appendix 1 should be used on the field form to prevent misunderstandings.

- ‘Bag #’, allows more than one bag to be recorded per batch (e.g., bags 4 and 5)

Record the name of the person who identified the fish in the field ‘Field Id. Name’. If several people were involved, record the person who was responsible for quality control. Finally, if no fish are caught in a seine haul, even though the equipment is functional and is applied appropriately, mark a ‘1’ in the ‘No Catch’ box to ensure this important information is not mistaken for an omission by the field crews.

Bulk Weights or Volumes

Bulk weights are obtained by sorting fish into similar species or groups and weighing them as a group. Count the number of fish in the bulk sample. Net all of the fish and allow the water to drain. Place all of the fish into a tared weighing bin and record the bulk weight of the sample to the nearest gram. The weighing bin should contain enough water to cover the fish, this will reduce handling stress. In the event that no weigh scale is available, change in volume of water within a beaker can be used as an alternate means of determining weight. The conversion formula is:

$$y(gm)= \text{volume displaced (ml)}*1.018$$

For example, if a catch of Rainbow Darters displaced 200 ml of water, the estimated weight of this catch would be 204 gm. Note: this method provides only an estimate of weight, as it assumes similar densities between species and stages of fish.

3.6 Species Confirmation

Preserved fish need to be identified by a knowledgeable/certified individual. Contact the ROM or OMNRF Fisheries Policy Conservation Branch, Fisheries Section for potential taxonomists that could meet this task. Provide a photocopy of the original Fish Sampling Form so the contents can be recorded on the form, either under the bulk fish data or on the back of the form (see example in Appendix 2). Record the name of the taxonomist and their level of certification (if applicable) on the form under ‘Lab Identification’.

The following protocol is suggested for correcting bulk sample identifications:

1. If a bag contains a mixture of two or more species of the same genus, rerecord the data for that sample to the genus level (e.g., if the bag contains Longnose and Blacknose Dace, record as *Rhinichthys* sp. - code ‘226’).

2. If a bag contains several species of different genera, rerecord the data to the lowest taxonomic level that appropriately describes the sample (e.g., Northern Redbelly Dace, Creek Chub and Bluntnose Minnow would be recorded as minnow family – code ‘180’).

3. Record a weight and count for the appropriate code. For Lab Identification Results, add the new species and counts, but leave the weight box empty.

The weight and count data should be accurate to the level of identification. Crews should staple a copy of the sheet used for lab identification to the original field sheet, changing codes on the field sheets as necessary. In Examples C and D in Appendix 2, the Species or Family number for the Bulk Sample 1 (Bag # 1) would be changed from 380 (sculpins) to 381 (Mottled Sculpin) to reflect the lab identification results.

3.7 Tips for Applying this Module

Like electrofishing, the effective use of a seine net in the varying substrate and flow conditions of streams is aided by experience. If you do not have experience using a seine net, try to get an experienced person to help for a couple of days at the beginning of your project.

If the survey is being conducted to generate a species presence list, replicate hauls should be conducted within each habitat unit until no new species are collected. This generally takes at least three hauls (but often may require 5 or 6 or even more)

For surveys to generate relative abundance estimates, be aware that catches can often increase between the first and second hauls as fish are attracted into the habitat unit as a result of disturbance of the substrates.

In deeper habitats it is recommended that surveyors tie each end of the leadline and float line to a sturdy pole to provide balance and help keep the net on the bottom.

Use flow through bins and avoid overcrowding fish in buckets to reduce mortality from stress and lack of oxygen.

Use anaesthetics (e.g., clove oil) to calm fish before handling and allow sufficient time for anaesthetized fish to recover before releasing them.

Expect to find unfamiliar species at a site. Although mortality should be minimized, preserve or photograph voucher specimens so that identifications can be confirmed.

Laminate and tape the species codes to the back of the clipboard.

Use Mandrak and Crossman (1992) and Holm *et al.* (2009) as a guide to species distribution within the study area and preserve or photograph voucher specimens of new species. Previous surveys within the watershed are also useful for developing expected lists of species.

4.0 DATA MANAGEMENT

Upon returning from the field;

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

2. Ensure the data is entered into a digital storage system, such as FWIS, and save backup copies that are stored in a separate location from the master copy.

Once entered the information should be contributed to the provincial repository where it can be shared with a large number of users province-wide. Data sharing will increase efficiencies and lead to a better understanding of how to manage streams. To meet the requirements of the "Licence to Collect Fish for Scientific Purposes", the mandatory collection report must be sent to OMNR. For more details see Section 6: OSAP Data Management and check for updates at the Comap.ca\fwis website.

5.0 ACKNOWLEDGEMENTS

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Appendix 1

Study Design Considerations

Portt *et al.* (2008) conclude that seines are much more variable in their capture efficiencies among species and habitat types and, overall, are often not as effective as electrofishers. However, in the right habitat, this technique can provide the most effective sampling technique for capturing selective species of fish.

Portt *et al.* (2008) provide the following suggestions for those surveys directed at rare species of fish:

> "Benthic fishes are more likely to escape a seine than midwater and surface fishes, and coarse substrates provide more escape routes than smooth, fine-grained substrates (Parsley *et al.* 1989; Pierce *et al.* 1990). Poos *et al.* (2007) examined the effectiveness of bag seines and backpack electrofishers for sampling four species at risk (Eastern Sand Darter, Greenside Darter, Blackstripe Topminnow and Spotted Sucker) in the Sydenham River, Ontario. They concluded that a backpack electrofisher was more effective at detecting the species at risk, detected higher relative abundances, and required fewer sampling stations to detect a species at risk in a watershed. Patton *et al.* (2000) compared seines to electrofishers in fine-substrate watercourses. Their results indicated that seining 200 m of stream was required to catch 90% of the species present, compared to 150 m for electrofishing. It was estimated that seining 300 m or electrofishing 200 m would result in100% of the species present being captured. The watercourses in the study conducted by Patton *et al*. (2000) were particularly suited for seining, and the difference in efficiency between electrofishers and seines for sampling species richness would probably be much greater in streams with coarse substrates or greater structural habitat diversity."

Appendix 2

Example Fish Sampling Forms

Example A:

Note that the field identification was carried out by a Certificate Level 2, therefore each of these taxa could be identified to species. No new taxa were identified for this watershed, therefore no fish were preserved. One netter was inexperienced (was not certified with the appropriate number of hours of experience). No channel morphology data was collected in the same year, therefore site length and width data was collected.

Fish Sampling with Seines

Mandatory Fields In Grey
Must be filled out for processing

Date (mm-dd) 2010-07-20

Stream Name: WILMOT CREEK

Stream Code: WM1

Sample: 1

Coll. Area: 1

Run: 1

Site Code: 3CDW

Scientific Collectors Permit: 9678903

Net Type: 2

Net Type
1 = Straight
2 = Bag

Mesh Size
Wing: 2
Bag: 2

Mesh Sizes
0 = N/A
1 = 1/8 inch
2 = 1/4 inch

Collection Area Length (m): 45.5

Transect Width (m): 5.6 6.0 5.4

Depth and Hydraulic Head

	Depth 1	H Head 1	Depth 2	H Head 2	Depth 1	H Head 3
T1	55	6	77	7	48	4
T2	62	10	72	15	66	11
T3	75	8	84	13	68	9

Deviations *(Check all that apply)*
☒ Inexperienced Sampler ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B O	P S	Sp Name/Remarks
1	076	120	15	☐☐	☐☐	RAINBOW TROUT
2	076	96	9	☐☐	☐☐	"
3	078	53	5	☐☐	☐☐	BROWN TROUT
4	078	102	10	☐☐	☐☐	"
5	210	22	8	☐☐	☐☐	BLACKNOSE DACE
6	210	28	9	☐☐	☐☐	"
7	212	62	8	☐☐	☐☐	CREEK CHUB
8	212	56	7	☐☐	☐☐	"
9	163	126	45	☐☐	☐☐	WHITE SUCKER
10	163	158	56	☐☐	☐☐	"
11	209	22	4	☐☐	☐☐	FATHEAD MINNOW
12	209	34	7	☐☐	☐☐	"
13	198	12	3	☐☐	☐☐	COMMON SHINER
14	198	18	7	☐☐	☐☐	"
15				☐☐	☐☐	
16				☐☐	☐☐	
17				☐☐	☐☐	
18				☐☐	☐☐	
19				☐☐	☐☐	
20				☐☐	☐☐	

Comments: FIRST TIME SEINING FOR CB

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	0	20	24	0	-	RAINBOW TROUT
2	078	0	2	4	0	-	BROWN TROUT
3	210	0	7	20	0	-	BLACKNOSE DACE
4	212	0	4	30	0	-	CREEK CHUB
5	163	0	3	150	0	-	WHITE SUCKER
6	209	0	2	12	0	-	FATHEAD MINNOW
7	198	0	2	9	0	-	COMMON SHINER
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: EL CB

Recorder: EL

Field ID (init. & last name): S TRUTTA

Cert. Level: 2

Lab ID (init. & last name):

Cert. Level:

Entered/ Scanned: 2010/11/11 EL

Verified: 2010/11/12 CB

Corrected: 2010/11/12 CB

Example B:

Note that the field identification was carried out by a Certificate Level 1, and the taxa captured were identifiable to species at this level. No new taxa were identified for this watershed, therefore no fish were preserved. Channel morphology data was collected in the same year, therefore no site length or width data was collected.

Fish Sampling with Seines

Mandatory Fields In Grey
Must be filled out for processing

Date (mm-dd) 2016-07-20

Stream Name: WILMOT CREEK

Stream Code: WM1

Sample: 1

Coll. Area: 1

Run: 1

Site Code: 3CDW

Scientific Collectors Permit: 9678903

Net Type: 2

Mesh Size Wing: 2

Mesh Size Bag: 2

Net Type
1 = Straight
2 = Bag

Mesh Sizes
0 = N/A
1 = 1/8 inch
2 = 1/4 inch

Collection Area Length (m) 45.5

Transect Width (m) 5.6 6.0 5.4

Depth and Hydraulic Head

	Depth 1	H Head 1	Depth 2	H Head 2	Depth 1	H Head 3
T1	55	6	76	7	48	4
T2	62	10	72	15	66	11
T3	75	9	81	12	68	9

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B / O	P / S	Sp Name/Remarks
1	076	115	40	☐ ☐	☐ ☐	RAINBOW TROUT
2	076	78	7	☐ ☐	☐ ☐	"
3	076	75	6	☐ ☐	☐ ☐	"
4	076	253	475	☐ ☐	☐ ☐	"
5	076	215	376	☐ ☐	☐ ☐	"
6	076	130	85	☐ ☐	☐ ☐	"
7	076	70	6	☐ ☐	☐ ☐	"
8	076	68	3	☐ ☐	☐ ☐	"
9	076	60	2	☐ ☐	☐ ☐	"
10	078	210	301	☐ ☐	☐ ☐	BROWN TROUT
11	078	195	270	☐ ☐	☐ ☐	"
12	078	95	17	☐ ☐	☐ ☐	"
13	163	150	42	☐ ☐	☐ ☐	WHITE SUCKER
14	163	122	31	☐ ☐	☐ ☐	"
15	163	201	77	☐ ☐	☐ ☐	"
16				☐ ☐	☐ ☐	
17				☐ ☐	☐ ☐	
18				☐ ☐	☐ ☐	
19				☐ ☐	☐ ☐	
20				☐ ☐	☐ ☐	

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: EL CB

Recorder: CB

Field ID (init. & last name): S TRUTTA

Cert. Level: 1

Lab ID (init. & last name):

Cert. Level:

Entered/ Scanned: 2010/11/15 EL

Verified: 2010/11/14 CB

Corrected: 2010/11/15 EL

Example C:

This field record shows a combination of individual and bulk data. Note that the field identification was carried out by a Certificate Level 1, therefore cyprinidae and sculpins were preserved. The crew separated *Rhynichthys* sp., as they were confident that this group was either Longnose or Blacknose Dace. Total lengths of young of year (< 100 mm) Rainbow and Brown Trout were bulk weighed and recorded as Group 1. Scale samples were taken from representative fish in the sample.

Fish Sampling with Seines

Mandatory Fields In Grey
Must be filled out for processing

Date (mm-dd): 2010-07-20

Stream Name: WILMOT CREEK

Stream Code: WM1

Sample: 1

Coll. Area: 1

Run: 1

Site Code: 3CDW

Scientific Collectors Permit: 9678903

Net Type: 2

Mesh Size Wing: 2

Mesh Size Bag: 2

Net Type
1 = Straight
2 = Bag

Mesh Sizes
0 = N/A
1 = 1/8 inch
2 = 1/4 inch

Transect Width (m): 5.6 | 6.0 | 5.5

Collection Area Length (m): 45.5

Depth and Hydraulic Head

	Depth 1	H Head 1	Depth 2	H Head 2	Depth 1	H Head 3
T1	55	5	76	7	48	4
T2	62	11	72	15	66	11
T3	74	9	81	12	68	9

Deviations *(Check all that apply)*
☐ Inexperienced Sampler ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☐ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B	P	O	S	Sp Name/Remarks
1	076	115	40	☐	☐	☐	☒	RAINBOW TROUT
2	076	78	7	☐	☐	☐	☒	"
3	076	75	6	☐	☐	☐	☒	"
4	076	253	475	☐	☐	☐	☒	"
5	076	130	376	☐	☐	☐	☒	"
6	076	70	85	☐	☐	☐	☒	"
7	076	210	410	☐	☐	☐	☒	"
8	078	212	301	☐	☐	☐	☒	BROWN TROUT
9	078	195	270	☐	☐	☐	☒	"
10	078	65	—	☒	☐	☐	☐	"
11	077	130	35	☐	☐	☐	☒	ATLANTIC SALMON NO CLIPS
12	077	120	30	☐	☐	☐	☒	"
13	076	65	—	☒	☐	☐	☒	RAINBOW TROUT
14	076	63	—	☒	☐	☐	☒	"
15	380	25	3	☐	☐	☐	☐	SCULPIN
16	380	31	4	☐	☐	☐	☐	"
17	226	64	5	☐	☐	☐	☐	RHINICHTHYS
18	226	48	3	☐	☐	☐	☐	"
19	180	7[illegible]	5	☐	☐	☐	☐	CYPRINIDAE
20	180	62	3	☐	☐	☐	☐	"

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	1	10	24	0	—	RAINBOW TROUT
2	078	1	2	4	0	—	BROWN TROUT
3	380	0	30	102	6	1	SCULPIN
4	226	0	9	32	9	2	RHINICHTHYS
5	180	0	8	41	8	3	CYPRINIDAE
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: CB EL

Recorder: EL

Field ID (init. & last name): S TRUTTA

Cert. Level: 1

Lab ID (init. & last name):

Cert. Level:

Entered/ Scanned: 2010/11/13 EL

Verified: 2010/11/14 CB

Corrected: 2010/11/15 EL

Example D:

Lab identification results are recorded on this field sheet. Note that the bag number must be recorded to enable summary reports to accurately record results to the most accurate level of identification. The summary report will be able to report that the bulk catch of sculpins were of one species e.g., Mottled Sculpin, as long as the bag number and number of fish are recorded.

Fish Sampling with Seines

Mandatory Fields In Grey
Must be filled out for processing

Date (mm-dd): 2010-07-06

Stream Name: WILMOT CREEK

Stream Code: WM1

Sample: 1

Coll. Area: 1

Run: 1

Site Code: 3CDW

Scientific Collectors Permit: 9678903

Net Type: 2

Mesh Size: Wing: 2 Bag: 2

Net Type
1 = Straight
2 = Bag

Mesh Sizes
0 = N/A
1 = 1/8 inch
2 = 1/4 inch

Transect Width (m): 5.2 6.0 5.5

Collection Area Length (m): 46.0

Depth and Hydraulic Head

	Depth 1	H Head 1	Depth 2	H Head 2	Depth 1	H Head 3
T1	55	5	76	7	48	4
T2	62	11	72	15	66	11
T3	74	9	81	12	68	9

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B	P	O	S	Sp Name/Remarks
1	076	115	40	☐	☐	☐	☒	RAINBOW TROUT
2	076	78	7	☐	☐	☐	☒	''
3	076	75	6	☐	☐	☐	☒	''
4	076	253	475	☐	☐	☐	☒	''
5	076	130	376	☐	☐	☐	☒	''
6	076	70	80	☐	☐	☐	☒	''
7	076	210	406	☐	☐	☐	☒	''
8	078	212	301	☐	☐	☐	☒	BROWN TROUT
9	078	65	—	☒	☐	☐	☐	''
10	078	195	270	☐	☐	☐	☒	''
11	077	130	35	☐	☐	☐	☒	NO CLIPS ATLANTIC SALMON
12	077	120	30	☐	☐	☐	☒	''
13	076	65	—	☒	☐	☐	☒	RAINBOW TROUT
14	076	63	—	☒	☐	☐	☒	''
15	380	25	3	☐	☐	☐	☐	SCULPIN
16	380	31	4	☐	☐	☐	☐	''
17	226	62	5	☐	☐	☐	☐	RHINICHTHYS
18	226	48	3	☐	☐	☐	☐	''
19	180	78	5	☐	☐	☐	☐	CYPRINIDAE
20	180	62	3	☐	☐	☐	☐	''

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	1	10	24	0	—	RAINBOW TROUT
2	078	1	2	4	0	—	BROWN TROUT
3	380	0	30	102	6	1	SCULPIN
4	226	0	9	32	9	2	RHINICHTHYS
5	180	0	8	41	8	3	CYPRINIDAE
6	—	LAB IDENTIFICATION RESULTS —					
7	381	-	6	—	—	1	MOTTLED SCULPIN
8	210	-	7	—	—	2	BLACKNOSE DACE
9	211	-	2	—	—	2	LONGNOSE DACE
10	212	-	4	—	—	3	CREEK CHUB
11	198	-	2	—	—	3	COMMON SHINER
12	209	-	2	—	—	3	FATHEAD MINNOW
13							
14							
15							

Crew Leader (init. & last name): S TRUTTA

Crew: CB EL

Recorder: EL

Field ID (init. & last name): S TRUTTA

Cert. Level: 1

Lab ID (init. & last name): S GIBBS

Cert. Level: 2

Entered/ Scanned: 2010/08/01 EL

Verified: 2010/08/03 CB

Corrected: 2010/08/03 EL

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4

Assessing Physical Processes and Channel Structure

TABLE OF CONTENTS

INTRODUCTION

The modules in this section provide standard methodologies for assessing habitat in wadeable streams. The data collected will allow analysis of the channel structure (e.g. cover, substrate), channel processes (e.g. hydrology, sediment transport), and the stream's suitability for biota. Standardizing data collection procedures enables comparisons to be made across spatial and temporal scales by reducing error and controlling biases. Providing standard methodologies that vary in the accuracy of the data collected offers flexibility for users to accommodate different study designs.

A summary of the procedures, the effort required to implement them, and the accuracy of data collected for each are provided below. Additional details are provided in the Introduction section of each module. New in version 10 is the recognition that headwater sampling that is applied in either a constrained (where access is an issue) or unconstrained (where access is not an issue) generates data with differing biases limitations. As such, modules S4.M10 and S4.M11 are the first to vary mostly by the study design to which they are applied.

Some of the modules in this section require the use of transects. These can be used to collect data for more than one module (i.e. modules can be applied individually or in conjunction with each other).

Accepted standard protocols in this section include:

S4.M1: Rapid Assessment Methodology for Channel Structure

This module is designed to provide visual estimates of channel structure, substrate and bank condition. The Rapid Assessment Methodology for Channel Structure (RAM) adapts the point-transect approach, by visually classifying the habitat along transects. RAM can be completed in much less time than it would take to complete the full point-transect method (S4.M2, see below) and produces a more repeatable assessment than conventional visual assessments. RAM is best applied to studies that are designed to evaluate overall conditions across spatial scales.

S4.M2: Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions

This module provides screening level and diagnostic techniques to evaluate the physical conditions important to biota in wadeable streams. Screening level techniques are described for evaluating riparian conditions, bank vegetation, sinuosity, bankfull width, confinement and velocity. Diagnostic techniques offer more precision to quantify channel roughness, low flow width and depth, substrate composition and diversity, amount of wood material, instream cover and vegetation, and degree of undercutting. The sampling effort applied for each attribute is determined by the level of precision required to demonstrate the relationships between biota and physical habitat characteristics. This module can be used for studies to evaluate change in conditions across temporal or spatial scales.

S4.M3: Bankfull Profiles and Channel Entrenchment

This module describes a quantitative method for measuring the bankfull cross-sectional profile. Techniques for recording channel entrenchment (i.e. a measure of channel confinement within the floodplain) are also outlined. Two approaches are described for demarcating the line to which the profiles are measured. The use of a laser level is more expensive and slightly more time consuming, but generates a more accurate measure of bankfull area and is therefore considered diagnostic. The standard approach involves using a tape measure that is pulled as taught as possible.

Identifying the bankfull level requires a basic understanding of stream dynamics. While the methods described in this module are intended to provide reliable and repeatable measures, they require interpretative skills. Further, bankfull profile measurements are more easily applied on stable channels. This module is best applied as a monitoring or assessment tool for evaluating changes in the channel profile that may result from geomorphic processes.

S4.M4: Rapid Assessment Surveys of Stream Discharge and Perched Culverts

This module contains instructions for estimating discharge on “all” wadeable streams using qualitative methods. These methods are used mainly for reconnaissance purposes as they confirm the presence of flow, provides a measure of relative discharge, and information on the suitability of sites for more rigorous sampling. The use of these preliminary observations will ensure that field studies are planned and conducted effectively and efficiently.

Data collected using this module will have higher error rates than more quantitative surveys as outlined in S4.M5.

S4.M5: Measuring Stream Discharge Quantitatively

This module contains instructions for measuring discharge on wadeable streams, using the Volume/Time Method and the Area Times Velocity Method. The data are useful for long-term monitoring and impact assessment studies. These procedures can be used for characterizing baseflow conditions or for determining a point-in-time response to a storm event.

S4.M6: Crest Stage Gauges: Rapid Assessment of Response to Storm and Drought Events

This module describes an economical and reliable method of measuring the maximum depth of water over a period of time (i.e. typically through a storm event). These methods collect screening level information about the flashiness of a stream and are suitable for large-scale surveys which require an evaluation of many sites. This module can provide an indicator of the watershed's response time and pattern to a storm/drought event.

S4.M7: Standardized Procedures for Measuring Site Slope

This module provides instructions for measuring changes in the elevation of the stream bed or water surface between two or more locations within a site. When combined with site length, the techniques are useful for measuring the average slope of the bed and the water surface in a site. The methods are also appropriate for generating a longitudinal profile of the site if differences in elevation between specific morphologic features (e.g. riffles versus pools) are recorded. These methods can be applied to diagnostic surveys that measure small changes in bed elevation, however there are more efficient, albeit expensive, approaches than those described in this module.

S4.M8: Rapid Assessment Methodology for Instream Substrate Sampling

This module describes techniques for conducting a "hybrid" screening/assessment level assessment of substrate composition through an entire site. The techniques employed are a cross between a traditional Rapid Assessment Methodology (RAM) and a standard survey approach in that crews use rapid assessment approaches to locate sampling points and then apply a standard approach to measure substrate composition. If applied without bias, this approach can generate an accurate assessment of the proportion and sizes of substrate particles throughout a site.

S4.M9: Instream Crossing and Barrier Attribution

This rapid assessment module is intended to augment the Dams and Barriers and Provincial Dam Inventory by providing a tool to inventory dams that are less than 1 metre in height as well as other potential barriers and sources of flow constriction that might affect fish and sediment passage. This includes culverts, low head dams, storm sewer outfalls or natural barriers such as rock ledges, beaver dams and sluiceways.

S4.M10: Constrained Headwater Sampling

This module describes a rapid assessment method for characterizing the amount of water and sediment transport and storage capacity within headwater drainage features (HDFs). It is designed to be applied at road crossings which enables surveyors to work within municipal road allowances. Site boundaries are defined to be in proximity of road crossings and features are determined based on dominance. Additionally, this module provides a means of characterizing the connectivity, form and unique features associated with each HDF. The objective of this module is to describe a methodology that will provide standardized datasets to support science development and monitoring.

S4.M11: Unconstrained Headwater Sampling

This module describes a rapid assessment method for characterizing the amount of water and sediment transport and storage capacity and drainage feature types found on an extended landscape where access is generally unconstrained. It is designed to provide information support to the many municipalities and Conservation Authorities that have developed headwater management guidelines. Many of the objectives and methods are comparable to those described in S4.M10 with the exception of site boundary determination, which is determined here based on physical feature boundaries rather than arbitrary distances.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 1

Rapid Assessment Methodology for Channel Structure[1]

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APPENDICES

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[1] Authors: L. W. Stanfield and M. L. Jones

1.0 INTRODUCTION

Techniques for conducting screening level assessments of fish habitat conditions are described in this module. While this methodology is defensible and variance can be quantified, data collected using this tool are mostly visual and are therefore inherently biased. A procedure for calibrating the biases is also described.

This module provides a Rapid Assessment Methodology (RAM) which is a screening level characterization of stream habitat at a site. Data collected includes substrate, depth, instream morphology and bank stability. The RAM incorporates the point-transect approach which improves repeatability over conventional non-point transect visual assessments (Hawkins *et al*. 1993). It is best applied in studies that have one of the following objectives:

- to evaluate a large number of sites with limited time and resources
- conduct a screening level investigation of habitat suitability at a site for specific fish species.

If more accurate results are required for measuring substrate composition, the module is easily adaptable to incorporating the Rapid Assessment Methodology for Instream Substrate Sampling (S4.M8). If the site is to be a component of a monitoring program or more accurate data for all attributes are required the use of the Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions (S4.M2,) module should be considered.

2.0 PRE-FIELD ACTIVITIES

A typical habitat survey of a site should take between 10 to 20 minutes. A two-person crew is recommended for safety. Field surveys should follow a training program (see Appendix 1).

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1, Site Identification and Documentation)
- Equipment check

The following equipment is required:

1. RAM Field Forms on waterproof paper
2. Pencils
3. Metre stick
4. Tape measure
5. Maps

Optional equipment includes:

6. Calculator
7. Hip chain
8. Flagging tape
9. Compass
10. Site marking equipment and
11. Camera

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

Procedures outlined below include defining site boundaries, recording site information, and measurement of channel features, bank conditions and substrate.

3.1 Recording the Site Identification Information

The module should be done in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and S1.M2 - Screening Level Site Documentation **or** S1.M3 - Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available.

Record the ‘Site Type’ as a calibration (C) or survey (S) site. A calibration site is one at which both RAM and the point-transect methodology data are collected and used to develop the correction factors for the RAM data (Appendix 1 and 2).

3.2 Defining the Site Boundaries

The site boundaries are defined as per S1.M1. If no accurate data on site length are available, record the approximate length of the site (±3 m). This is accomplished by either chaining up the centre of the stream (most accurate) or by pacing up the channel or the banks, depending on site conditions. Record the site length on the Site Identification Form, mark with an asterisk (*), if anything other than chaining was used to obtain this measurement, and include an explanation in the ‘Comments’ section indicating that the site length was estimated. On the RAM Field Form (Appendix 3), record the appropriate unique identifiers for the site (see S1.M1).

3.3 Setting up Transects and Observation Points

Begin at the downstream end of the site and walk upstream (observing and recording the habitat conditions as you go) until the top of the site is reached. If chaining is used to measure site length, crews may mark the transect locations on the banks during the return trip to the bottom of the site. The number of transects required and the number of observation points per transect is determined by the minimum width of the site. If the stream is greater than 3 m wide throughout the site, use 10 transects and at least 6 observation points per transect; otherwise estimate the stream width at the narrowest location and refer to Table 1. Transects should be evenly spaced along the site and the same number of observation points applied on each transect. Note, surveyors may choose to apply a sampling scheme that generates 100 data points per site to ease data interpretation (i.e., 10 transects and 10 points per transect).

Beginning at the first downstream transect, visually locate the appropriate number of observation points along the transect. Depth, velocity and point substrate measurements are made directly below the observation point, whereas cover and maximum particle size measurements are made within a visualized 30 cm ring centered on the observation point (referred to as the ‘observation area’) (Figure 1).

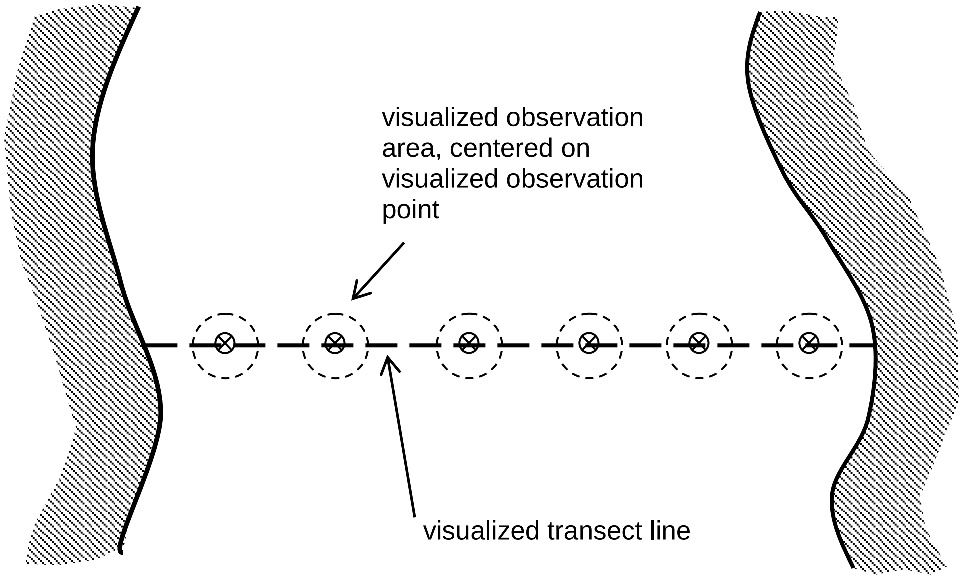

Figure 1: ‘Observation Areas’ (30 cm diameter) and Transect.

Table 1 - Relationship Between the Minimum Stream Width and the Minimum Number of Observation Points Required per Transect

Minimum Stream Width (m)	Number of Transects	Number of Observation Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.5	15	3
< 1.0	20	2

3.3.1 Channel Structure

A variety of techniques may be used to collect channel structure data, depending on the experience of the crew and the complexity of habitat. Techniques include collecting most of the data from shore in relatively homogenous sites or by walking across each transect, stopping at each observation point to collect data.

At each observation point measure hydraulic head (velocity) to classify habitat into four categories: pools, glides, slow riffles and fast riffles (Table 2). Then measure/estimate water depth to classify points into shallow, moderate, intermediate or deep habitats. Finally, determine whether there is unembedded cover present or absent. Cover is assessed within a visualized 30 cm ring centered on the observation point (see section 3.3.2, Instream Cover of this module). Combine these three measures (hydraulic head, depth and cover) to classify and record each observation in the ‘Channel Structure’ section of the RAM Field Form using the dot tally method (one dot per observation point).

Hydraulic Head

The difference in height of water between the front and back of a vertically held ruler that is placed at right angles to the flow of water (see S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions for more details).

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

Table 2 - Description of Habitat Categories (Adapted from Aadland *et al.* 1991)

Habitat Categories	Descriptions
'Pools'	Hydraulic head of 0 to 3 mm
'Glides	Hydraulic head of 4 to 7 mm (evidence of little turbulence and moderate velocities)
'Slow Riffles'	Hydraulic head of 8 to 17 mm (fast velocities)
'Fast Riffles'	Hydraulic head greater than 17 mm (very fast velocities)

3.3.2 Instream Cover

Measure cover within a visualized 30 cm ring centered on the observation point. Record and document the occurrences and all types of unembedded cover present (e.g., cover with interstitial spaces that enable small fish to hide underneath the object) within each sample area, using the dot tally method (Table 3). For example, if there is a boulder and log at one observation point record **one** dot in each of the boxes for 'Cover Types': 'Round Rock' and 'Wood'.

Instream Cover

A cover particle is any object that touches the water within the sample area, is **<u>at least 100 mm wide</u>** along the median axis and of sufficient density to block >75 % of sunlight from reaching the stream bottom. A cover particle can consist of a mat of materials such as twigs, macrophytes, or the bank. The mat must still meet the median diameter size and light penetration restrictions.

Table 3 - Definitions for Cover Types

Cover Type	Description
'Flat Rock'	The longitudinal axis is at least twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis > 2.
'Round Rock'	The longitudinal axis is less than twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis < 2.
'Wood'	Living or dead woody materials (includes mats of twigs, shrubs).
'Macrophytes'	Living aquatic and terrestrial non-woody plants.
'Bank'	Bank material which contain soils (fine materials) i.e., undercuts and slumped banks or parts of banks which have become dislodged and are now lying in the main channel.
'Other'	Any other type of material not covered by the above categories (e.g. tires, refrigerators, cars).

Flat versus Round Rocks

Flat and round rocks are recorded separately based on the different levels of suitability of these cover types for various species of fish (Ed Crossman, Royal Ontario Museum, pers. comm.).

3.3.3 Substrate Types

This section assesses the substrate and sediment transport characteristics of the site, within the context of the type of parent material available to the stream. For sediment transport purposes, there are three types of channels commonly found in Ontario – bedrock, alluvial and detrital. Bedrock streams can either be erodible (shale) or not (granite). Alluvial streams have parent material of either fine (sand), medium (gravel), or coarse (cobble) particulate materials. Detrital streams ae typically of low gradient, have high volumes of wood and therefore low erosive power and store large volumes of detritus, commonly referred to as gavia feces. In these systems there is generally long periods of time between flows that modify the channel through bedload movement. As such it may be sufficient to simply walk the banks and apply a visually based rapid survey to record the amount of area occupied by gavia feces.

In order to understand the relationship of parent substrate materials and bedload transport, measurements and comparisons are made between **maximum particle** and **point particle** sizes.

3.3.3.1 Point Particle

Across each transect, visually estimate the percentage of substrate (in 10% increments) as fines (sand), gravel, cobble or bedrock. Record the percentages using the dot tally procedure, where each dot accounts for 10% of the transect. For example, if the proportions are sand

(10%), gravel (80%) and cobble (10%), there would be one dot for each of fines and cobble, and 8 dots for gravel. There should be a total of 10 dots per transect, and 100 dots when 10 transects are completed. If the technique of walking across each transect is used, surveyors may choose to evaluate substrate below each observation point as a more accurate alternative.

3.3.3.2 Maximum Particle

At each observation area (i.e., 30 cm circular sampling area) on the transect, estimate and record (dot tally) the maximum particle size observed based on substrate categories listed in Table 4.

Dealing with Bedrock and Hardpan clay

If either bedrock or hardpan clay are picked as a point particle then the maximum particle would be the largest particle movable by the stream within the cover ring. Conversely, if particles are picked and hardpan clay or bedrock is present in the observation area, record the largest particles that are movable by the stream. It may be that no other materials are present, in which case bedrock or hardpan clay would be recorded for both measurements. In some bedrock and hardpan clay streams there will be a fine (opaque) layer of silt that has been trapped by algae or slime that covers the bedrock. Ignore this fine layer in the determination of substrate particle size.

Table 4 - Descriptions of Substrate Categories (adapted from Dodge *et al.* 1984)

Substrate Categories	Median Axis of Largest Particle Observed is
‘Gavia feces’	Dense mat of detritus found in deposition areas
‘Fines’ (sand, silt, clay)	< 2 mm.
‘Gravel’	2 to 100 mm.
‘Cobble’	101 to 1000 mm.
‘Bedrock’	> 1000 mm.

3.3.4 Habitat Stability

This section provides guidance on how to measure ‘Mean Stream Width’, ‘Mean Depth at Crossover’, ‘Maximum Particle Size’, and ‘Bank Stability (e.g., ‘Eroding Bank’, ‘Vulnerable Bank’, ‘Protected Bank’, ‘Deposition Zone’).

3.3.4.1 Stream Width at Crossover

At the bottom of the site (i.e., at crossover point), measure and record the wetted width of the stream in the box marked ‘Mean Stream Width (m)’. Record the width to the nearest tenth of a metre.

3.3.4.2 Mean Depth at Crossover

At the same crossover transect estimate the average water depth. Water depth at crossover points should be relatively uniform across the channel. The measurement could be taken using several techniques (e.g., measurement of several points across the transect with a metre stick or a wading rod). Record the water depth to the nearest 5 mm, (e.g. a water depth of 17 mm should be recorded as 15 mm).

3.3.4.3 Maximum Particle Size

Within the site boundaries, find and measure the largest rock that has been moved by the stream. Ignore rocks that are likely to be erratics or other rocks in the stream that have obviously been in place for long periods of time. For example, if erosion is evident on either side of the rock, it should not be included in this measure. If there are several rocks that are similar in size, a representative rock should be selected. Measure and record the median axis (to the nearest mm) in the 'Maximum Particle Size' box on the RAM Field Form.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

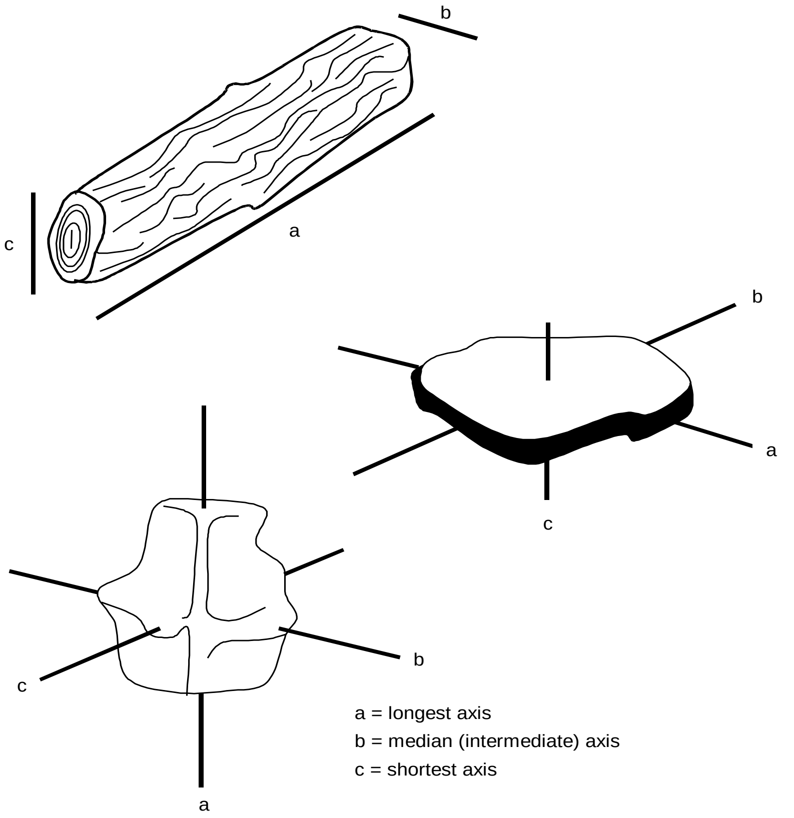

Figure 2: Measuring the Median Axis of Cover and Substrate.

3.3.4.4 Bank Stability

Categorize both banks of each transect using the following categories (Table 5). Record using the dot tally method.

Table 5 - Descriptions of Bank Stability Categories

Bank Stability Categories	Interface between Water and Bank	Bank Soil/Substrate	Characteristics of Bank
'Eroding Bank'	Steep, >45º	Erodible materials	Undercut (by at least 5 cm) or shows signs of recent slumping (e.g., no or little vegetation present
'Vulnerable Bank'	Steep, >45º	Erodible materials	Shows no recent signs of erosion (e.g., undercuts or slumping) and protected by a mat of live vegetation
'Protected Bank'	Steep, >45º	Non-erodible materials (e.g., rock, boulders or hardened clay)	Vegetation may or may not be present, includes banks armoured by humans
'Deposition Zone'	Gentle, <45º	Generally, materials which have been deposited by the river during its flood condition	Point bars inside bends of streams

3.4 Tips for Applying this Module

Crews using this module should have experience with the point-transect methodology (S4.M2). It is strongly recommended that crews be trained and have enough field experience to ensure repeatability.

Project managers should establish a training program for crews at the outset of the study and a follow-up assessment to ensure that data are acceptable (Appendices 1, 2).

Data should be recorded while proceeding up the stream and then summarized before leaving the site.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g., FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The rapid assessment methodology benefitted from discussions held to develop the Watershed Report Card for Community Groups and specific input by John Parish.

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Appendix 1

Training Crews in the Use of RAM

RAM data is most valuable when it can be collected by a crew in a consistent manner such that strong correlations can be established between it and more rigorous methods (e.g., S4.M2 - Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions). We recommend the following procedures for training field crews in the use of this module to maximize the utility of the data collected:

Carry out the point transect survey and RAM at as many transects as needed for the crew to feel confident in their results. Ensure that the types of habitat assessed cover the range expected in the overall study.

1. Set up a transect line and mark the location of each observation point.
2. Using the criteria on the RAM Field Form, visually classify the instream habitat and substrate at each observation point and then rate the bank conditions as to their vulnerability to erosion.
3. Repeat the process at each observation point and on the banks using the point transect methods described in S4.M2 - Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions.
4. Compare the results of the two methods, discussing where results differ and why.
5. Repeat this process until there is congruence between the two methods. Compare results for each category of habitat at the end of each transect and again at the completion of the training period. All visual observations should be within 1 category of the point-transect data and there should be at least 90% agreement in the number of classes determined using each method (i.e., number of shallow pools using point transect / RAM should exceed 0.9).
6. As a final stage, we recommend that several transects be evaluated before the tape measure is set up, to ensure that crews are able to visually establish the appropriate spacing for both transects and observation points.

The time required to train crews will depend greatly on their experience. Managers should be prepared to allocate at least two sites (one day) for this exercise.

Appendix 2

Developing Calibration Ratios for RAM

Introduction

Here we describe how the methods of Doloff *et al.* (1993) can be used to develop calibration coefficients for data collected using the point transect methodology (S4.M2) and RAM (S4.M1). This enables users to develop a higher degree of accuracy in their estimates of habitat than is generally possible if only RAM is used. This task requires four steps:

- establishing calibration and study sites and the sampling sequence
- collecting field data
- establishing the calibration coefficients
- application of correction factors to data and calculate confidence limits

Step 1: Establishing calibration and study sites and the sampling sequence

Project managers must determine (randomly) how many sites to sample for calibration. This number will be the greater of 10 sites or 10 % of total sample sites. These will become locations where both RAM and the point transect methods will be applied. These sites are referred to as calibration sites. Establish a sampling schedule that balances logistics with the need to spread the collection of calibration site data randomly across the duration of the study.

Note: If multiple crews are used on a survey and there are consistently different biases (i.e., one crew is always high and the other low we recommend that independent calibration be developed for each crew). Any site within your study area or comparable areas of geology can be used as calibration sites for your crews, provided the habitat does not measurably change between the two sample periods. Therefore it may be possible for studies to use data from other studies to develop calibration ratios as a cost saving measure.

Step 2: Field Data Collection

Collect the field data, ensuring that at any calibration site, the RAM data is collected first. Only after the RAM has been collected for the entire site should the point transect surveys be initiated.

Step 3: Developing Calibration Ratios

After entering and verifying that all data is correct, extract the appropriate data required for the study and summarize the results. The data points should be plotted and the R^2 value between the methods should be greater than 0.50. If it is not, do not attempt to create calibration coefficients. Use data from the calibration sites to develop calibration coefficients for each attribute of interest as follows:

$$\hat{Q} = \sum_{i=1}^{n} m_i / \sum_{i=1}^{n} x_i$$

where,
m_i = point transect habitat variable for each calibration site *i*; *i* = 1, 2,... n
x_i = RAM estimate of habitat variable for each site *i*; *i* = 1, 2,... n

For example, the results of a point transect and RAM survey for the percent cover are shown below:

Point Transect:	10, 15, 17, 3, 68, 23, 24, 14, 9, 12 = 195
RAM	5, 10, 20, 0, 50, 10, 20, 20, 10, 10 = 155

The calibration ratio for this variable would be:

$$\hat{Q} = 195/155 = 1.26$$

Step 4: Application of correction factors to data and calculate confidence limits

The adjusted habitat scores ($\hat{M}$) for the study can be estimated by multiplying the mean value for the attribute from all of the sites in the study (T_x) by the calibration ratio ($\hat{Q}$).

$$\hat{M} = T_x \hat{Q}$$

For example if the mean estimate of cover for the entire data set was 24, then the corrected estimate would be:

$$1.26 \bullet 24 = 30$$

This technique is only appropriate for large-scale basin wide surveys as it does not correct individual site biases.

The uncertainty of the estimate for each habitat attribute for the entire survey data set can be calculated from sample data using:

$$\hat{V}(\hat{M}) = \frac{N(N-n)}{n(n-1)} \sum_{i=1}^{n} (m_i - \hat{Q} x_i)^2$$

where

N = the total number of sites surveyed using the point transect technique

n = the total number of sites surveyed using the RAM

m_i = measured estimate of the habitat variable *i.*

$\hat{Q}x$ = predicted estimate of habitat variable *i.*

This equation approximates the variance $(\hat{V})$ for large sample sizes (i.e., > 10 samples). This equation shows that the variance depends on two very different factors, sample size and consistency in application of the RAM. First, variance decreases as the sample size increases, a manager can always reduce variance in the study by increasing the proportion of the sites sampled, using both the point transect and RAM. Second, the summation term expresses the squared differences between the habitat attributes measured using the point transect and RAM. The more closely correlated the results of the two methods are, the lower the variance will be. The other way to reduce variance is to ensure that the field procedures for measuring the RAM and transect methods are applied consistently for all sample sites.

The 95 % confidence intervals for the habitat attributes can be estimated using the following:

$$\hat{M} \pm t_{0.05;\, n\, -\, 1}\sqrt{\hat{V}(\hat{M})}$$

For more information on this technique see Doloff et al. (1993).

Note: Check the data for obvious errors and outliers and either correct or delete as appropriate.

Appendix 3

Example Rapid Assessment Methodology Field Form

Rapid Assessment Methodology Field Form

Mandatory Fields In Grey
Must be filled out for processing

Stream Code: WM1
Site Code: 3CDW
Sample:

Date YY MM DD: 2010 – 06 – 21

Site Type
☒ Calibration ☐ Survey

Stream Name: WILMOT CREEK

Crew Leader (initial & last name): S TRUTTA

Crew: SS

Recorder: SS

Channel Structure

Depth (mm)	Pools (Hydraulic Head = 0-3 mm)		Glides (Hydraulic Head = 4-7 mm)		Slow Riffles (Hydraulic Head = 8-17 mm)		Fast Riffles (Hydraulic Head > 17 mm)	
	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present
0 - 100 mm	04	02	02	02	05	04	02	
101 - 600 mm	08	03	08	02	09	03	01	
601 - 1000 mm	01	01	02			01		
> 1000 mm								
Total # Points	13	06	12	04	14	08	03	

Note:
Grey hatched areas are for tally marks.

Instream Cover

Cover Types	Flat Rock	Round Rock	Wood	Macrophytes	Bank	Other
Number of Points	06	10	04	0	01	0

Substrate Types

	Fines (<2 mm)	Gravel (2-100 mm)	Cobble (100-1000mm)	Bedrock (>1000mm)	gavia feces
Point Particle	12	32	16	0	0
Maximum Particle	10	20	30	0	0

Bank Stability

Mean Stream Width (m): 5.5
Mean Depth at Crossover (mm): 25
Maximum Particle Size (mm): 250

Eroding Bank	01	Angle > 45°, erodible soil, undercut or bare soil
Vulnerable Bank	09	Angle > 45°, erodible soil, no sign of recent erosion
Protected Bank	0	Angle > 45°, non-erodible material/soil
Deposition Zone	10	Angle < 45°, (gradual slope from river), fine grained sediments

Comments
PATH ON RIGHT SIDE OF STREAM

Ent/Scanned	Verified	Corrected
SS	JB	JB

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 2

Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions[1]

TABLE OF CONTENTS

APPENDICES

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[1] Authors: L. W. Stanfield, J. Parish and M. Stoneman

1.0 INTRODUCTION

The data collected using this module can be used to compare physical conditions of streams spatially or temporally. It can also be used to identify limiting features of the physical habitat. The procedures within this module can be completed individually (e.g. to evaluate only substrate) but it is recommended that the entire module be completed. The advantage of this module over the RAM (S4.M8) is that all data collected are actual measurements which improves accuracy and allows for a wider range of statistical interpretation of the data because the data are not bound by pre-determined categories. This module also provides the user an opportunity for post-survey interpretation of the data.

Transects established for this module can also be used for S4.M1, Rapid Assessment Methodology for Channel Structure, S4.M3, Bankfull Profiles and Channel Entrenchment and S4.M5, Measuring Stream Discharge Quantitatively.

2.0 PRE-FIELD ACTIVITIES

A three-person (two surveyors, one recorder) crew can complete the survey in two to three hours. A fourth person will expedite the process as they can establish transects while others take measurements. Since most of the time-consuming measurements occur at the ends of the transects (e.g. bank angle, bank vegetation, undercuts etc.), smaller streams will take longer to complete because more transects are required.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this module, the following equipment is required:

1. Channel Morphology Data Form(s) (preferably on waterproof paper)
2. Pencils
3. Metre sticks (two, at least one metre stick must be wooden)
4. Tape measures (two, 30 m or longer)
5. Bank grid (see definition below)
6. Cover ring (30 cm diameter ring mounted on a pole; Figure 1)
7. Flagging tape

8. Spikes or tent pegs (four, 25 cm long), one or more spring clamps, or two bungee cords
9. Compass
10. Calculator (waterproof, or in re-sealable bag)

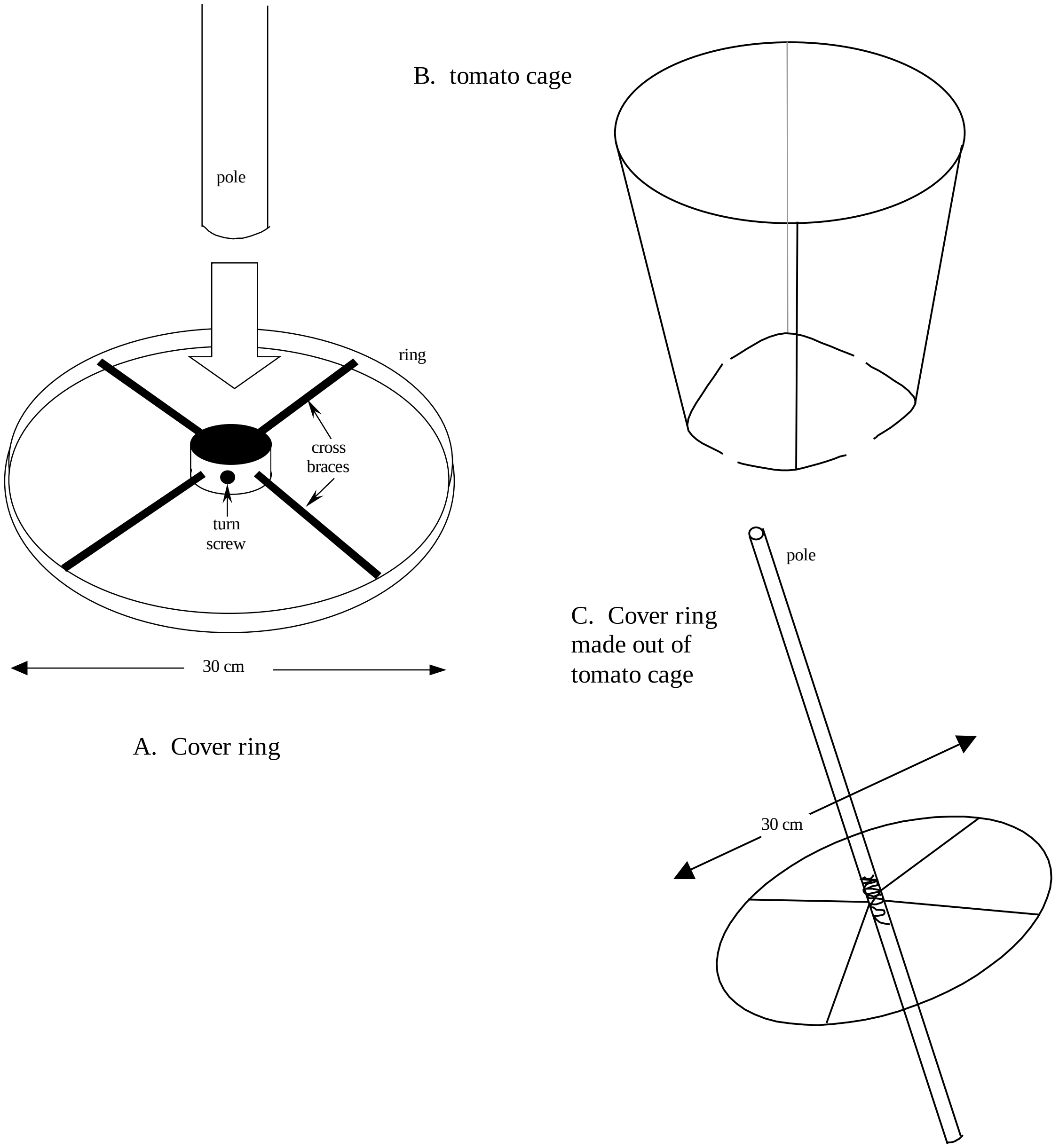

Figure 1: Cover Ring.
A cover ring can be constructed according to the plan in (A). This requires welding capabilities and results in a ring that moved up and down the pole as required. To construct the cover ring from a suitably sized tomato cage (B), snip the support braces at the junction of the second ring. Fold the braces back and bend them around the support pole (C).

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

Optional equipment includes: bank profile tool (Figure 11), and field calipers. To mark the upstream and downstream boundaries of the site, four metal rods (i.e. Rebar, approximately 1 m in length) can be used.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available. The survey always begins at the bottom (downstream) end of the site and proceeds sequentially to the top. Each transect begins on the left bank (as determined while looking upstream). The data collection process is detailed below.

3.1 Overview of Sampling Procedures

Step 1: Ensure that site boundaries S1.M1, Defining Site Boundaries and Key Identifiers, Section 3.2, Identifying the Site Boundaries have been established and a sketch of the site can be completed (refer to S1M3 Assessment Procedures for Site Feature Documentation, Section 3.2, Making a Site Sketch).

Step 2: Determine the ‘Minimum Width (m)’ of the stream. This is used in conjunction with the ‘Site Length (m)’ for determining the ‘Number of Transects’ required, their longitudinal spacing (‘Transect Spacing (m)’), and the number of points for each transect (‘Number of Points/Transect (N)’).

Step 3: At the bottom of the site, establish the first transect.

Step 4: At each transect, measure the ‘Active Channel Width’, assess the bank characteristics and vulnerability to erosion, generate a cross-sectional profile of the banks: measure the horizontal depth of undercuts (‘Amount of Undercut’), ‘Bank Angle’, bank (substrate) composition (‘Bank Particle Median Diameters’), vegetative cover (‘# of Vegetated Squares on Bank’), and the ‘Dominant Vegetation Type’.

Step 5: Record the following data at each observation point along each transect: water depth (‘Depth’), ‘Hydraulic Head’, ‘Cover Types Present’, whether or not the cover is embedded (‘Cover Quality’), ‘Aquatic Vegetation Type Present’, substrate particle size immediately below the observation point (‘Particle Sizes’, ‘Point’), and largest substrate particle within the cover ring (‘Particle Sizes’ ‘Maximum in Ring’).

Step 6: At each transect, record the stream bearing (‘Compass Bearing’).

3.2 Site Length, Minimum Width and Number of Transects

Site length is measured by chaining up the centre of the stream. Ensure that the lower and upper boundaries of the site are clearly marked. One person stands at the bottom of the site in the middle of the stream to mark the starting point. A second person proceeds upstream until the stream changes direction (or until the end of the tape is reached). The second person then marks the point, measures the distance, and waits for the first person to reach the mark before proceeding upstream to the next mark location (Figure 2). At the centre of each curve in the stream, the second person should mark the location and call for the first person to move up. Do not simply stretch the rope around the corners, as it will not be measuring up the middle. This process is repeated until the total site length is measured.

Record the site length in metres on the Site Identification and Channel Morphology Data Forms (e.g. 48 m).

The number of transects required and the number of observation points per transect is determined by the minimum width of the site. If the stream is greater than 3 m wide throughout the site, use ten transects and six observation points per transect; otherwise, measure the stream width at the narrowest location and refer to Table 1.

Table 1: Relationship Between the Minimum Stream Width and the Number of Observation Points Required per Transect.

Minimum Stream Width (m)	Number of Transects	Number of Observation Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.5	15	3
< 1.0	20	2

Record the ‘Minimum Width (m)’, ‘Number of Transects’, and the ‘Number of Points/Transect (N)’ on the first sheet of the Channel Morphology Data Form. If the stream width is greater than 3 m, record ‘>3 m’.

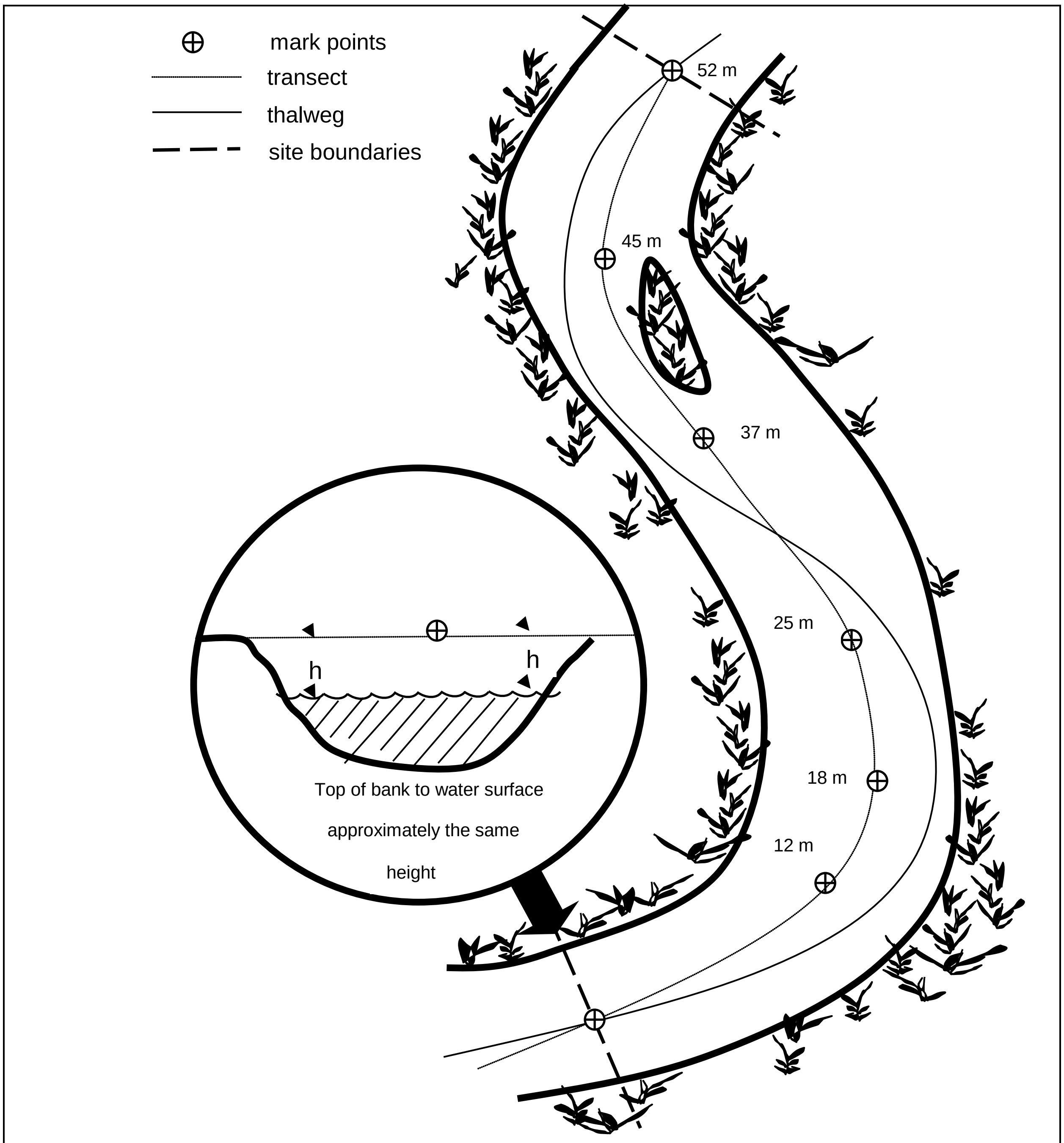

Figure 2: Site Boundaries and Length Determination.
First crossover point occurs at < 40 m, therefore continue to the next crossover.

3.3 Determining the Longitudinal Spacing of Transects

To determine transect spacing within the site, divide the length of the site by the number of transects required minus one (i.e. ‘Transect Spacing’ = ‘Site Length’ / (Number of Transects’ – 1)). For example, if a site is 52 m long and requires 10 transects, the transects would be spaced at 5.8 m (52/(10-1) = 5.8 m). Transects would be situated at the 0, 5.8, 11.6, 17.4, 23.2, 29.0, 34.8, 40.6, 46.4 and 52.2 m marks. The actual transect location can be rounded to the nearest metre. Record the ‘Transect Spacing’ on the Channel Morphology Data Form (Appendix 1). Transect locations should not be shifted.

3.4 Setting Up the Transect and Measuring the Active Channel Width

Transects should be established perpendicular to the general direction of flow (Figure 3). To set up a transect, stake both ends of a tape measure into the banks so that it is reasonably level and taut. Always start on the left side of the river while facing upstream.

***Hint**: To save time when doing bank measurements locate the ends of the tape at least 1.5 m back from the edge of the bank (Figure 4). There are many tools that can be used to secure the tape to the bank including bungee cords, quick release clamps, long spikes, surveyor and gardening stakes. Ensure that the tools are well marked with bright colours.*

Measure and record the active channel width (see definition below) on the Channel Morphology Data Form. Divide the active channel width by the number of observation points (Table 1) to determine panel width. Sampling will be conducted at the mid-point of each panel and these points are referred to as observation points. (see example below and Figure 4). If an observation point falls on an island or point bar within the active channel, treat it as an observation point and record the appropriate information. Mark the location of each observation point on the tape measure using flagging tape before taking any measurements.

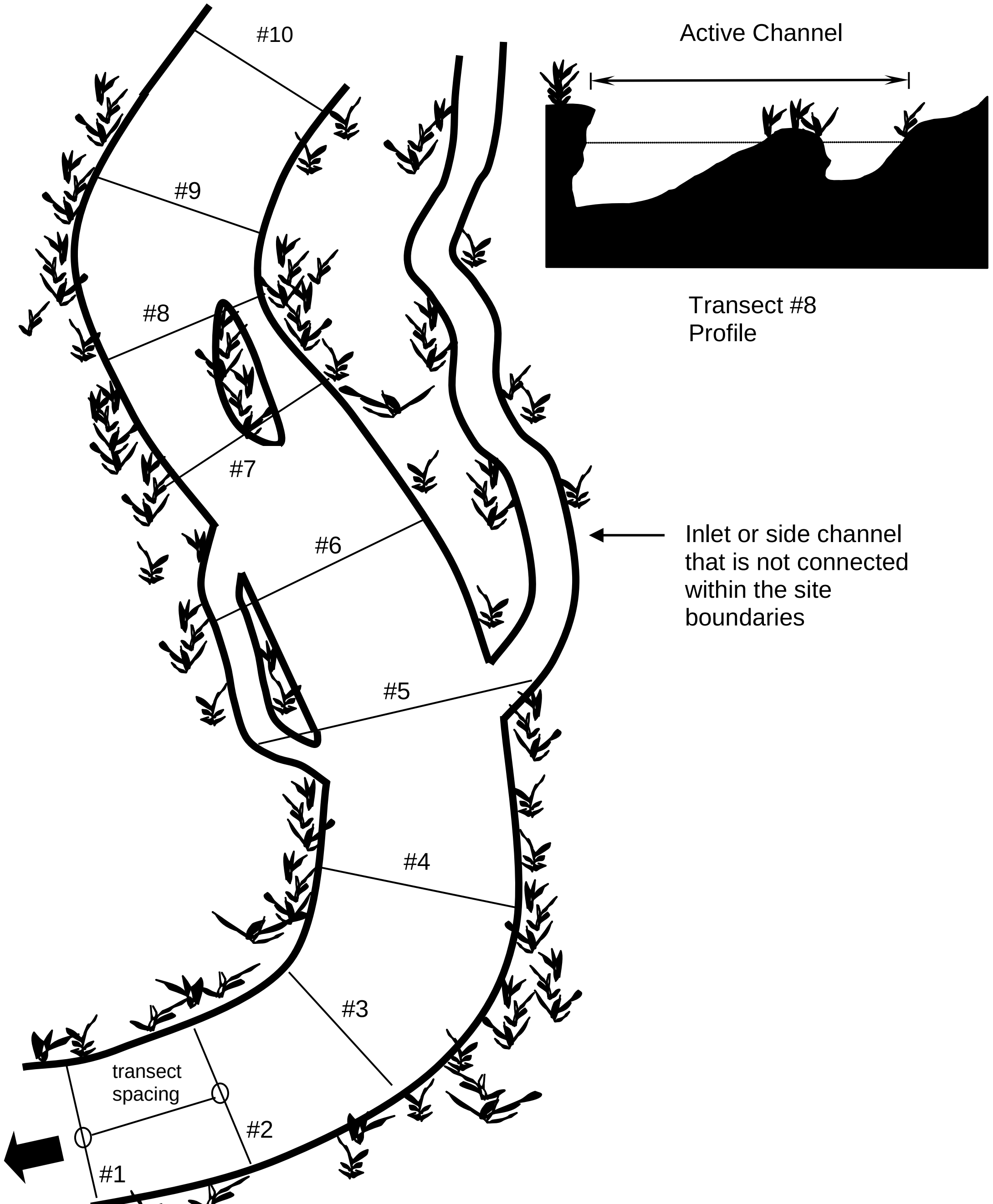

Figure 3: Setting up a Transect Sampling Design.

The thalweg can often be used to assist in determining the appropriate orientation of the transect (angle relative to channel). Transect lines 5 and 6 cross a side channel that is connected within the site and 7 and 8 cross an island. These are considered a part of the active channel. Transect line 5 crosses a side channel that is not connected within the boundaries of the site; and this side channel is therefore not considered to be part of the

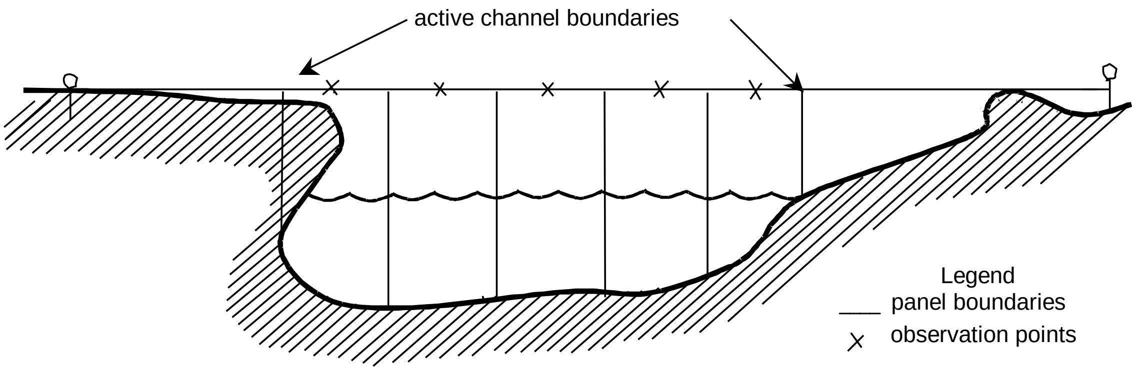

Figure 4: Setting up a Transect Line and Locating the Active Channel.

Active Channel

The active channel is the area between the two outside banks, which includes all connected water at the time of the survey. This includes actively flowing as well as stagnant areas provided there is no land barrier that separates it from the main channel. The transect boundaries are at the bank-water interface (i.e. where the water meets the land; when undercuts are present, see Figures 4 and 5).

Rules for defining the active channel:

1. Side channels or braids are included if both the inlet and outlet occur within the sample site.
2. The mouth of a tributary is included only if it located on a transect
3. Backwater pools (wet areas adjacent to the active channel that are fed by intergravel flow) are included if they are located within the high flow channel, are located below the top of bank, and there is visible flow from the pool into the stream.
4. Mid-channel bars and islands are included in the cross section (Figure 3).

Observation Point Calculation Example

For a stream that has an active channel width of 2.9 m wide, and low variance in velocity, five panels are sampled. The point spacing would be 2.9/5 = 0.58. This number actually represents the boundary of a set of panels that transect the stream, with each observation point located in the centre of each panel. To determine the actual location of the observation points, divide the first panel in half, and for each additional location add 0.58. The first observation point would be at 0.29 m (i.e. 0.58/2 = 0.29). The second point would be at 0.29 + 0.58 = 0.87 m. The complete list of observation points is 0.29, 0.87, 1.45, 2.03 and 2.61 m.

Note: Observation point locations are dependent on whether the tape extends beyond the bank water interface. For example if the left bank water interface occurs at 1.5 m on the tape then the first observation point for the above example would be at the 1.79 m mark on the tape.

Hint: *To help identify the location of the observation points along each transect, tie strands of flagging tape on the tape measure so that they can be easily slid into position to mark each observation point.*

Hint: *Always double-check the spacing of the flagging tape before starting to record the data.*

3.5 Describing the Banks

Measurements of bank undercuts, angle, composition and bank vegetation are made along a 1.5 m extension of the transect line[2] described in Section 3.4, Setting Up the Transect and Measuring Stream Width (see also Figures 5 and 6). Note that all depth or height measurements are to be made in millimeters.

3.5.1 Undercuts

Undercut banks are measured if they occur on the transect line as described in Section 3.3. Note that undercut banks may be out of the water. Only record undercuts if they are greater than 50 mm and ensure that the deepest undercut is measured regardless of where it occurs in the transect. Measure and record the maximum depth of any undercut as follows (Figures 5 and 6):

1. Place a straight edge vertically against the outermost protruding edge of the bank.
2. Place a ruler into the deepest part of the undercut perpendicular to the straight edge.
3. Record the depth of the undercut in the box marked ‘Amount of Undercut’, to the nearest 10 mm. If the depth of the undercut exceeds 1000 mm, record as ‘1001’, signifying that the depth is greater than 1000 mm.

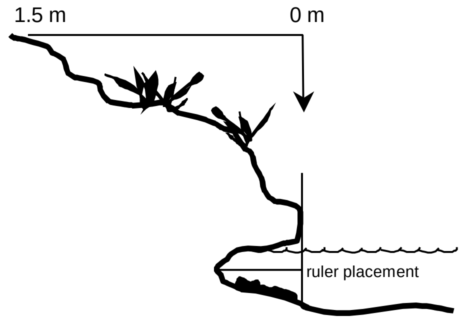

Figure 5: Measuring Depth of Undercuts in the Stream.
The ruler should be moved around until the deepest part of the undercut is located.

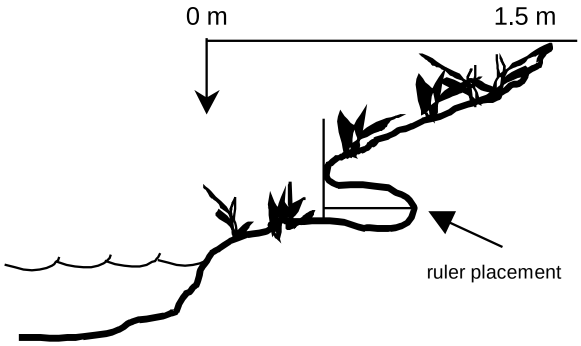

Figure 6: Measuring Depth of Undercuts that are Out of the Water.

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[2] Note, the height of the transect extensions may differ from the original transect line. The 1.5 m extensions do not have to be at the same height on both banks.

3.5.2 Bank Angle

Bank angle is a measure of the slope of the bank which can be used in determining stream bank stability. Four height measurements taken at predetermined horizontal distances from the bank edge are used to determine bank angle.

General principles to be followed are outlined below.

Bank angle is measured from a short profile of the left and right banks of the stream. The profile is obtained by setting a level horizontal line (tape) above the bank extending a minimum of 1.5 m inland from the furthest protrusion of the bank into the stream (Figures 7 - 10) and measuring the distance of the tape to the bank surface. Each bank measurement is independent and the height of the tape does not have to be the same on both sides of the stream.

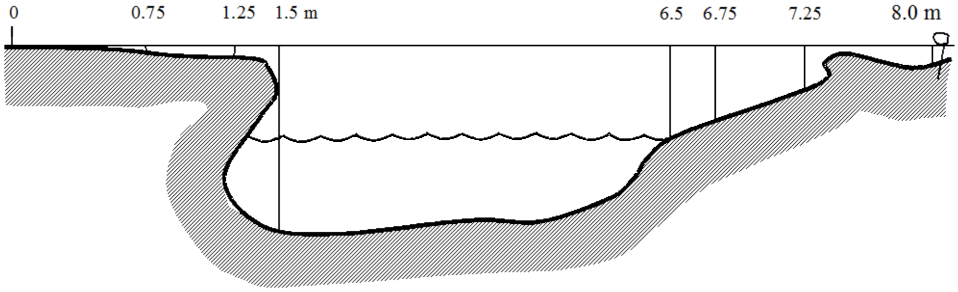

Figure 7: Incorporating Point Measurements Along the Transect.

The tape is anchored at 1500 mm from the furthest protrusion of the bank on both sides of the stream.

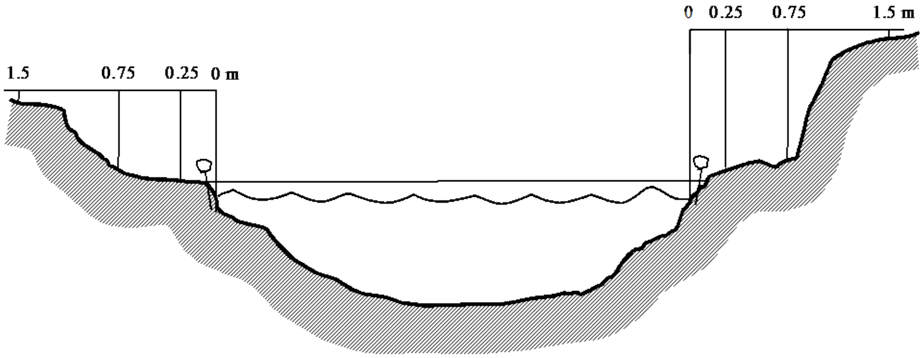

Figure 8: Setting up Independent Bank Transects.

The tapes are at different heights on both banks and are anchored at 1500 mm from the furthest protrusion of the bank on both sides of the stream.

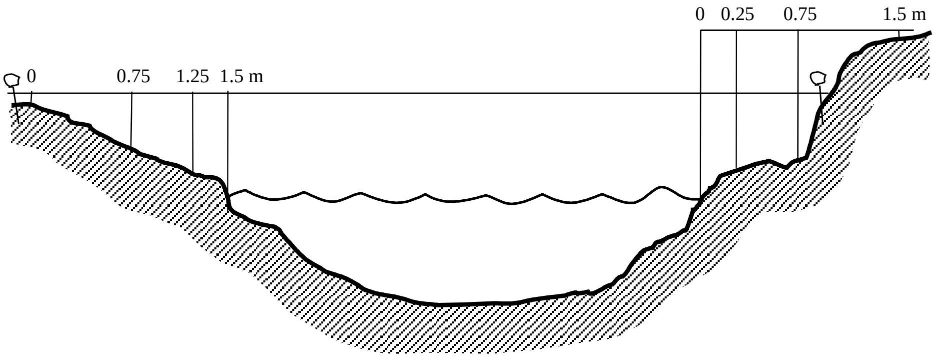

Figure 9: Setting up Separate Transects Incorporating Point Measurements on Both Banks.

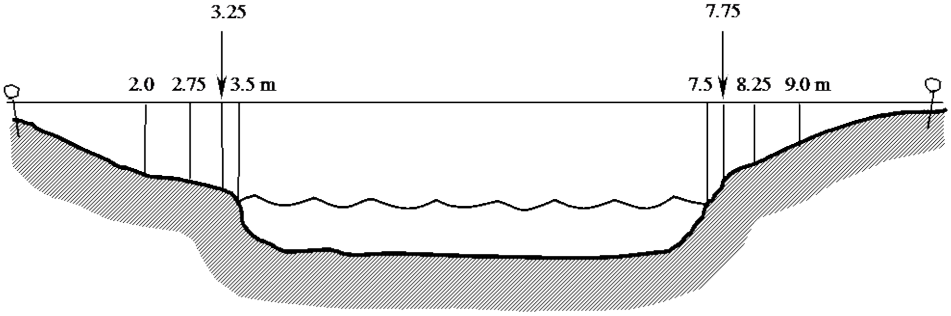

Figure 10: Incorporating Point Measurements Along a Transect That Extends Beyond the Width of the Channel Where Measurements Will be Made.

In this situation the tape extends beyond 1500 mm from the furthest protrusion of the bank on both sides of the stream.

Four vertical measurements are taken from the horizontal tape down to the bank. These vertical measurements are taken at the 0.0 and at 0.25, 0.75 and 1.5 m from the furthest protrusion of the bank into the stream. If any of the vertical heights are greater than 2 m within the transect, the bank is steep and the appropriate box should be marked with an 'X' (i.e. '>2m' for Left or Right Bank) under 'Bank to Tape Height'. No additional vertical height measurements are required if this condition exists.

Different techniques may be used to take measurements that will be used to calculate bank angle (e.g. transect line (Figures 7 - 10) or bank profile tool (Figure 11)). The application of any of these methods will be dictated by existing bank conditions.

Staff from the Toronto and Region Conservation Authority designed a tool to assist them with measuring the bank profiles. The tool consists of two pieces of wood (one with a slot cut through the middle), connected by a wing nut so that it can swivel and move vertically. Ruler markings can be put on the vertical piece to help with the first height measurement and the locations (0.25, .75 and 1.5 m) of the observations points should be marked on the horizontal piece. A small level(s) can be placed on the wood to ensure the tool is at 90°. An adaptation of this device is to hang three tailors tape measures at the appropriate locations on the horizontal bar that can easily be read off as to the height from the ground to the bar.

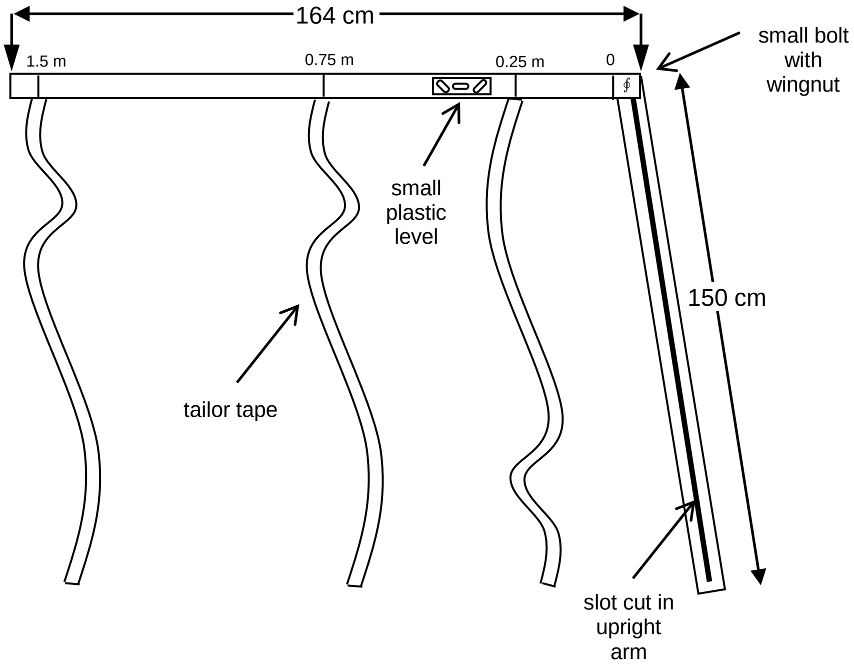

Figure 11: Schematic and Photo of Bank Profile Tool.

Where undercuts are present, the measurements begin at the furthest protruding edge of the bank (i.e. the height measurement at 0.0 m would be from the tape to the stream bottom (Figure 7).

Record each of these measurements to the nearest 5 mm on the ‘Bank Angle’ section of the Channel Morphology Data Form (Appendix 1).

***Hint**: A vertical measurement greater than 1000 mm may be taken by joining two metre sticks end to end.*

***Hint**: If the transect intersects a tree, move the transect to the nearest side. If a log or brush pile interferes with the vertical measurements, adjust the placement of the metre stick or bank profile tool.*

3.5.3 Bank Composition

This section describes how to determine the soil composition of the banks. The type of substrate that makes up a bank influences its stability; silt and sand are more vulnerable to erosion.

At the four points where the bank angle was measured (e.g. 0.0, 0.25, 0.75 and 1.5 m from the active channel boundary), determine the substrate immediately below each point. While looking away, randomly select a particle and measure the median axis. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Channel Morphology Data Form for the left and right bank; otherwise record standard sizes found in Table 2. Remove undecomposed organic material (e.g. leaves, sticks), before making substrate measurements. Decomposed organic material should be classified as silt.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 12). Rocks will often lie with the median axis at right angles to the flow.

Table 2: Substrate Descriptions and Size Categories.

Material	Description	Size to be Recorded
‘Unconsolidated Clay’	Very hard packed when dry and sticky when wet	‘0.01’
‘Consolidated Clay’	Hard even when wet, slippery, gray in colour, often laminated	‘0.011’
‘Silt’	Feels soft like a powder or flour	‘0.05’
‘Sand’	Gritty, sizes >0.05 and < 2 mm	‘0.10’
‘Bedrock’	Exposed bedrock	‘1111’
‘Concrete’	Human made materials such as concrete or asphalt	‘2222’
‘Gavia feces’	Dense mat of floating detritus that generally fills the entire water column	‘8888’
Measured particles	Between 2 mm and 1000 mm.	Median axis
‘Large Boulders’	> 1000 mm but not attached to bedrock	‘1001’

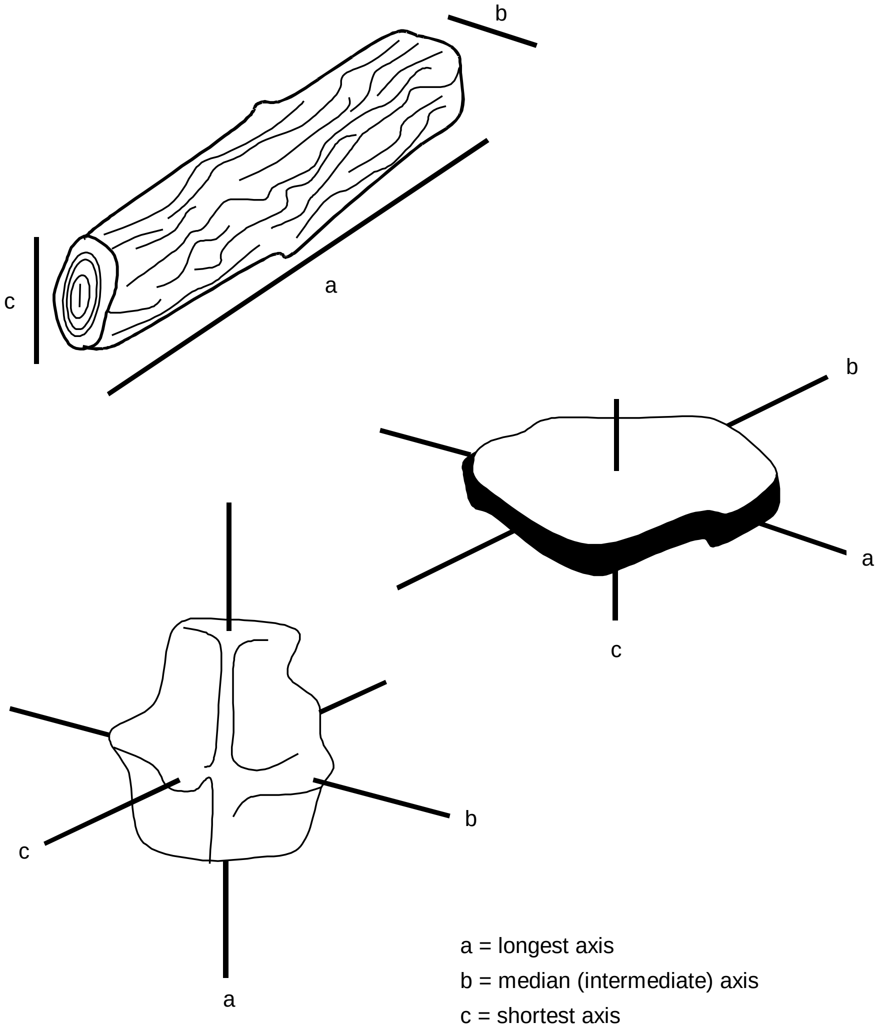

Figure 12: Measuring along the Median Axis of Objects.

Note that large material (i.e. greater than 1000 mm wide), are classified as ‘Large Boulders’ or ‘concrete’. To ensure accuracy of data entry, place a ‘0’ in front of all decimal points (e.g. ‘0.01’). **Be sure to measure all particles that are close to 2 mm in diameter to avoid misclassifying small particles.**

3.5.4 Bank Vegetation Cover and Type

This section describes how to identify the dominant vegetation type and measure the amount of rooted vegetation on each bank.

3.5.4.1 Dominant Vegetation Type

The ‘Dominant Vegetation Type’ is assessed within a rectangular plot (2 m x 1 m) which extends 1 m upstream and 1 m downstream of the transect line and 1 m back from the furthest protruding edge of the bank (Figure 13). The dominant vegetation type within the plot is determined using a hierarchical system. A dominance in the plot of wetland vegetation is sufficient to trigger a designation of wetland. Following this category the hierarchy is based on the largest vegetation type found: Wetland > Forest > Scrubland > Meadow > Cropland > Lawn > None (the vegetation types are defined in Table 3 below). For example, if a plot includes a tree and a patch of long grass, it would be classified as ‘Forest’, even if greater than 75% of the plot has no vegetation. The designation of none only applies for plots where no woody vegetation is present.

Hint: *On the Channel Morphology Data Form, put an ’X’ in only* ***one*** *box under ‘Dominant Vegetation Type’.*

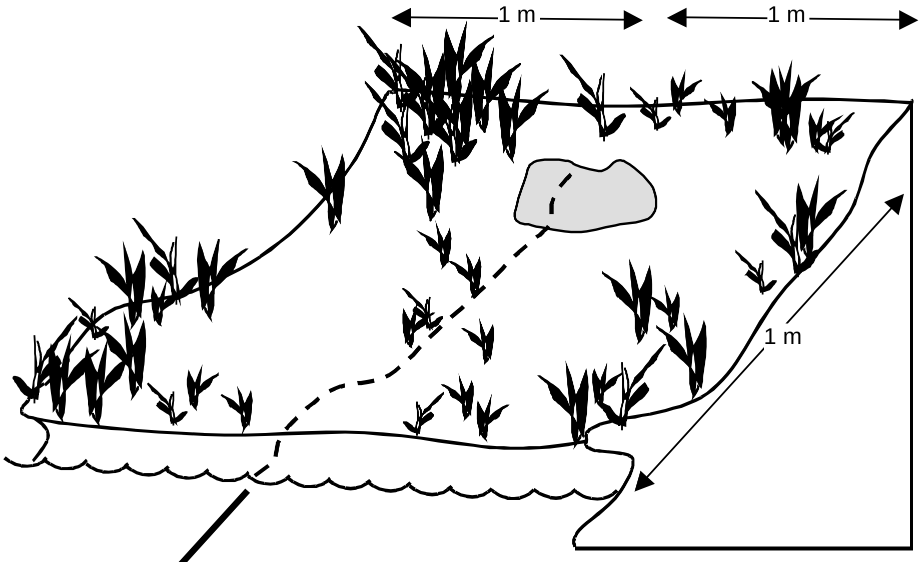

Figure 13: Sketch of the Plot used to Evaluate Dominant Vegetation on the Bank.

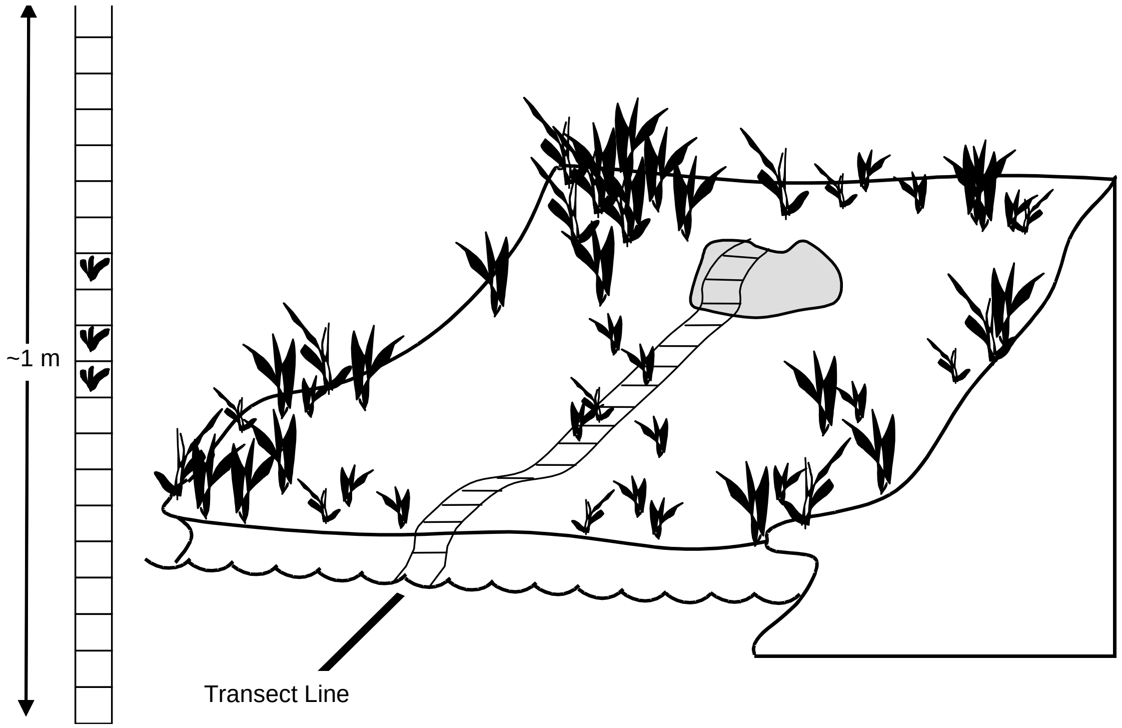

Figure 14: Sketch of the Bank Grid Placement.

Table 3: Bank Vegetation Types.

Vegetative Community	Description
‘None’	Over 75% of the soil has no vegetation.
‘Lawn’	Grasses that are not allowed to reach a mature state due to mowing.
‘Cropped Land’	Planted in agricultural crops in most years; plants typically arranged in rows (due to machine-planting); may be subject to periodic tillage.
‘Meadow’	Unmanicured grasses and sedges, no woody vegetation in the plot
‘Scrubland’	Small trees or shrubs interspersed with grasses and sedges (a transitional area between meadow and forest, no trees > 10 cm in diameter at breast height).
‘Forest’	At least one large living tree > 10 cm dbh, or 5 m in height within the plot
‘Wetland’	Dominated by water tolerant wetland plants including rushes, and water tolerant trees or shrubs

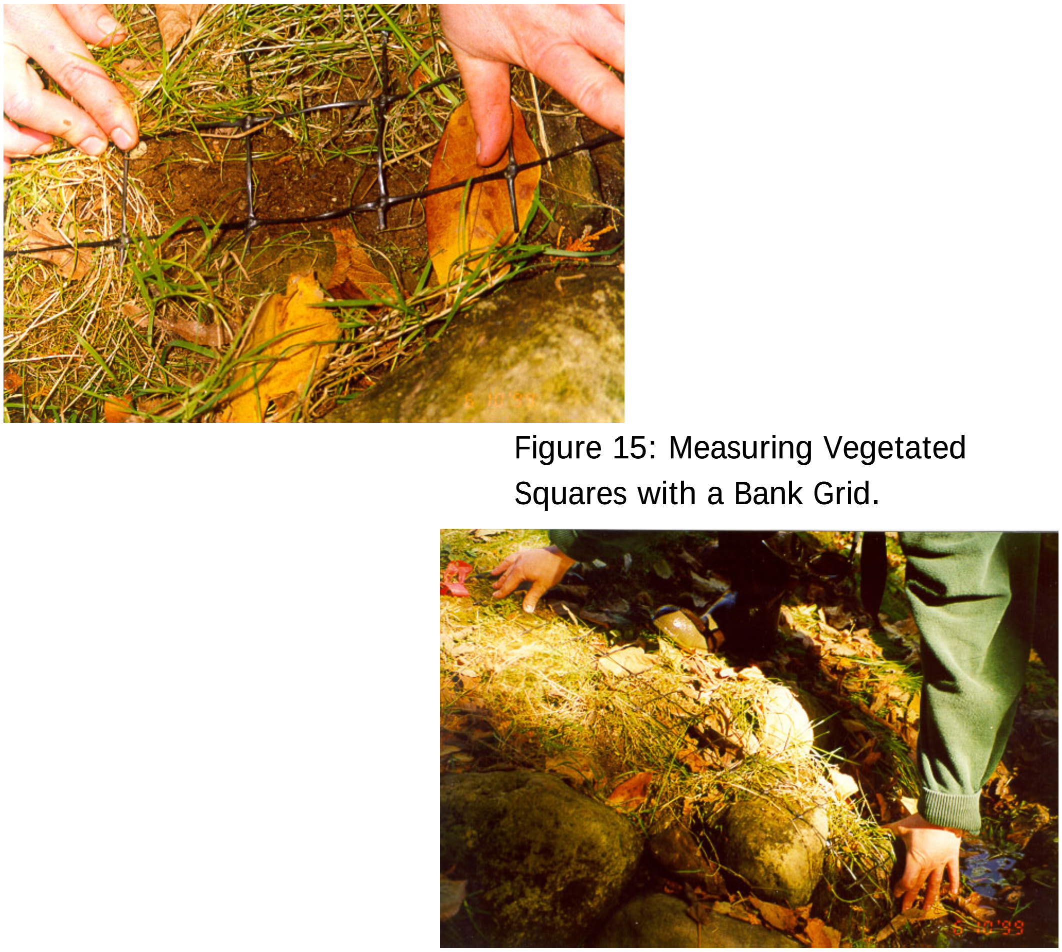

Figure 15: Measuring Vegetated Squares with a Bank Grid.

3.5.4.2 Rooted Vegetation Measurement

The bank grid is used to quickly estimate the extent of rooted vegetation that acts to stabilize substrate on each bank. Starting at the bank-water interface, lay the bank grid up the bank along the transect line (Figures 14 and 15).

Bank Grid

A bank grid is used to record the amount of living bank vegetation and provides quantitative and repeatable measurements. A bank grid measures roughly 100 cm long by 5 cm wide, and is comprised of 20 blocks (roughly 5 cm long). Older bank grids had 16 blocks but as of 2013 it is expected that all grids will have 20 blocks. Lengths of the grid may be available from Jeff Vandenberg (jvandenberg@trca.on.ca).

Count the number of grid cells that have any **live** rooted vegetation growing within the cell. One blade of grass rooted in the soil constitutes live vegetation in a grid cell, but grass hanging or lying over a cell are not included. **Live roots, mushrooms and moss are also considered live vegetation.**

Algae and lichens are not considered in this measurement. To qualify as having no live vegetation, all of the soil or substrate in the grid cell must be barren, covered with dead material, or covered with lichens.

Hint: *Where dead materials cover the soil or vegetation is matted down, pull back the material to see whether the soil is exposed or whether live material is growing underneath.*

Record the number of grid cells with live vegetation in the box marked '# of Vegetated Squares on Bank', on the Channel Morphology Data Form.

3.6 Point Measurements Along the Transect

The following six measurements should be made in the stream, at each of the previously identified observation points (e.g. Section 3.4 Setting Up the Transect and Measuring Stream Width) along the transect (Figure 4; specific details in each section below):

- Water depth (or negative height, for islands and other protruding features)
- Hydraulic head
- Cover (amount and type)
- Aquatic Vegetation
- Point Particle Size
- Maximum Particle Size

Obtain a depth and hydraulic head estimate from every point. For observation points that fall on islands, large exposed rocks, etc., measure the negative height, vegetation cover and particle sizes. For points that fall in locations that are unsafe to sample because of depth, presence of gavia feces or other factors estimate the various measures and record an asterisk beside the observation and why this is the case in the comments field (e.g. deep gavia feces present).

3.6.1 Water Depth

At each observation point: stand a wooden metre stick on the pavement boundary (see definition below) with the thin edge facing into the current (Figure 16). If the ruler lands on a boulder or other object above the pavement boundary which is less than 30 cm in diameter (i.e. smaller than the diameter of the cover ring) move the ruler to the nearest edge of the object and measure the water depth at the pavement layer. If the object is larger than 30 cm in diameter, measure the water depth at the observation point. Ensure that the ruler is straight and that it does not dig into the substrate. Always measure the height of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler).

Pavement Boundary

The pavement boundary represents the bottom of the active flowing channel and is identified as the point where substrate particles form a fairly uniform layer across the bottom (Figures 16 and 17). This may be difficult to determine in areas dominated by coarse material. In these instances, put the ruler between the coarse materials to the lowest layer of material that is visible.

Record the water depth in mm in the column marked 'Depth' on the Channel Morphology Data. This measure should be recorded to the nearest 5 mm. If the water is deeper than 1000 mm, record '1001' mm. If for safety reasons water depth cannot be measured or estimated, record '-999' in the 'Depth' field.

3.6.1.1 Islands and Large Rocks

Mid-channel islands, bars, and large exposed rocks (e.g. any solid object with a median diameter greater than 30 cm) are measured as negative height. These characteristics contribute to the complexity and roughness of the channel and are used for three-dimensional habitat modeling. As such record all habitat data, with the exception of hydraulic head which will be recorded as -99.

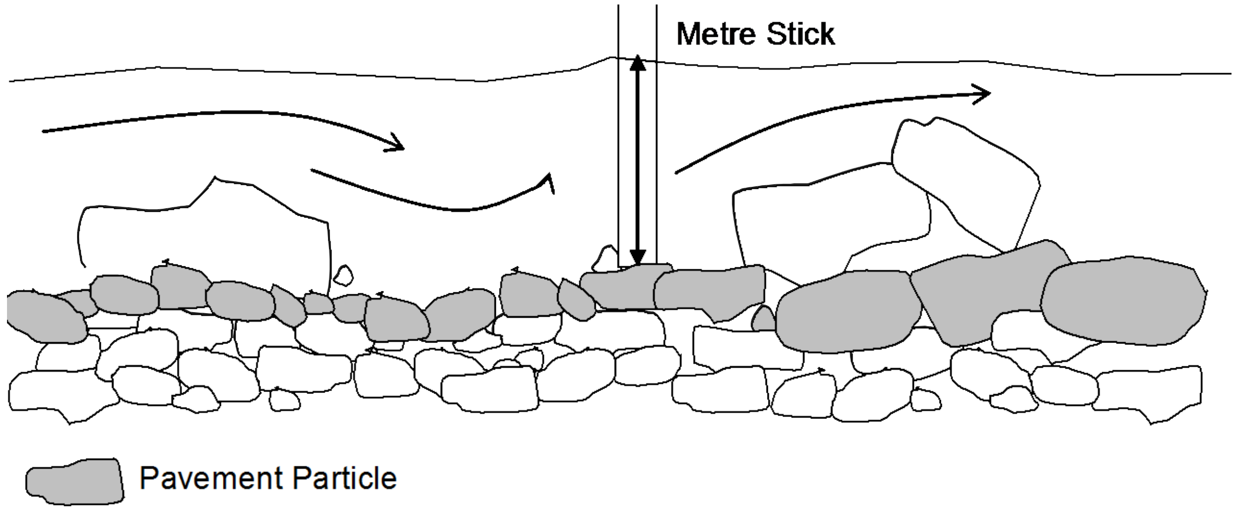

Figure 16: Measuring Water Depth to Pavement Layer.

Figure 17: Photograph of Pavement Distinction.

There are two methods to measure the negative height, one for small features and another for braided channels and large islands.

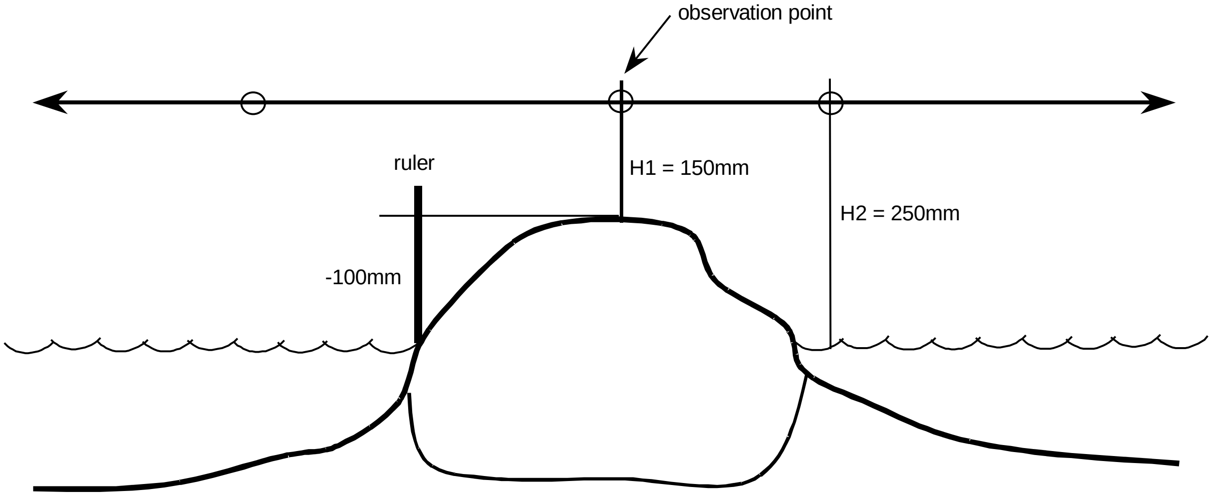

Figure 18: Measuring Negative Height of an Island.

Negative height of island = height from water to ruler laid parallel to water surface (-100 mm), **or** difference in height between H1 and H2 (150 – 250 = -100 mm).

Small features: lay a level ruler across the feature at the observation point and use a second ruler to measure its height above the water level (Figure 18).

Braided channels and large islands: stretch a tape measure across the feature (level the tape by setting it at right angles to the flow and setting it at a uniform height) and measure the height from the water to the tape (H2) and from the island to the tape (H1). The difference between the two heights is the negative depth (or height) at this observation point. Record the height as a **negative** number in the column marked 'Depth'.

3.6.1.2 Undercuts, Log Jams and Other Obstructions

When an observation point falls on an undercut or some other obstruction, record the depth of water under the obstruction (Figure 19). Adapt available tools as necessary (e.g. flexible metal rulers, poles) to measure the depth.

3.6.2 Hydraulic Head

Hydraulic head is measured at each observation point as a surrogate for velocity (adapted from Henderson 1970). If more accurate velocity information is required (e.g. flow monitoring or discharge calculation), a velocity meter can be used to complement the hydraulic head data. These procedures are described in S4.M5, Measuring Stream Discharge Quantitatively.

At the observation point, turn the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 20). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then

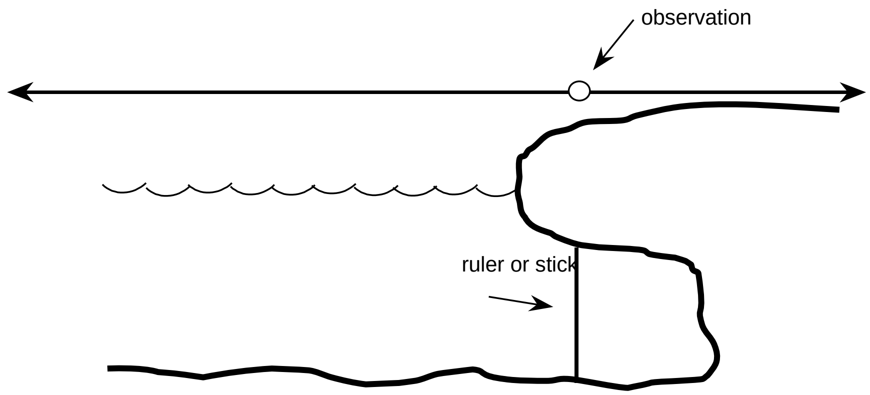

Figure 19: Measuring Water Depth in Undercuts or Log Jams.

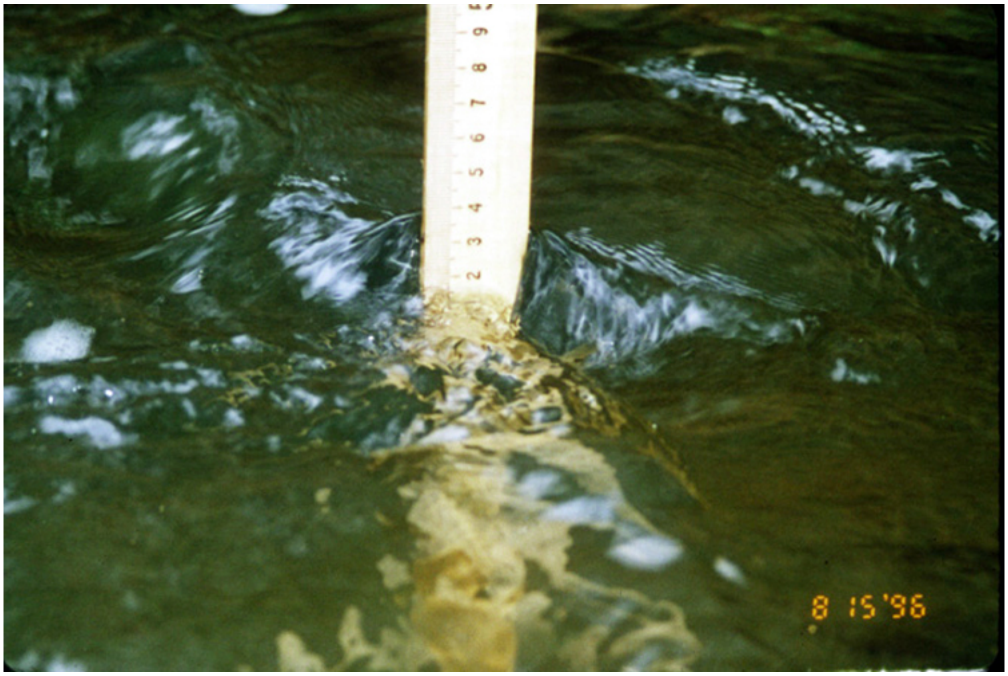

Figure 20: A Point Measurement of Hydraulic Head.
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

measure the height difference between the front and back of the ruler (Figure 20). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked 'Hydraulic Head' on the Channel Morphology Data Form.

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). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

3.6.3 Substrate Particle Size Distribution

In this section, point particle and maximum particle size are measured at each observation point. These measures are used to characterize the stream for its suitability for various species and to provide information on geomorphic characteristics (e.g. sediment transport and sorting).

If observation points fall on mid-channel islands, bars or large exposed rocks particle size distribution should still be determined as these particles contribute to the overall substrate characterization for the site. If the presence of a deep layer of organic material (gavia feces) prevents the stream bottom from being accessed, record the point and maximum particle sizes as having gavia feces (8888).

Dealing with Bedrock and Hardpan clay

If either bedrock or hardpan clay are picked as a point particle then the maximum particle would be the largest particle movable by the stream within the cover ring. Conversely, if particles are picked and hardpan clay or bedrock is present in the observation area, record the largest particles that are movable by the stream. It may be that no other materials are present, in which case bedrock or hardpan clay would be recorded for both measurements. In some bedrock and hardpan clay streams there will be a fine (opaque) layer of silt that has been trapped by algae or slime that covers the bedrock. Ignore this fine layer in the determination of substrate particle size.

3.6.3.1 Point Particle Size

Select and remove the particle immediately below the observation point and measure its width along its median axis (Figure 12); for very large particles measurements may be taken in the stream. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Channel Morphology Data Form; otherwise record standard sizes found in Table 2. Where possible, remove undecomposed organic material (e.g. leaves, sticks), before making substrate measurements.

3.6.3.2 Maximum Particle Size

After centering the 30 cm ring on the observation point, select the largest particle within or touching the ring and measure its width along the median axis. If the median width is less than 2 mm, estimate its size using the criteria provided in Table 2. Record the particle size in the box entitled ‘Maximum in Ring’ on the Channel Morphology Data Form.

Hint: *If there is a mixture of smaller particles within the 30 cm ring, such as silt/sand or clay/silt, catalogue point particle size as the smaller particle size (e.g. silt (0.05)), and the maximum particle size as the largest particle size (e.g. sand (0.10)). This is to avoid biasing the sample.*

3.6.4 Cover for Fish

Cover is traditionally the most difficult attribute of stream habitat to measure repeatably. Cover presence is determined and classified by its quality and type. This technique uses a 30 cm ring attached to a rod by cross bars (Figures 1, 21) to produce repeatable measurements (Stanfield and Jones 1998).

Instream Cover

A cover particle is any object that touches the water within the sample area, is **<u>at least 100 mm wide</u>** along the median axis and of sufficient density to block >75 % of sunlight from reaching the stream bottom. A cover particle can consist of a mat of materials such as twigs, macrophytes, or the bank. The mat must still meet the median diameter size and light penetration restrictions.

Place the centre of the pole on the observation point. Look for any cover which is in the water and in the ring (i.e. within or in contact with the ring). If observation points fall on mid-channel islands, bars or large exposed rocks, cover should still be determined as these areas may be used by fish under conditions of higher flow.

The cover quality is determined with respect to embeddedness. Unembedded cover provides overhead and velocity protection for small fish and has at least a 4 cm overhang. Embedded cover provides only a velocity refuge and has less than a 4 cm overhang (e.g. the interstitial spaces around the cover object are filled with material). This can either be determined visually or by feeling around the object to determine whether there is at least 4 cm of overhang. When an observation is recorded as having only embedded material, this means that this area is not suitable habitat for burrowing fish.

Record the number that best reflects the cover composition for each observation point in the 'Cover Quality' box as follows:

0 = no cover is present
1 = only embedded cover is present
2 = at least some unembedded cover is present

There should only be one number for each observation point.

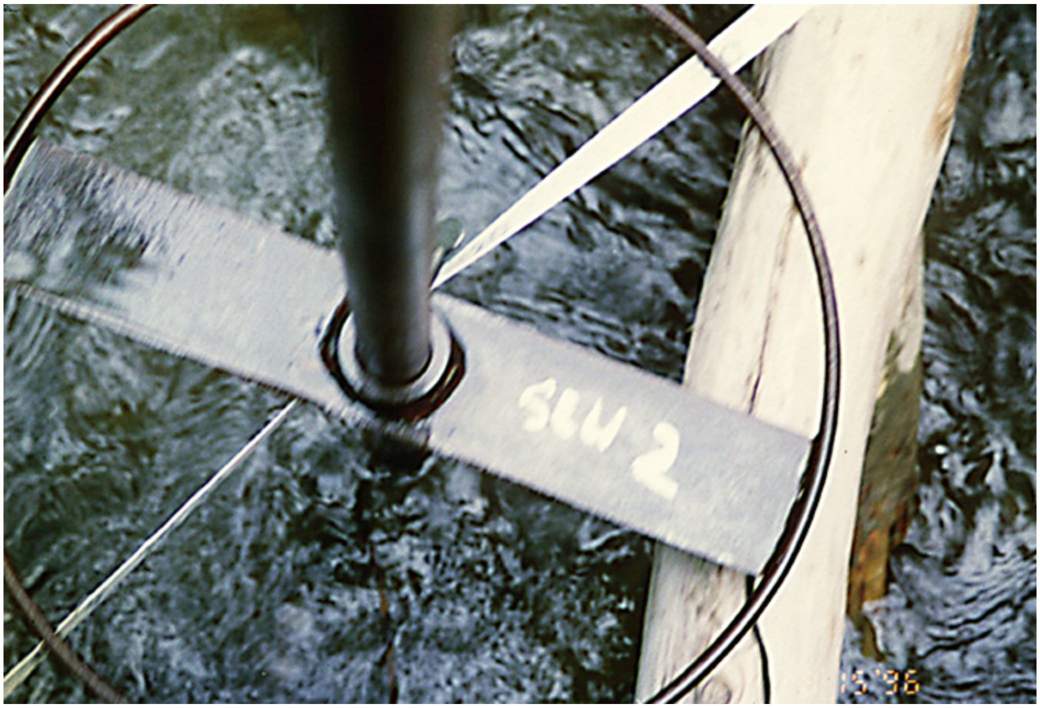

Figure 21: Cover Ring (30 cm in diameter), Showing the 'Observation Area'.

Hint: *Determine whether mats are sufficiently dense by placing a hand under the mat and estimating whether greater than 75% of light is blocked. The cover material must be in contact with the water within the observation area. Finally, for any materials and particularly for wood, measure the median axis on the branch that is* ***within the observation area****. In other words, if the observation area contains a 1 cm wide branch of a large tree, this would not be considered as cover. Conversely, if the observation area contains a 12 cm wide branch of a large tree, this would be considered cover.*

Once the cover quality has been determined, list all the cover types corresponding to the cover quality (cover types are defined in Table 4). For example, if there is an unembedded flat rock and an embedded log, only record the unembedded flat rock. If a point has an unembedded flat rock and an unembedded log, both are recorded. Similarly, if an embedded log and an embedded flat rock are present, record both types. See the Channel Morphology Data Form for these examples.

Table 4: Definitions for Cover Types.

Cover Type	Description
'Flat Rock'	The longitudinal axis is at least twice as long as the shortest axis, i.e. ratio of longitudinal axis/shortest axis > 2.
'Round Rock'	The longitudinal axis is less than twice as long as the shortest axis, i.e. ratio of longitudinal axis/shortest axis < 2.
'Wood'	Living or dead woody materials (includes mats of twigs, shrubs and roots).
'Macrophytes'	Any living aquatic or terrestrial non-woody plants (includes grasses and sedges if they hang in the water.
'Bank'	Bank material which contain soils (fine materials) i.e. undercuts and slumped banks or parts of banks which have become dislodged and are now lying in the main channel.
'Other'	Any other type of material not covered by the above categories. Typically, this includes tires, refrigerators, cars, etc.

Hint: *On the Channel Morphology Data Form, ensure that dashes are placed in cover categories that are not present; i.e. empty boxes indicate that an attribute was not assessed, not that that it was not present.*

3.6.5 Aquatic Vegetation

At each observation point, record the presence of any of the following vegetation types which are rooted within the 30 cm ring or attached to substrate or wood within the 30 cm ring: 'Filamentous Algae', 'Non-Filamentous Algae', 'Moss', 'Macrophytes', 'Watercress', 'Grass', and 'Terrestrial Plants' (Table 5).

Hint: *On the Channel Morphology Data Form, ensure that dashes are placed in vegetation categories that are not present; i.e. empty boxes indicate that an attribute was not assessed, not that that it was not present.*

Often, vegetation and particularly moss that is attached to the sides of boulders, cannot be seen. Therefore, pick up and closely examine the substrate for vegetation. Slime and algae must be differentiated by rubbing the objects (see Table 5). A thin layer of slime is not considered vegetation, unless green algae are found when the rock is rubbed.

Note: Crews have had difficulty distinguishing between fine silt, slime and brown algae, therefore recording brown algae and slime is not required.

If any of the macrophytes can be identified, record their common names in the comments box of the Channel Morphology Data Form.

Table 5: Definitions for Aquatic Vegetation Types

Vegetation Type	Description
‘Filamentous Algae’	Filamentous green algae, have hair-like filaments, are slimy to the touch, and are often attached to rocks.
‘Non-Filamentous Algae’	Non-filamentous green algae are slimy to the touch with no hair-like filaments.
‘Moss’	Small plants (2-20 cm) found in a matted colony on coarse substrate and wood. They are distinguished from plants by the absence of a distinctive stem or true leaves. The plant feels rougher than most vascular plants or algae and the rhizoids anchoring the plant are finer than typical plant roots.
’Macrophytes’	Many different species, all are rooted in the stream bottom and have obvious stems or leaves or filaments (examples: *Veronica* spp., pondweed, tape grass, arrowhead, bulrush and cattail).
‘Watercress’	Dark green, non-woody stems with flat, broad, opposite compound leaves with 3 to 9 leaflets per stem. Often found in large clusters along margins of stream. They are indicators of groundwater inputs and are also nitrate fixers.
‘Grass’	Terrestrial grasses (as opposed to tape grass or eelgrass) which are growing in the stream. Terrestrial grasses tend to be found at the margins of the stream.
‘Terrestrial Plants’	Firm stemmed plants that occasionally grow on the margins of streams, such as jewelweed, stinging nettles, poison ivy, willow, dogwood, etc.

3.7 Recording Stream Bearing

Compass bearings are used to produce scaled maps of the stream channel.

Facing upstream, lay the compass anywhere on the transect tape, lining up the bottom edge of the compass with the tape (i.e. so that the bearing is perpendicular to the transect). Turn the dial on the compass until the north arrow is lined up with the north needle. Then, read and record the compass bearing to the nearest degree on the Channel Morphology Data Form. Using this method, 0° is magnetic north.

3.8 Measuring to the Next Transect

After completion of the measurements for the transect, check over the results to ensure they are complete and legible. Measure the distance to the next transect along the mid-point of the stream, before removing the tape measure. Set up the next transect (Figure 3).

Hint: *Use two tape measures, leaving the first transect in place while the second one is set up. This way, the recorder gets additional time to check for problems with data collected on the* *previous transect. If problems arise, it is much easier to redo the measurements if the tape is still up, rather than having to set up the transect again.*

3.9 Tips for Applying this Module

Remember that left and right banks are identified while looking upstream.

Learn to identify stinging nettles and poison ivy. Wear elbow-length rubber gloves for doing the vegetation grid count where these species are common.

On every data form, record the standard site identification data and the sample number. On the first sheet, also record the ‘Site Length’, ‘Minimum Width’, and the calculated ‘Transect Spacing’.

Remember that a sample consists of one full set of data for each module, regardless of how many days it takes to do it.

Make sure that all fields have data recorded <u>before</u> taking down the tape measure.

Record ‘-99’ (‘-999’ for depth) to indicate that a measurement could not be performed.

Finally, record any irregularities in the way the data were collected in the ‘Comments’ field.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The channel morphology module benefitted from discussions with: Jeff Andersen, James Beebe, Dave Bell, Scott Gibson, Scott Jarvie, Ian Kelsey, Ken Minns, John Lyons, T. Simonson and Lee Wang. Repeatability surveys that were the cornerstone to this module were carried out by: C. Byrne, M. Kary A. Kauppinen, and A, Sluiter. Students of the Central Hastings Secondary School under the leadership of Bill Mitchell assisted with the testing of the repeatability and ease of application of several procedures.

6.0 LITERATURE CITED

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Appendix 1

Example Channel Morphology Data Form

Please note that this example is from a transect that includes a bank profile measurement on the left bank (extends 1500 mm beyond the bank).

Channel Morphology

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3CDW

Sample: 01

Transect No.: 01 of 10

Bearing (D): 3

Min. Width (m): 3.2

No. of Transects: 10

Points per Transect: 6

Site Length (m): 52.0

Transect Spacing (m): 5.8

Active Channel Width (m): 3.4

Point Spacing (m): 0.56

Date (mm-dd): 2000-08-01

Transect & Point Layout

Use this table to determine the number of transects & points required, given the minimum stream width.

Minimum Width (m)	No.Transects at Site	Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.49	15	3
< 1.0	20	2

Calculations:

Transect Spacing = Site Length / (No. of Transects - 1)

Point Spacing = Active Channel Width / Points per Transect

1st Point = Point Spacing / 2 (from left bank)

		Measure depth & hydraulic head to nearest 5 mm		Particle Sizes (mm)		Cover								Aquatic Vegetation Types Present						
Point No.	Location (m)	Depth (mm)	Hydraulic Head (mm)	Point	Max. in Ring	Unmeasurable	Quality	Wood	Round Rock	Flat Rock	Macrophyte	Bank	Other	FL	AL	SS	MC	WC	GR	TR
1	1.78	5	0	3	12	☐	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	2.34	45	5	18	135	☐	1	☒	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
3	2.90	95	15	400	400	☐	2	☐	☒	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐	☐
4	3.46	40	10	0.10	180	☐	2	☐	☐	☒	☐	☐	☐	☐	☒	☒	☐	☐	☐	☐
5	4.02	70	30	5	40	☐	1	☒	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
6	4.58	15	5	12	120	☐	2	☒	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐

Bank Angle & Particle Median Diameters
(Bank to tape height; if a height is >2m use check box, else enter values in proper observation points)

		> 2 m	0 mm	250 mm	750 mm	1500 mm	Amount of Undercut (mm)	No. of Veg. Squares on Bank
Left Bank	Height	☐	850	600	240	0	100	8
	Substrate Diameters		240	10	3	1		
Right Bank	Height	☐	700	420	180	0	180	12
	Substrate Diameters		120	50	20	3		

Dominant Vegetation Type
(Check box of the dominant type within the 1 x 2 m area)

	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest
Left Bank	☐	☐	☐	☐	☒	☐	☐
Right Bank	☐	☐	☐	☐	☐	☒	☐

Table Codes

Particle Sizes:
Measure all particles between 2.00mm and 1000mm

Material	Size
Unconsolidated Clay	0.01
Consolidated Clay	0.011
Silt	0.05
Sand	0.10
Large Boulders	1001
Bedrock	1111

Cover Quality:
0 = No Cover
1 = Embedded Cover
2 = Unembedded Cover

Aquatic Vegetation Types:
FL = Filamentous Algae
AL = Non-Filamentous
SS = Moss
MC = Macrophytes
WC = Watercress
GR = Grass
TR = Terrestrial Plants

Comments: CLAY EXPOSED ON LEFT BANK.

Crew Leader (initial & last name): S BEAL

Crew	Recorder	Ent/Scanned	Verified	Corrected
J.BYE, S. SALAK	S.S.	2000/10/18 J.B.	2000/11/10 A.C.	2000/11/11 S.B.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 3

Bankfull Profiles and Channel Entrenchment[1]

TABLE OF CONTENTS

Appendices

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[1] Authors: L. W. Stanfield and J. Parish

1.0 INTRODUCTION

This module outlines methodologies for measuring bankfull profile and the entrenchment of wadeable streams.

In alluvial streams, bankfull stage (i.e. depth of flow) is defined as the point at which the channel is completely full just prior to flows overtopping the banks and occupying the floodplain (Wolman and Leopold 1957). The flows at bankfull stage are typically considered the channel forming flows.

In streams flowing through channels that are affected by bedrock, roots and woody material, large glacial deposits etc., an equivalent to the bankfull stage (trim line depth) is identified as the upper limit of a regularly scoured zone and a distinct change in vegetation.

Stream surveys are rarely conducted during the bankfull stage of flow because of the risk to safety of surveyors etc. Usually the depths of flow during conditions that enable sampling and measurement-taking are lower than bankfull stage flow and this parameter must therefore be estimated (Newbury and Gaboury 1993). This module provides methods for consistently and accurately measuring the bankfull level, providing an approximation of bankfull stage flow.

This module also provides methodologies for measuring entrenchment, the degree to which the stream is restricted from accessing the floodplain, or how incised the stream is within the valley (i.e. the valley width/bankfull width). Entrenchment width is the width of the flood-prone area of a channel at twice the height of its maximum bankfull depth from the channel bed. If the channel is not entrenched this may be a very high value in low relief landscapes.

This module builds on data collected in S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions, and is used to assess channel processes and diagnose potential channel instability. It also provides a means of quantifying the rate of change in the channel width:depth profile.

Although the bankfull profile may be used to estimate channel forming discharge in certain cases, the procedure required for this is not covered in this manual. This module provides an evaluation of the bankfull profile that is independent of the flow conditions in the stream. Bankfull profile is more reliable for monitoring changes in the channel geometry and stability than the profiles produced in S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions.

The bankfull profile methods have been tested for repeatability by comparing the measurements made by inexperienced and experienced crews. The test results showed a high degree of consistency.

This module can be used independently or in conjunction with S4.M5, Measuring Stream Discharge Quantitatively, and/or S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions (e.g. at all or a subset of the transects).

2.0 PRE-FIELD ACTIVITIES

A crew of two to three people is required to complete this module in 10 to 15 minutes per transect.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment list is required:

1. ‘Bankfull Profile and Transect Discharge’ forms on waterproof paper
2. Pencils
3. Metre sticks (two)
4. Tape measures (two, 30 m long)
5. Flagging tape
6. Spikes (four, 25 cm long), tent pegs (four)
7. bungee cords or spring clamps to ensure tape is taught (two),
8. Calculator (waterproof or in re-sealable bag)

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

The application of this module is determined by study design. Sampling design should consider transect location (e.g. regular spacing or just on crossovers), number of bankfull profile measurements, site length, and number of sites to be sampled. Adding additional transects to the study design reduces the error of the measurement for the entire site.

3.0 FIELD PROCEDURES

This module must be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. Record the site identification data (‘Stream Name:’, ‘Stream Code’, ‘Site Code’), the ‘Sample #’, the ‘Site Length (m)’, the calculated ‘Transect Spacing (m)’ and the “Transect # ____ of ____’ in the site identification area on the Bankfull Profile and Transect Discharge field form (Appendix 1). Use one form per transect. Ensure that transect numbers are consistent with other modules being applied at the same site.

3.1 Bankfull Profile Procedure

The bankfull profile protocol is most effective when completed on crossovers[2]. An overview of the data collection procedures is described below:

1. Use previously established site boundaries to determine the location for the bankfull profile (where applicable)
2. Identify the bankfull level (where applicable)
3. Establish the transect, measure the channel width and determine spacing for observation points
4. Measure the height of the channel at all appropriate locations on the transect
5. Repeat Steps 1-4 for remaining transects as defined by the study design

3.1.1 Determining Transect Location to Identify Bankfull Level

The first transect is established at the downstream end of the site provided there are no obscuring features present (Table 1). If no obscuring features are found mark the box entitled ‘None Present’ on the Bankfull Profile and Transect Discharge form and set up the transect. If any obscuring features (Table 1) are observed relocate the transect since these features will affect flow (Figure 1) and bias the data. If the transect needs to be relocated, mark an ‘X’ on the field form to indicate the type of obscuring feature. The location of subsequent transects will be determined according to the study design.

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[2] The crossover is located where the thalweg is in the middle of the channel at bankfull discharge. It also represents the location where velocity is uniform across the channel and is at the lowest velocity during a bankfull discharge event.

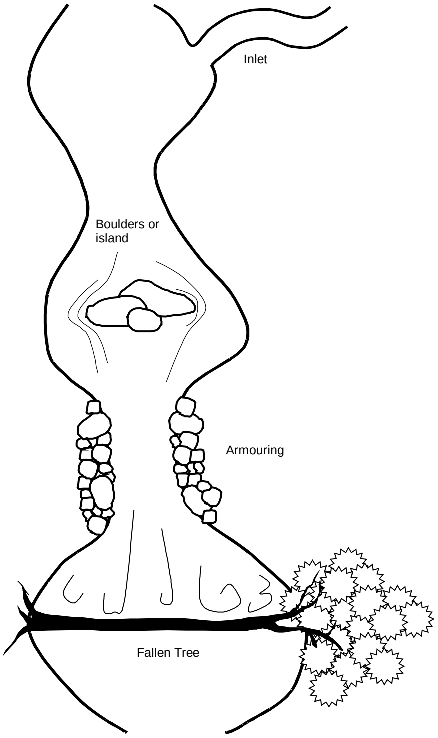

Figure 1: Effects of Obscuring Features on Channel Morphology.
If any of these features are observed refer to Table 1.

Table 1 - Criteria for Identifying Obscuring Features that Necessitate Transect Relocation

Obscuring Feature	Distance of Feature from Transect	Description
'Trampled Banks'	Within 5 m	Trampled banks from animals or machinery.
'Wood Deflectors'	Within 5 m	Large logs or trees which impede the flow causing bank erosion on either side of the deflector.
'Inorganic Deflectors'	Within 5 m	Mid-channel islands, large rocks (erratics), etc., that are sufficiently large to cause erosion on either bank.
'Armouring'	Within 5 m	Rip rap, gabion, concrete, etc., placed on the banks.
'Inlets'	Within two stream widths upstream or six stream widths downstream	Presence of tributaries that provide sufficient discharge to produce a plume or delta, or major outfalls emptying into the channel.

Possible options for sampling designs include:

- profiles conducted on one or more crossovers (i.e. upstream and/or downstream site boundaries, other crossovers located within these limits)
- for surveys that are performed in conjunction with S4.M2, Point Transect Sampling for Channel Structure, Substrate and Bank Conditions, profiles can be conducted along all transects as defined in that module
- profiles conducted at selected locations within the site where the bankfull channel is well defined

3.1.2 Identifying the Bankfull Level

There are two ways of identifying the bankfull level: 1) using visual indicators of bankfull level or by 2) using the minimum width:depth ratio indicator. The latter involves the least error (high reliability) but is labour intensive and is mainly used on terraced streams or to corroborate the visual indicators of the bankfull level method[3]. The bankfull level can be identified in the field using the minimum width:depth ratio or it can be determined after the field survey, in the office. The latter requires that the data collected for the bankfull profile (‘Vert Ht to Tape (mm)’) are corrected, yielding the ‘Vert Ht to Bankfull Level (mm)’.

3.1.2.1 Visual Indicators of Bankfull Level Method

Examine each bank for visual indicators of the bankfull level (Table 2). The left and right banks are defined when looking upstream. Visual indicators are features that provide evidence of the boundaries of the bankfull channel. Visual indicators of the bankfull level should be found on both banks at the transect and at other locations up and downstream.

Table 2: Visual Indicators of the Bankfull Level (a detailed description of the indicators is provided in Appendix 2).

Indicator	Reliability Rating
• ‘Inflection Point’ (i.e. change in bank slope)	High
• Change in ‘Bank Material’ sand/silts to clays or gravels • ‘Top of Point Bar’ or terraces • Changes in ‘Vegetation’ from alders to willows or from grasses to tall herbaceous vegetation	Medium
• Lichens, Water Stains and Thatch • Worm Holes and Swallow Nests	Low

Each indicator has been rated from high to low in terms of its reliability. In some instances, high reliability indicators (e.g. inflection points) will occur on one bank while low reliability indicators occur on the other bank. In these instances, the higher reliability indicator takes precedence. However, it

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[3] One exception for the utility of this method is in bedrock controlled ‘U’ shaped channels that do not reflect current hydrologic conditions. In these channels visual indicators are more reliable.

is best to use a variety of indicators and/or the minimum width:depth ratio method to corroborate the bankfull level. The height of the bankfull indicators above the water surface should be similar on both sides of the channel and should be comparable at different locations within the site and the surrounding reaches.

For each bank, document the indicators used in determining the bankfull level by marking an ‘X’ in the appropriate box(es).

In uniform reaches, or selectively at crossover transects of similar width, the height of the bankfull indicators above the water surface should be similar. Bankfull heights that are widely different should be re-inspected before leaving the reach. It may be useful to string a measuring tape or survey ribbon between strong indicators along the banks to see if the heights are confirmed by indicators between the transects.

***Hint**: It is often useful to hold the hand level at the height of a likely indicator and scan upstream, downstream, and across the channel for similar indicators. These can then be checked by sighting back from the other side of the stream to confirm the general height of the scour line or bankfull indicators on and adjacent to the transect.*

3.1.2.2 Minimum Width:Depth Ratio Indicator Method

The bankfull level occurs at the minimum width to depth ratio in the profile (Figure 2). To determine this measurement in the field, measure the width of the channel and the height to the inflection point (tape) at each inflection point (i.e. each potential location of the bankfull level). Calculate the width:depth ratio at each location and establish which one represents the bankfull level. Then set up the tape at this location as outlined in Section 3.1.3, Setting up the Transect.

Alternatively, the bankfull level can be calculated later in the office. With this scenario, the tape is set up so as to include the widest part of the channel. The height to the tape (‘Vert Ht to Tape (mm)’) and location on the tape (‘Horiz Loc (m)’) are recorded at every inflection point in the profile (along with the locations described below). With this scenario, the bankfull height is determined in the office using the procedures illustrated in Figure 3, by correcting the field data (yielding the ‘Vert Ht to Bankfull Level (mm)’).

Resources and crew experience will determine which option is chosen with respect to bankfull level identification and bankfull profile measurements (i.e. field identification of bankfull level or correction of bankfull profile (vertical) measurements).

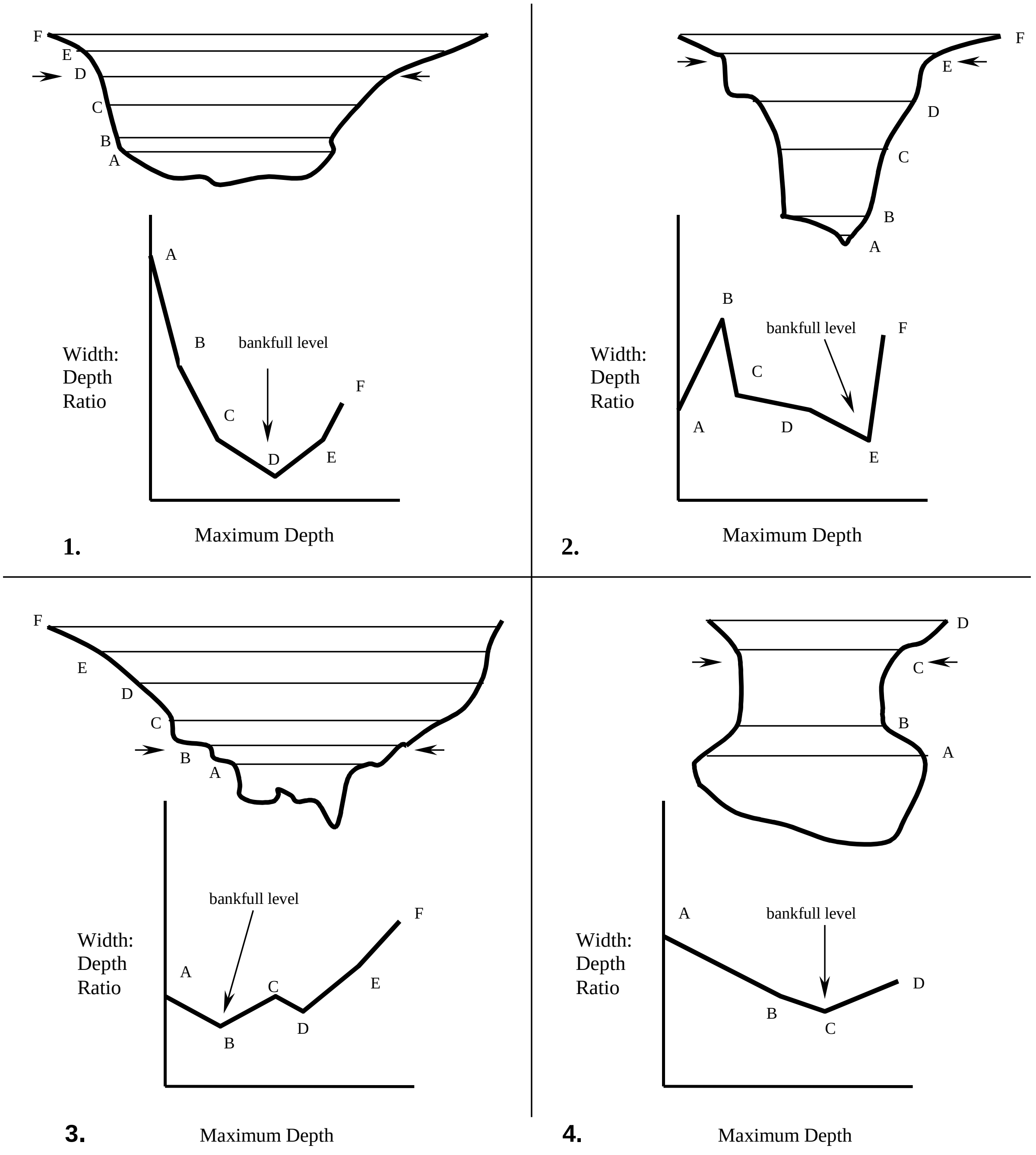
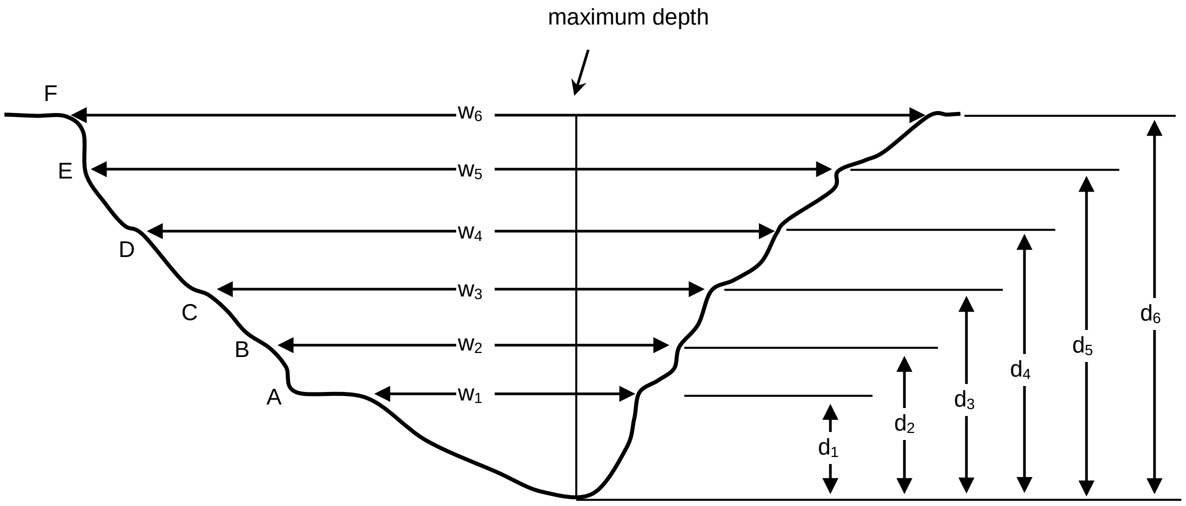


Figure 2: Determination of Bankfull Level Using Minimum Width:Depth Ratio.

Letters indicate the location of inflection points, with arrows indicating the major inflection point to be used to determine bankfull level. As can be seen in each accompanying graph, the major inflection point also has the lowest width:depth ratio. Abandoned terraces can be distinguished from bankfull level using this same graphing method.



$$W : D_{i\ (i=A...F)} = \frac{w_{i\ (i=1...6)}}{d_{i\ (i=1...6)}}$$

Figure 3: Calculation of Width:Depth Ratio for Determination of Bankfull Level and Correction Factor to Convert the High Terrace Profile to the Bankfull Level.

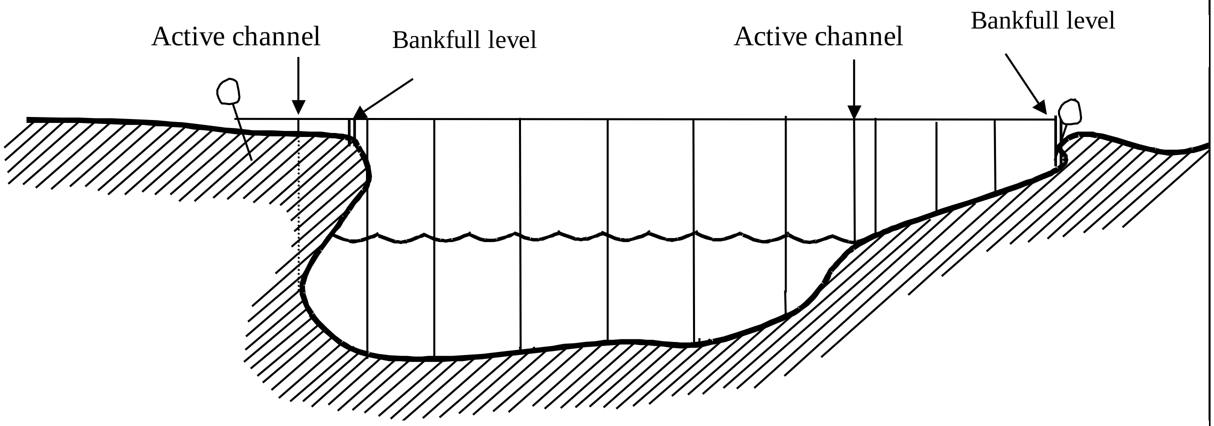
To estimate the height of the Bankfull channel, use the graphical methodology illustrated in the previous figure. If the Bankfull level is determined to be D, then the correction factor used to convert the profile from F to the bankfull profile at D is given by d_6-d_4. Each height taken on F that lies within the bankfull width (i.e. w_4) should have d_6-d_4 subtracted from it to obtain the height for the bankfull profile.

On the field form, indicate that the minimum width:depth ratio was used to determine bankfull level, by marking an 'X' in the appropriate box.

3.1.3 Setting up the Transect Cross-section

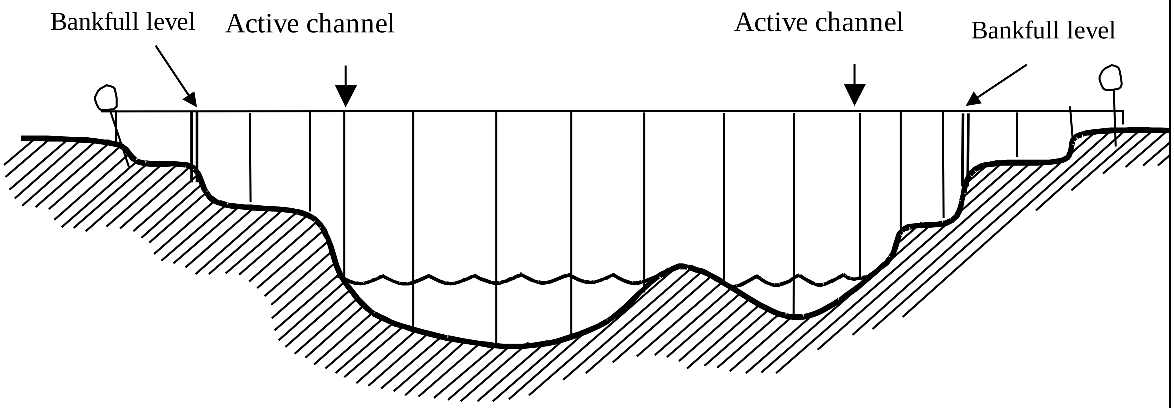
Stretch and secure the tape measure taut and level across the channel at the height of the bankfull level, or at the top of the terrace (depending on the methodology used). The tape can be secured with bungee cords or spring clamps at the appropriate locations. Check that it is level by setting at equal heights above the water surface. A laser level can also be used to establish the reference level where the width of the stream makes it difficult to keep the tape level (see below).

Set up the transect as shown in Figure 4 if only this module is being completed, and refer to Figure 5 if this module is being completed in conjunction with S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions.



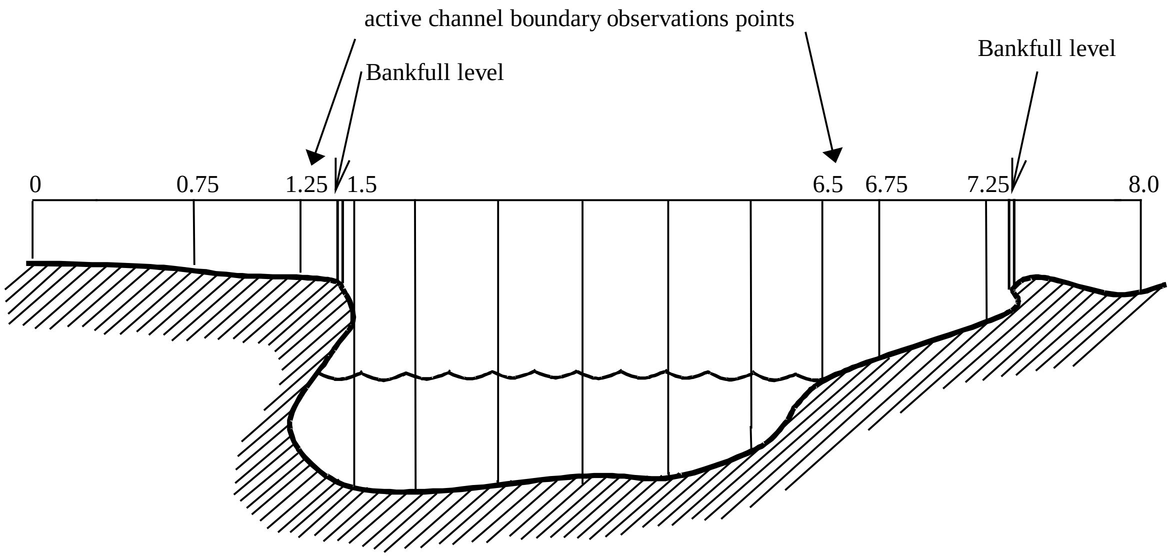
Left bank active channel location can be identified, height to tape is from bank. Height from water level is recorded at bank edge.

A. Outside bend with point bar.



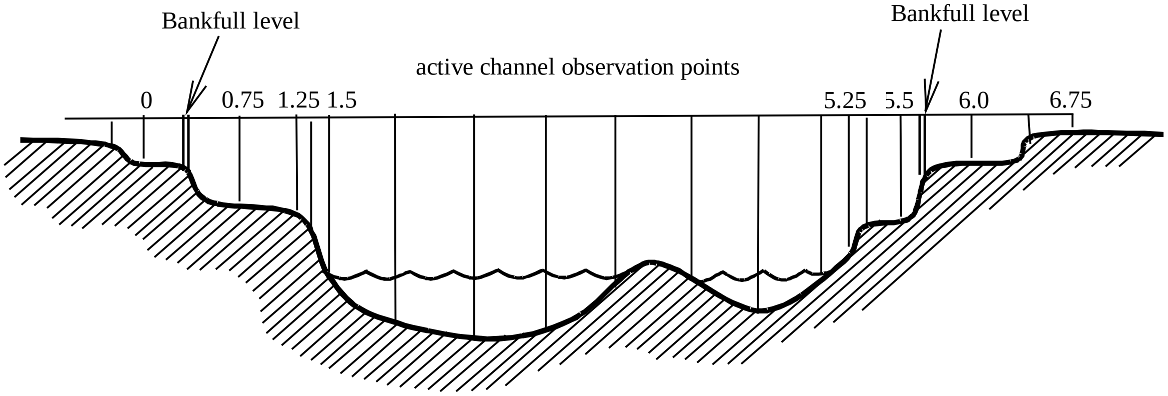
B. Terraced channel at cross-over.

Figure 4: Measuring Bankfull Level Cross-sectional Profiles (i.e. if only completing this module).



Note: measurement of height from water surface to tape is typically done on the left bank.

A. Outside bend with point bar.



Note: application of this module in conjunction with S4.M2 will result in additional observation points.

B. Terraced channel at cross-over.

Figure 5: Measuring Bankfull Level Cross-sectional Profiles (e.g. with S4.M2 data also being collected).

Using a laser level to identify a level line for depth measurement

Position the laser on one side of the stream, level with the top of the tape measure and aim it so at to intersect with the top of the tape on the other side of the stream. Use the tape measure to mark locations of measurements and make depth measurements to the laser line. Make sure to wear the appropriate safety glasses during the survey.

The number of observation points used will vary with stream width (Table 3 and Point Observation Calculation Example). In channels that have uniform depth, the stream width is divided by the number of observation points to determine panel widths. The observation points are located in the centre of each panel. Mark each observation point and the inflection points on the tape.

Also locate and mark the deepest part of the channel. Depth at this location is used in subsequent analysis to verify the bankfull location (Figure 2).

Table 3: Relationship between the Stream Width and the Minimum Number of Panels to Sample for Low Variance and High Variance Sites.

Channel Width (m)	Number of Panels to Sample	
	Transects with Low Variance in Velocity or Depth	Transects with High Variance in Velocity or Depth
> 3.0	minimum 8*	minimum 10*
1.5 – 3.0	5	8
1.0 – 1.5	3	6
< 1.0	2	4

* Add one panel for every 2 m increase in stream width i.e. 9 m wide = 11 (low variance) or 13 (high variance) panels.

Observation Point Calculation Example

For a stream that has an active channel width of 2.9 m wide, and low variance in velocity, five panels are sampled. The point spacing would be 2.9/5 = 0.58. This number actually represents the boundary of a set of panels that transect the stream, with each observation point located in the centre of each panel. To determine the actual location of the observation points, divide the first panel in half, and for each additional location add 0.58. The first observation point would be at 0.29 m (i.e. 0.58/2 = 0.29). The second point would be at 0.29 + 0.58 = 0.87 m. The complete list of observation points is 0.29, 0.87, 1.45, 2.03 and 2.61 m.

Note: Observation point locations are dependent on whether the tape extends beyond the bank water interface. For example if the left bank water interface occurs at 1.5 m on the tape then the first observation point for the above example would be at the 1.79 m mark on the tape.

3.1.4 Measuring the Water Level and Depth Profile Across the Channel

Measurement points for depth measurements will be located at:

- the outside edges (start and finish) of the transect;
- the location of the bankfull level on both banks;
- the active channel boundary on both banks

- calculated observation points
- inflection points
- the deepest point in the channel

Start the measurements on the left bank[4]. Record the height from the bank to the tape measure at the start of the transect. Record this height (mm) in the row entitled ‘Measurement 1’ on the field form. Measure the height of the channel (i.e. the height from the channel bottom (substrate) to the tape) at each observation point (as shown in Figure 6), inflection point, active channel boundaries, and at the location of the maximum depth. For each observation point location, record the tape measure reading location in m to the nearest 0.01 m (i.e. ‘Horizon. Loc (m)’) and the height in mm as observed (e.g. 18 mm) or rounded to the nearest 5 mm (e.g. 20 mm), whichever is easier for the crews. The accuracy of these height measures is considered to be 5 mm for all interpretations.

The active channel boundaries mark the area between the two outside banks which includes all connected water at the time of the survey. This includes actively flowing as well as stagnant areas provided there is no land barrier that separates it from the main channel (see S4.M2, Point Transect Sampling for Channel Structure, Substrate, and Bank Conditions). Regardless of where the active channel boundary occurs i.e. at the bank-water interface or under an undercut, measure and record the height from top of bank to the transect tape (Figure 4A, left bank). Also record the depth of water at the boundary of the active channel, even if it is zero. Where undercuts are present, obtaining depth measurements may require the use of alternate tools to obtain the measurement (e.g. shorter rulers, sticks, boots).

Figure 6: Measuring Height from Channel Bottom to Tape at the Active Channel Boundary.

3.2 Channel Entrenchment Procedure

The degree to which flows are contained within its floodplain during high flow events is a measure of entrenchment. Entrenchment width is used with bankfull width to assess channel confinement. Channel entrenchment is defined as a ratio

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[4] It may be easier to mark the locations of all the observation points prior to making the measurements.

of the width of the floodplain relative to the bankfull width. For consistency the measurement is standardized to a vertical depth of two times the depth of the maximum depth of the channel at bankfull flows (Rosgen 1996). Channel entrenchment is typically measured on the primary channel at the same time that bankfull width and maximum channel depth are measured. It is most easily applied at crossovers.

This method assumes the maximum depth of the channel to bankfull level has been determined from procedures listed above. To obtain the measurement, double the maximum channel depth and stretch a tape at right angles to the primary feature until it intersects with a bank.

If the entrenchment width is > 2 times the bankfull width the stream is considered unentrenched. For efficiencies, entrenchment need not be measured on streams for which the ratio is > 3. By definition surveyors record a width of 41 to indicate that the entrenchment width is > 3.
If it is obviously unentrenched simply record ‘41’ in the ‘Total Entrenchment Width (m)’ on the field form. For purposes of this manual (i.e. wadeable streams), an unentrenched < 20 m wide stream has an excess of 40 m of floodplain.

If this distance is less than 40 m, extend a tape measure from the metre stick at a height equivalent to the maximum channel depth and extend this tape away from the channel – parallel to and level with the transect – until it meets the ground (Figure 7). Repeat this procedure on the right bank. This can also be calculated by extending the tape across the stream until it touches bank on both sides at once. The entrenchment ratio is the total width/bankfull width.

Record the distance in the appropriate entrenchment width box (i.e. ‘Left Entrenchment Width (m):’ or ‘Right Entrenchment Width (m):’) to the nearest 0.1 m.

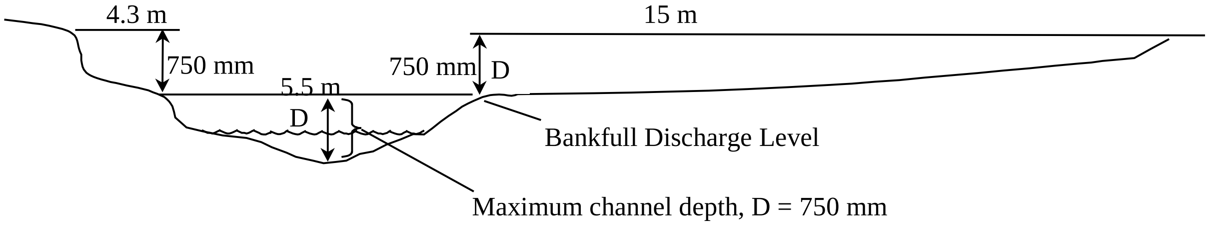

Figure 7: Measuring Channel Entrenchment.
The left bank entrenchment width is 4.3 m, the right is 15 m and the total width is 24.8 m.

With a three-person crew, the tape can often be extended across the channel to measure the total entrenchment width at once, rather than measuring the width on each bank separately. If this is the method used, record the total entrenchment width in the appropriate box on the data form (i.e. ‘Total Entrenchment Width’).

3.3 Tips for Applying this Module

Before measuring the bankfull profile and entrenchment at any transect, it is recommended that the field crew completes an initial reconnaissance of the site for bankfull indicators and the height of the bankfull level.

Since it may be difficult to identify bankfull level using channel indicators, it is recommended that replicate sites be used in the study design. This will allow quantification of variability among crews.

If indicators can only be found on one bank, use corroborative evidence to verify the location of the bankfull channel on the opposite bank. This method uses triangulation (Figure 8) to determine the height of the bankfull level (i.e. locations up and downstream and on the opposite bank are used to estimate the bankfull level).

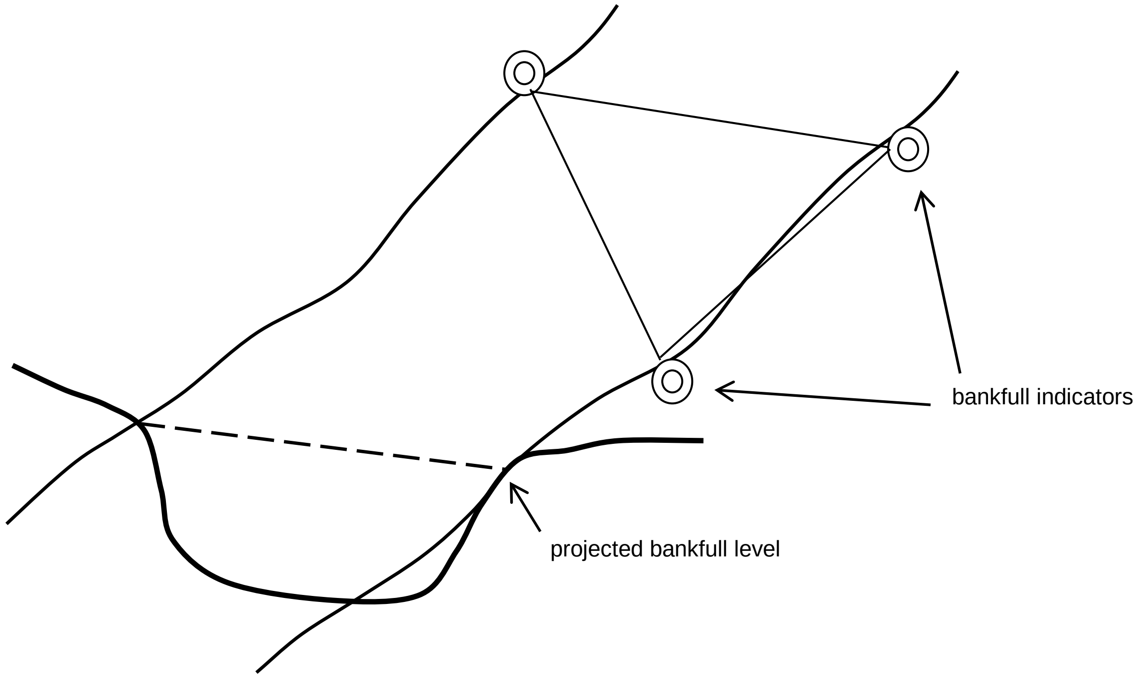

Figure 8: Bankfull Level Triangulation.

These procedures are designed to work on streams with natural banks and should not be used on streams with hardened or channelized banks. It is also very difficult to apply these methods on streams with very high roughness caused by an abundance of large woody materials, or streams that flow through wetlands.

A sample (i.e. ‘Sample #’) consists of one full set of data for each module, regardless of how many transects are surveyed or how many days are required to complete data collection.

The indicators should be applied in a hierarchical way, giving more weight to those with greater reliability. Multiple indicators should be used wherever possible.

The tape should be reasonably level and taut. A bungee cord can be used at the handle end of the tape measure to tighten the tape. Once the tape has been stretched, the handle should be locked in place and the bungee cord anchored to the nearest solid object.

Flagging tape should be tied loosely on the tape measure so that measurement points can be easily shifted.

The spacing of the observation points should be checked before recording data. All height measurements can be either recorded as observed (e.g. 18 mm) or can be rounded to the nearest 5 mm (e.g. 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

All field equipment should be marked with bright paint or flagging tape to increase visibility.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS) and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The bankfull profiles and channel entrenchment module was a long time in development, with intellectual input from Peter Ashmore, Derrick Beach, Scott Finucan, Jack Imhof, Craig McCrae, Bob

Newbury and Dave Rosgen, all contributing to the final product. Earlier studies to assess the repeatability of the module and that confirmed the value of sampling this metric using OSAP site definitions were carried out by Laurie Allen, Suzie Kostyniuk, Tommi and Johanna Linnansaari.

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Appendix 1

Example Bankfull Profile and Transect Discharge Field Form

Note that the survey was done in conjunction with S4.M5 Measuring Stream Discharge Quantitatively. The crew determined that the site was 5.25 m wide and there was minimal variance in the depth and velocities across the profile. Therefore, nine (minimum 8, + 1 observation point because the stream is 2 m wider than 3 m) equally-spaced observation points were established. The transect was set up such that Point-transect Sampling for Channel Structure, Substrate and Bank Conditions (S4.M2) measurements could also be conducted. The tape was set up at 1.5 m from the left bank.

Bankfull Profile/transect Discharge

Mandatory Fields In Grey
Must be filled out for processing

Transect No. 1 of 1
Page No. 1 of 1

Date (yyyy-mm-dd) 2010-08-10

Discharge Approximates Baseflow yes ☒ no ☐

Stream Name WILMOT
Stream Code WM1
Site Code 3CDW
Sample 01

Record only on the 1st transect.
Site Length (m) 44.2
Transect Spacing (m) 4.91

Discharge Approximates Baseflow?
☒ Yes ☐ No

Obstructions to Flow
(Check all applicable types)
☐ None Present ☐ Armouring
☐ Trampled Banks ☐ Inlets
☒ Wood Deflectors ☐ Other
☐ Inorganic Deflectors
Others

Indicators Used to Locate Bankfull Level

	Left Bank	Right Bank
Inflection Point	☐	☐
Bank Material	☐	☐
Top of Point Bar	☒	☒
Vegetation	☐	☐
Min. Width:Depth	☐	☐

Others
L
R

Entrenchment
Entrenchment Height = 2 x Max. Channel Depth
Entrenchment Width = horiz. distance from the location of the Max. Channel Depth to the bank at the Entrenchment Height
Record either the Left and Right width or the Total Width

Left Entrenchment Width (m) .
Right Entrenchment Width (m) .
Total Entrenchment Width (m) 24.8

Transect & Point Layout
Use this table to determine the number of measured points per transect, given the minimum stream width.

Minimum Width (m)	Low Variance in Velocity or Depth	High Variance in Velocity or Depth
> 3.0	8+1 every 2 m	10+1 every 1m
1.5 - 3.0	5	8
1.0 - 1.49	3	6
< 1.0	2	4

Point Spacing = Active Channel Width / Points per Transect
1st Point = Point Spacing / 2 (from left bank)

Active Channel Width (m) 5.3
Point Spacing (m) 0.58

Channel Profile

	Horiz. Loc. (m)	Vert. Ht. (mm)
Left BFD	1.50	960
Right BFD	8.24	847
Max. Chann. Depth	2.56	1765

Ht. Represents Bankfull? ☒ Yes ☐ No

Velocity Measurements
(Recommended depth ratio from stream bottom is 0.4 m)

	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
Left Active Chann.	1.50	960	0	-	-	-
Right Active Chann.	6.74	1280	0	-	-	-

Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
01	1.79	1640	300	180	-	0.0
02	2.37	1702	405	210	-	1.220
03	2.96	1728	515	309	-	2.060
04	3.54	1515	310	205	-	1.880
05	4.12	1435	235	141	-	1.590
06	4.71	1375	190	120	-	1.680
07	5.29	1353	166	96	-	1.880
08	5.87	1305	175	100	-	1.540
09	6.45	1290	215	129	-	1.470
10	7.50	900	0	-	-	-

Comments

Crew Leader (Init. & last name) J BEAL

Crew	Recorder	Ent/Scanned	Verified	Corrected
AC,SB	AC	SB	AC	SB

Appendix 2

Examples of Visual Indicators of the Bankfull Level Inflection Points (Reliability: High)

An inflection point is a change in the bank slope caused by a change in erosive power. For example, an inflection point occurs where slope changes (e.g. vertical to sloping, sloping to vertical, or from vertical/sloping to flat). Many banks have multiple inflection points (Appendix 2, Figure 1) that may reflect stream terraces or old floodplains. Therefore it may be difficult to select the appropriate inflection point (i.e. that caused by bankfull discharge).

As the erosive power of a stream increases with greater discharge, stress on the banks increases until the stream overflows the banks. Once the stream overflows its banks, erosion rates begin to decline as energy is dissipated over the flood plain. This change from an erosive to depositional state often causes an inflection point or change in bank slope to occur at the channel-defining stage. Where the banks are relatively steep, this inflection point can easily be identified, and is usually just below the top of bank (Appendix 2, Figure 2).

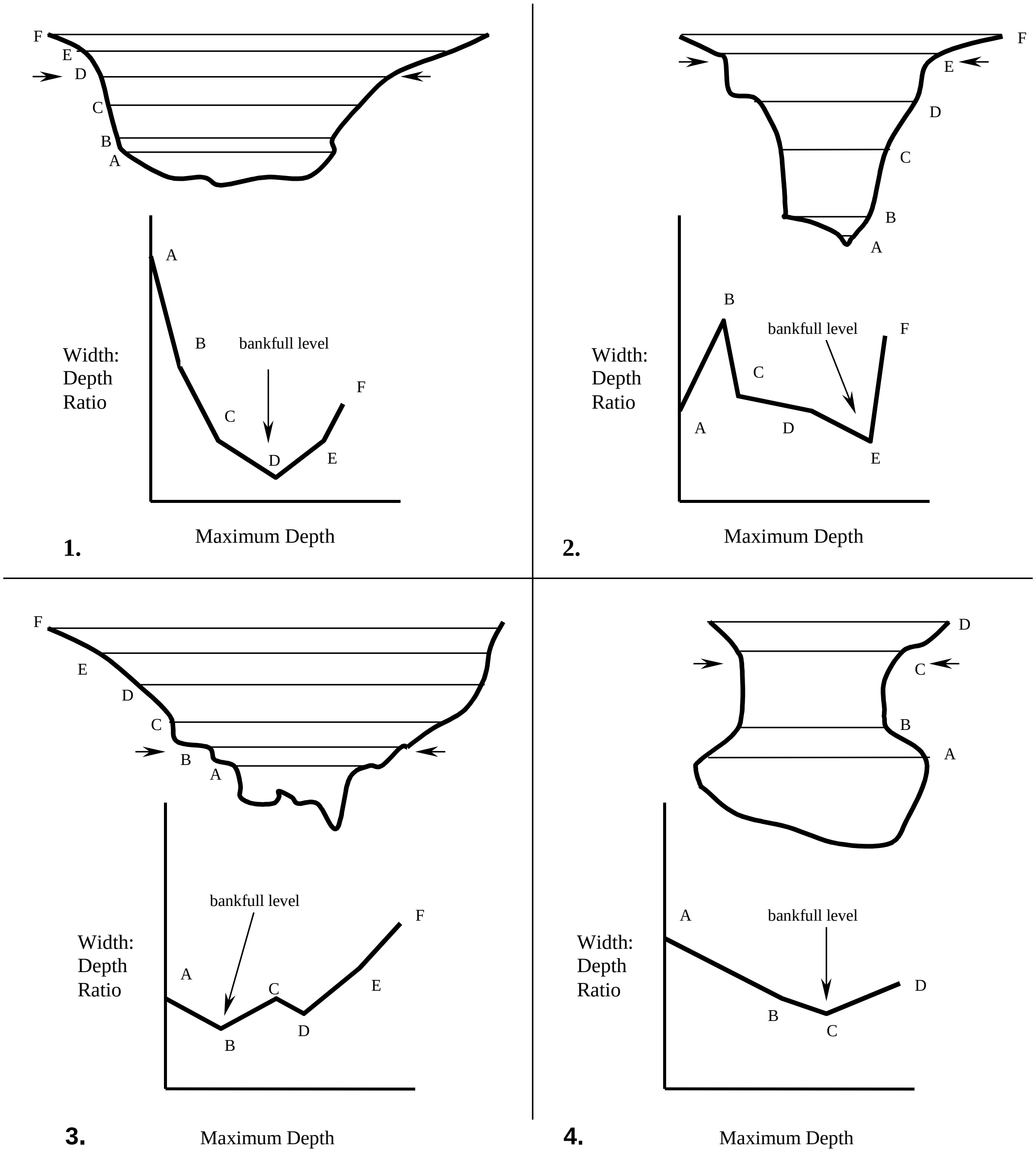
The bankfull level identified using inflection points should be verified using other indicators. For example, perennial vegetation often indicates older terraces or a humus layer is often observed between old and new terraces (Harrelson *et al.* 1995).

Changes in Bank Material (Reliability: Medium)

The dynamic forces leading to a change in bank slope can also produce a change in bank material from a coarser material (inorganic) on the bottom to a finer (organic or loam) material on top. This change in bank material can be an indicator of bankfull level (Appendix 2, Figures 3, 4) only when the finer material is loose and is a result of stream deposition and not a feature of the bank parent material (i.e. unconsolidated).

Top of Point Bars (Reliability: Medium)

Point bars are formed on the inside bend of scour pools (Appendix 2, Figure 5A). During bankfull discharge the top of the point bar is just submerged, providing an indicator of bankfull level. A cut bank or inflection point adjacent to the point bar may also be observed (Appendix 2, Figure 5B, Figure 6). This is another indicator of the depth of flow at bankfull level. The easiest way to identify the top of the point bar is by the presence of a small inflection point or a change in substrate material (i.e. coarser on the point bar to finer material in the flood plain).

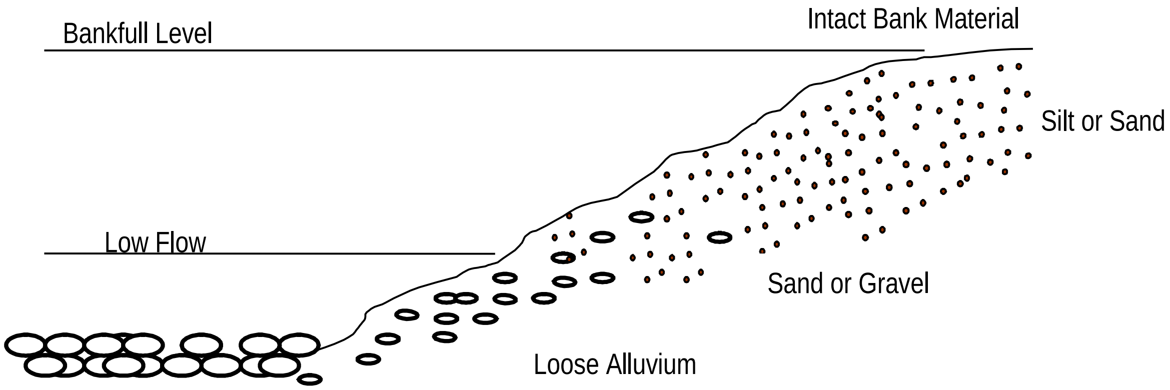


Appendix 2, Figure 1: Determination of Bankfull Level Using Lowest Width to Depth Ratio.

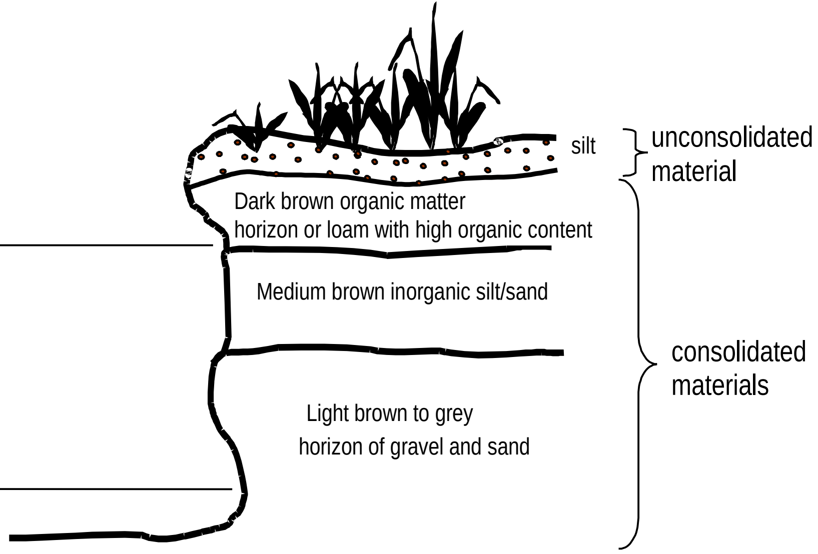
Letters indicate the location of inflection points, with arrows indicating the major inflection point to be used to determine bankfull level. As can be seen in each accompanying graph, the major inflection point also has the lowest width:depth ratio. Abandoned terraces can be distinguished from bankfull level using this same graphing method.

Appendix 2, Figure 2: Inflection Point As An Indicator of Bankfull Level.

Appendix 2, Figure 3: Change in Bank Material as an Indicator of Bankfull Level.

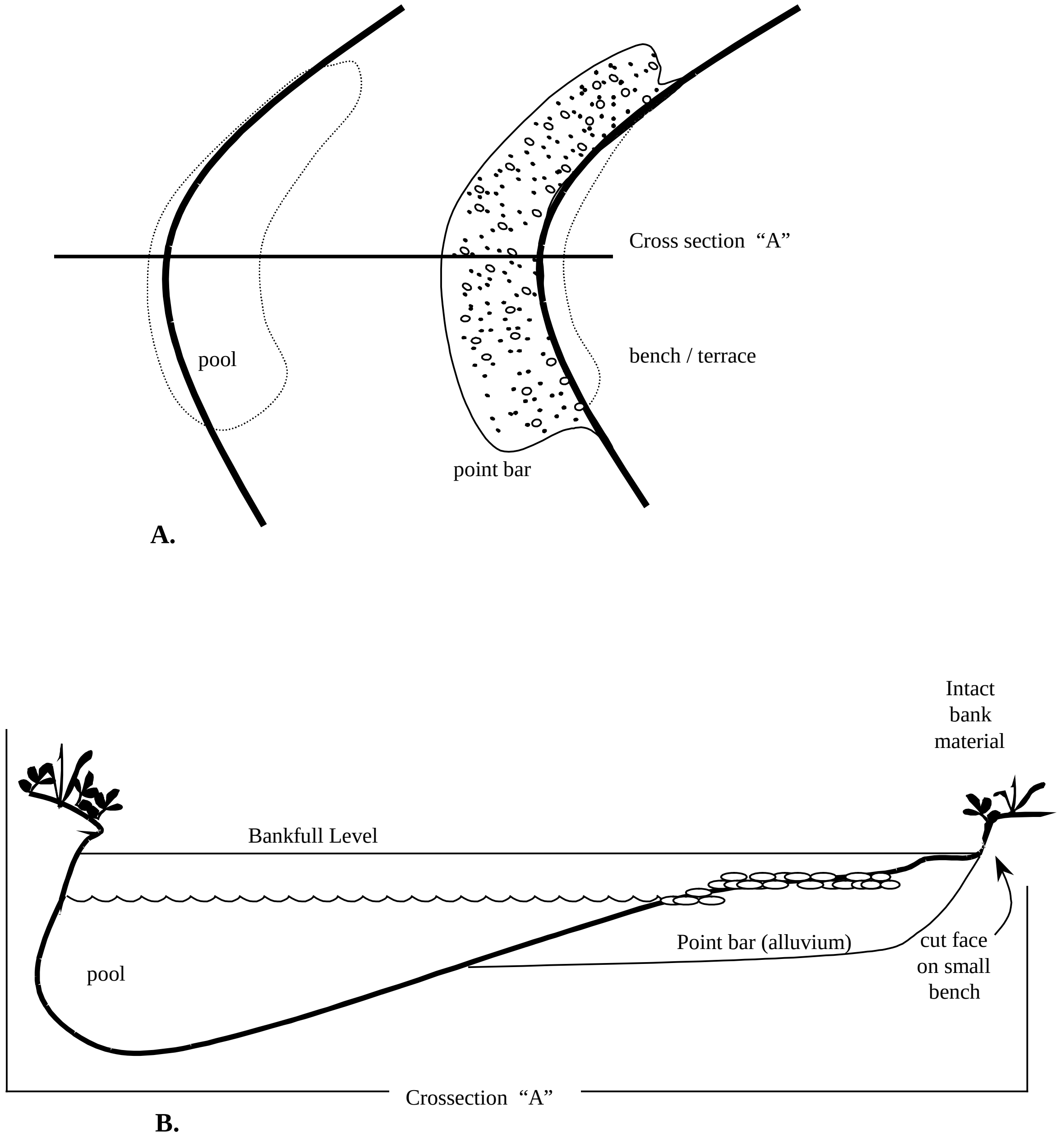


A. Banks with Low Transverse Profile



B. Steep Banks

Appendix 2, Figure 4: Change in Bank Material as an Indicator of Bankfull Level. Note the change from consolidated to unconsolidated materials which corroborates and inflection point.



Appendix 2, Figure 5: Using the Top of Point Bars to Identify the Bankfull Level

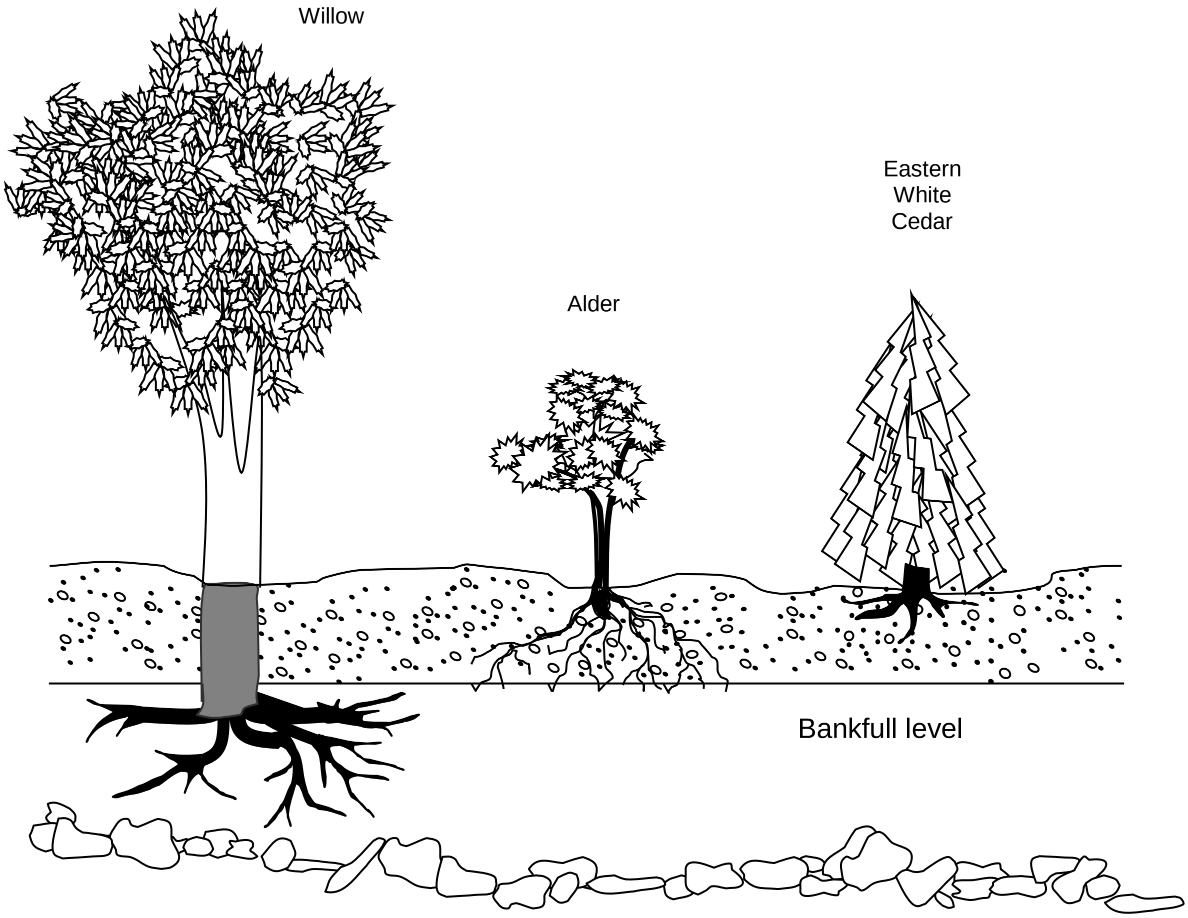
Appendix 2, Figure 6: Top of Point Bar as an Indicator of Bankfull Level.

Changes in Vegetation (Reliability: Medium)

The location where a change in the composition of vegetation, or root depth occurs can be used to corroborate other indicators of bankfull level. The roots of some water intolerant plants such as alder and to a lesser extent cedars will be above the layer of soil that is saturated with water for extended periods. This saturated soil level is generally 1 to 5 cm above the bankfull level. Willows (reddish roots) can tolerate more water and will extend below the bankfull level (Appendix 2, Figure 7). Ideally, if a bank has both alder and willow, the bankfull level will be located somewhere between the upper extent of the willow roots and the lower extent of the alder roots.

Changes in the Presence of Lichens, Water Stains and Thatch: (Reliability: Low)

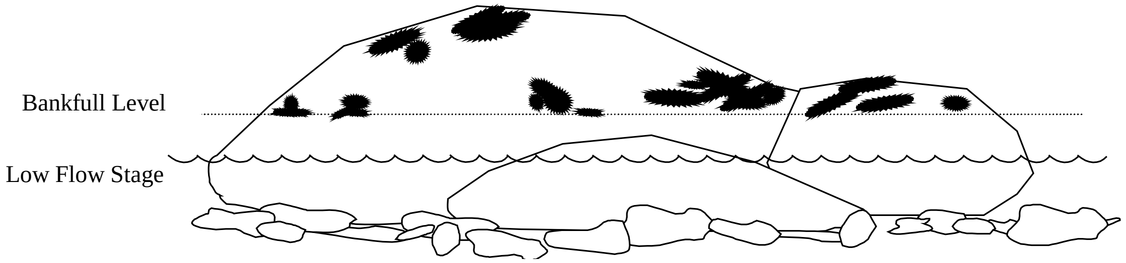
Lichens are able to attach and survive on boulders that are infrequently inundated with water, and are typically found above the bankfull level. A fairly distinct line generally indicates the part of the rock that is scoured clean of lichen (Appendix 2, Figure 8A). This line approximates the bankfull level.



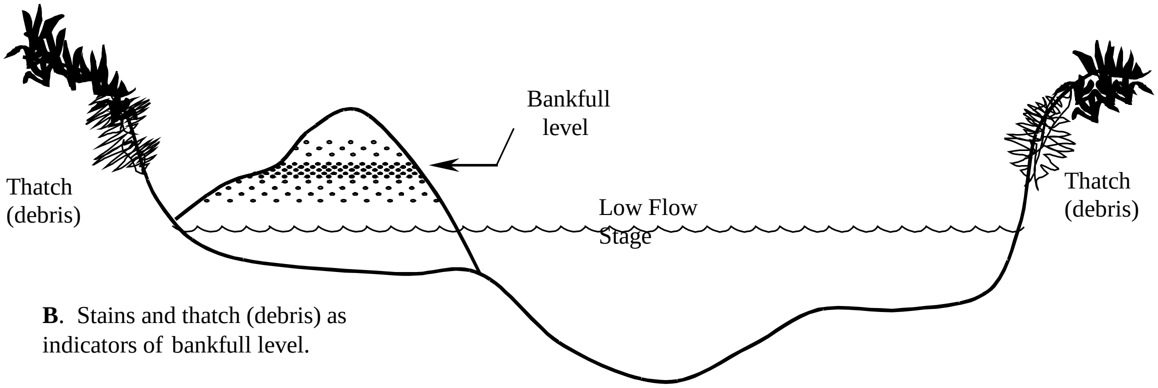
Appendix 2, Figure 7: Vegetation Roots as an Indicator of Bankfull Level.
Eastern white cedar and alder roots will not extend below bankfull level, while willow and dogwood roots do.

Water stains are usually poorly defined and reflect a continuum of flows that have produced the marks. Sometimes three separate bands are distinguishable: an upper faint stain, a middle dark stain and a lower lighter stain. Bankfull level is often approximated as the upper limit of the middle, darker band (Appendix 2, Figure 8B).

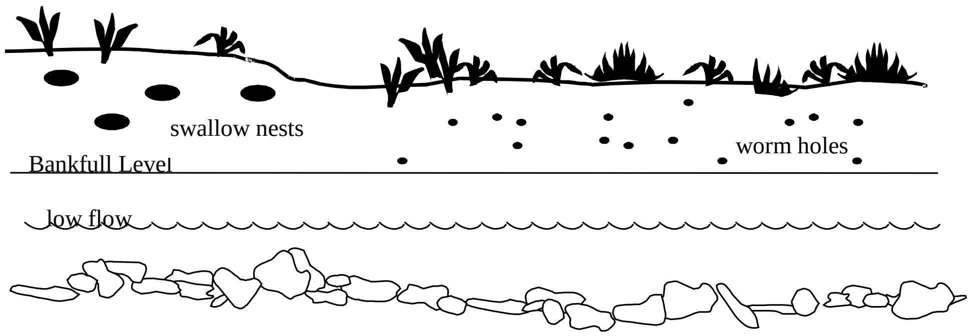
Thatch on the bank (debris and dead grass, Appendix 2, Figure 9) provides a low reliability indicator. (Appendix 2, Figure 8B) because intense flood events may redeposit these materials at a level not related to the bankfull level. This indicator should only be used if prior knowledge indicates that the stream has been recently exposed to a bankfull flow event.



A. Lichens as an indicator of bankfull level. Lichens live on boulders down to the bankfull level.



B. Stains and thatch (debris) as indicators of bankfull level.



C. Animal burrows as indicators of bankfull level.

Appendix 2, Figure 8: Other Indicators of Bankfull Level.
A) Lichens, B) Water Stains and Thatch (debris), and C) Animal Burrows.

Appendix 2, Figure 9: Recent Thatch on the Bank.

Presence and Absence of Worm Holes and Swallow Nests: (Reliability: Low)

Animals also like to keep their burrows or nests above the bankfull level. The presence of either wormholes or swallow nests will almost always be at or above the bankfull level (Appendix 2, Figure 8C).

ONTARIO STREAM ASSESSMENT PROTOCOL

Rapid Assessment Surveys for Stream Discharge and Perched Culverts[1]

TABLE OF CONTENTS

APPENDICES

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes a rapid assessment methodology for evaluating the flow condition of smaller streams and a standard approach for measuring discharge where perched structures exist. Presence and patterns of discharge within any stream channel is an important attribute to aquatic biota. It is essential to have information about flow conditions in order to understand how changes in flow are related to development and weather patterns. Unfortunately for predictive modellers, smaller streams tend to have more variability in flows and their response to alterations is generally less predictable than is the case with larger systems. As a result, practitioners must rely more heavily on field measurements of flow conditions and this module has been designed to assist with this task.

This module can be applied at any time on individual streams, but is most effective when applied across large areas within short time periods in order to generate comparative datasets. For comparative studies, this protocol is ideally designed to be applied 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. When applied within a watershed or across a similar terrain (e.g. base of the Oak Ridge Moraine), these surveys will provide a measure of the relative contribution of flow from headwater systems[3] that can support the development of water budgets.

This tool is best applied through a collaborative effort, involving enough surveyors to ensure that the entire watershed can be surveyed in one day, but can also be applied over multiple days by one crew. The volume by time discharge method is considered to provide the most reliable data on discharge of all the approaches, provided the flows are sufficiently small to capture all the flow in a bucket.

These rapid assessment or reconnaissance surveys fulfil several goals by identifying:

- Suitable locations and methods for stream gauging
- Sites with high or low discharge
- If a stream is flowing at a point in time (e.g. intermittent or permanent); and,
- Improving the field technicians' familiarity with the hydrological conditions and controls within the watershed.

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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.

This module has been applied in several watersheds as part of a “Check Your Watershed Day” event (Chau and Lancaster, 2012) (see inset box). To support further use of this module for such events and to show how it might be applied across ecoregions, the details of the event organization and study design components are also included.

The protocol is generally applied on stream crossings that convey flows from naturalized catchments, as these features can be correlated with GIS generated catchments. To assist surveyors with identifying these features it is advised that the protocol not be applied on drainage features that run parallel to a road or where stream crossings occur in close proximity to one another, e.g. less than 200 metres apart. Refer to Figure 1 for an illustration of crossings that should be assessed as part of this protocol. If a crossing is within 200 m of another crossing where discharge can be and is measured, the other crossing need only be assessed for whether it is perched. Other study designs may choose to include such features without any changes to methodologies (e.g. see S4.M10: Assessing Headwater Drainage Features). Results are less reliable when the wetted width exceeds approximately 3 m, but exact widths will vary depending on local conditions, mainly depth. Therefore crews will generally avoid these larger streams, or should plan to have more reliable methods available for measuring discharge at these locations (e.g. S4.M5: Measuring Stream Discharge Quantitatively).

Check Your Watershed Day (CYWD) Study Design:

Many of the CYWD events were implemented in partnership with a conservation authority that simultaneously conducted more rigorous discharge surveys at larger stream crossings. In this way an inventory of the low flow conditions across the entire watershed was obtained that ensured that all measures were relative to one another, as they were collected on the same day.

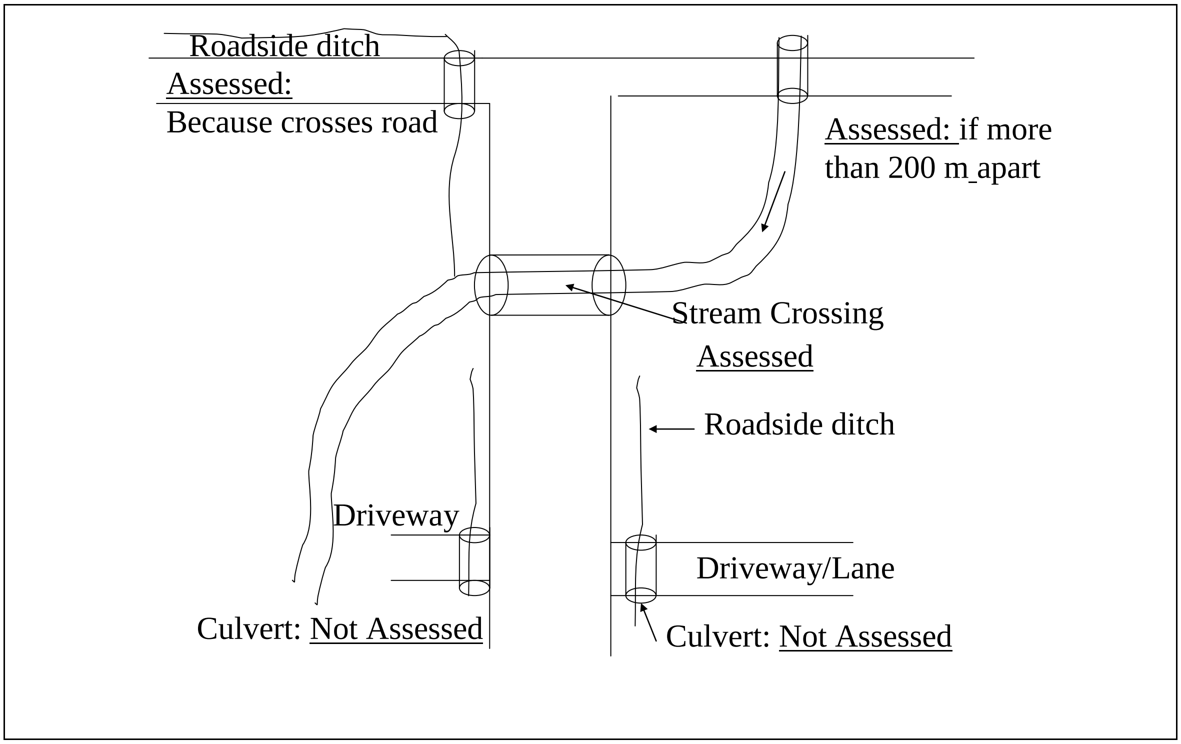


Figure 1. Illustration of stream crossings to be assessed using the Check Your Watershed Day protocol. Note: Only drainage features that cross the road are assessed.

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

Data collected using this module are less accurate and are biased compared to quantitative surveys (i.e. methods described in S4.M5, Measuring Stream Discharge Quantitatively). However, if the bias is consistent, users may be able to develop calibration ratios to adjust the data (see S4.M1, Rapid Assessment Methodology for Channel Structure).

2.0 PRE-FIELD ACTIVITIES

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

Pre-field activities should include:

- Landowner contact where necessary
- Documentation of site access and appropriate stream identifiers (see Section 3.1)
- Equipment check

For this protocol, the following equipment is required:

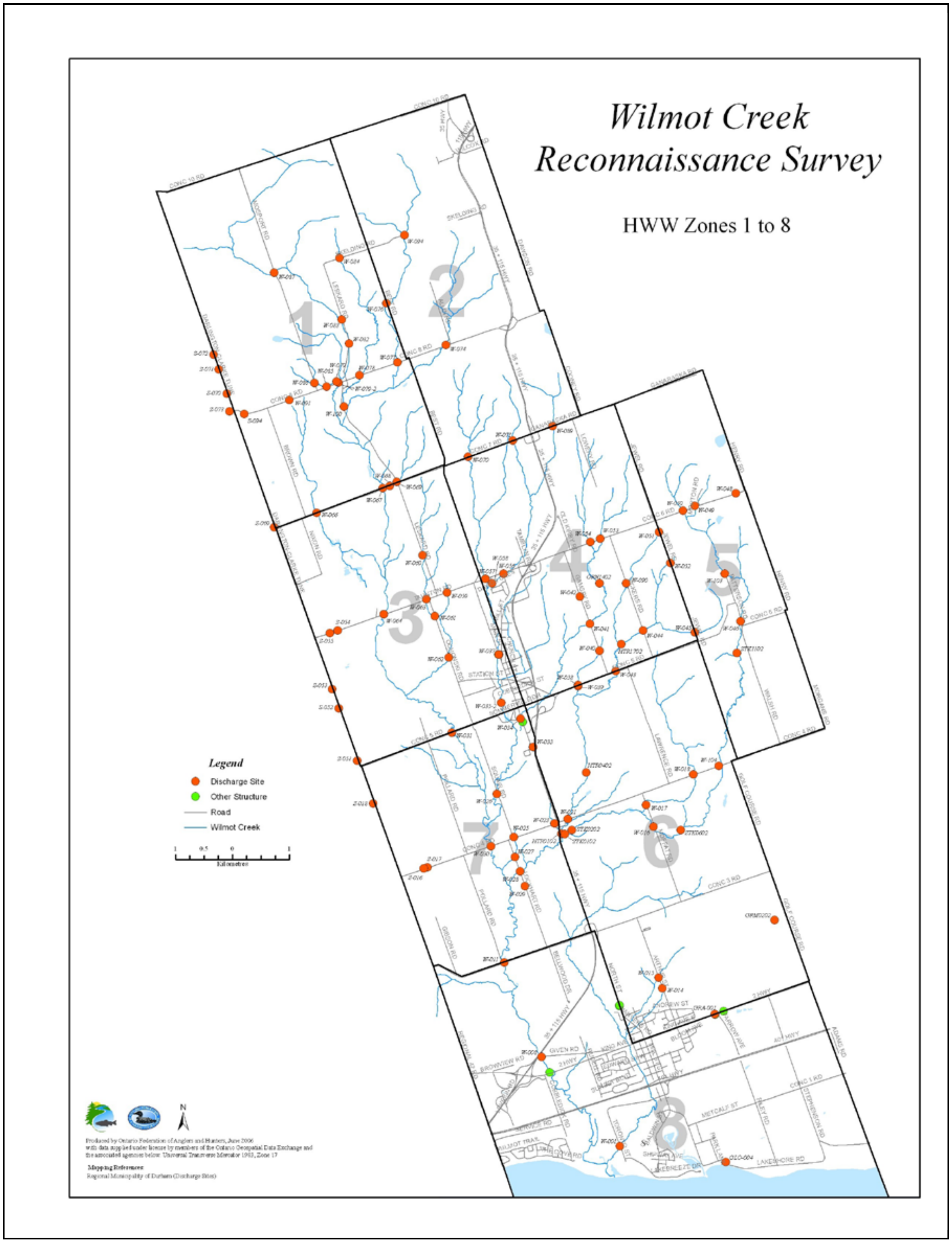
1. Metre stick (wooden)
2. Watch, with seconds indicator
3. Rubber boots or waders
4. Buckets and or funnels
5. Tape measure
6. Field sheets (Site Identification Form, Site Features Form, Rapid Assessment Survey for Stream Discharge and perched culverts)
7. Pencils and Pens
8. Floats
9. GPS unit (not required if sample site maps generated first)
10. Maps
11. Camera

For this module, road crossings over streams are ideally suited for baseflow surveys because they can be readily accessed and because they are public lands. Study design and selection of sampling sites are primarily determined by accessibility and predicted locations of major changes in discharge within the watershed (e.g. suspected groundwater discharge zones, sites near the confluence of tributaries), and sites upstream and downstream of water sources or sinks (e.g. outfalls, dams, pumping sites). Additional discharge sampling sites must be separated by at least 40 m and two crossovers (see Section 1, Site Identification and Documentation).

Crews should adhere to safety precautions and requirements set forth by their project managers, (e.g. 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 2). The 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 (Appendix 1). Project managers should ensure that these field sheets contain the key stream identifier information (stream name, stream code), the sample number, the sampling zone, the UTM grid number, and either a list of pre-identified sites or a process for identifying unique site codes to be used in the survey.



Produced by Ontario Federation of Anglers and Hunters, June 2006
with data supplied under license by members of the Ontario Geospatial Data Exchange and
the associated agencies below. Universal Transverse Mercator 1983, Zone 17

Mapping References:
Regional Municipality of Durham (Discharge Sites)

Figure 2. Example map for identifying sample zones.

3.0 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
6. Jumping height for fish

3.1 Documenting the sample site location

1. Each sample location is documented in four ways: Site Code and Map Notation
2. Address Description
3. UTM Coordinates
4. Photograph (optional)

3.1.1 Site Code and Map Notation

For existing sites, record the existing site code (if available) on the data sheet and cross off this site on the field map. For new sites, record a new site code on the data sheet and mark and label the site location on the map. Should alternate site codes be known (e.g. metal survey tags close to culverts), record these in the site description box[4].

Ensure that a process is established so new site codes are unique for each watershed. For example, crews will use the area or zone number as the first identifier and then a crossing number (e.g. A1C1) where the last number increases sequentially with each new site visited (e.g. A1C2). Two sites within a watershed cannot have the same identifiers.

3.1.2 Address Description

In rural areas, record the 911 address. In urban areas, record the street address for the closest unit to the stream crossing. Record this information in the "Description" section for each site (e.g. 24 inch culvert 40 m S of 1356 Ochonski Rd).

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[4] In the near future the field sheet will be modified to include an alternate site code box for this data. There is a field in FWIS for this information.

3.1.3 UTM Coordinates

Record the source of your UTM coordinates on the field sheet, e.g. GPS or GIS. Record the UTM coordinates for each site visited.

3.1.4 Photograph

If possible, use a camera to record the site access from the road and the sampling section of the stream. Be sure to include important nearby features. Include a sign with the site code in the picture for easy site identification after the sampling day.

3.2 Determining the sampling section of the stream

Attempt to access the stream on the downstream side of the road whenever possible as this will enable you to assess whether the crossing is perched (see Figure 3). If necessary for safety reasons or because there is a better location for measuring discharge upstream, move to this location once you have confirmed the “perched” status of the crossing. If you are sampling upstream, be sure to record this on the field sheet in the “Description” section.

At the stream, look for a section that is easily accessed and includes a section 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. These areas are typically found close to a crossover 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.

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 trough-like depression that carries water mainly during rainstorms or snow melts
- **Agricultural Areas**: areas where there is no evidence of flow under summer conditions and are therefore available to be worked by land owners

Strike a line through the remaining boxes in the field sheet for that site and move to the next site.

If two stream crossings occur in close proximity (e.g. < 200 m) and you can see that no new tributaries enter the system in between the crossings, measure discharge at the location which offers the best measurement. Check to determine if **both** crossings are perched and record this on the field form.

3.2.1 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 and record this as 'Perched Height' (mm) on the field sheet (Figure 3). Also measure the distance from the lowest part of the culvert (its center) to the water surface and record this as the 'Jumping Height' (mm) for fish.

Figure 3. Measuring depth to bed of perched culvert.

If the feature is dry, only record the perched height. Record these measurements to the nearest 5 mm.

3.3 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” in the appropriate box on the field sheet.

At three approximately equal spaced locations across the stream measure and record water depth (Figure 4) to the nearest 2 mm on the field sheet.

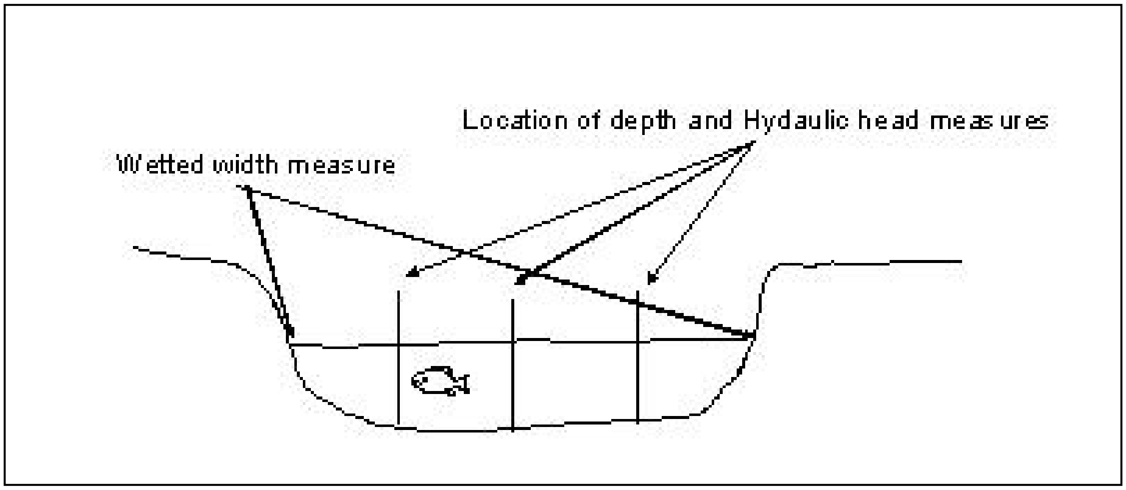

Figure 4. Location of measurements for wetted width and water depth.

3.4 Measuring stream discharge

If there is visible flow at the site, make an effort to measure the amount of discharge (or the amount of water flowing through the stream) by using one the following techniques. These are described in order of preference as each technique provides a different level of accuracy. The technique is used should be applied three times to improve the accuracy of the measurement (i.e. provide a mean measurement). If there is no flow at the site, record a “0” in the velocity box. If the stream bed is dry, mark an “X” in the box indicating that the site is dry.

In very small streams, you may need to temporarily modify the channel to create a uniform sampling area. This may require moving objects that interfere with flow (e.g. rocks sticks or grass) to provide uniform width and depth. Be sure to replace any objects moved after measurements are complete.

3.4.1 Technique 1: Volume/Time

For those locations where the stream is sufficiently small and flowing through a drop structure (e.g. perched culvert or weir) or has sufficient flow to enable a drop structure to be temporarily installed, a bucket and a stopwatch can be used to directly 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 (litres) and the time (seconds) to fill on the field sheet. Three separate volume/time measurements should be recorded on the field sheet. If flows are divided, or there is more than one culvert, do the measurements for each part of the flow and add the values together for recording on the field sheet. Make a note in the comments where this occurs.

3.4.2 Technique 2: Area / Velocity, 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 (HH) to measure velocity. Additionally, this technique should only be applied where the velocity of water at the site generates more than 2 mm of hydraulic head. These flows should be sufficient to enable hydraulic head to be used to measure velocity using the formula shown in Appendix 2. If the velocities are too slow (e.g. < 2 mm HH) use the floating object or visual estimation technique described below.

Hydraulic head (HH) is measured in millimetres 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 5). 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 (35 mm minus 16 mm). Record the hydraulic head to the nearest mm in the box marked 'Hydraulic Head (mm)' on the field sheet. Three separate HH measurements should be recorded on the field sheet.

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 difference 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). In this situation, increase the observation period for the height differential for a better measurement.

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.

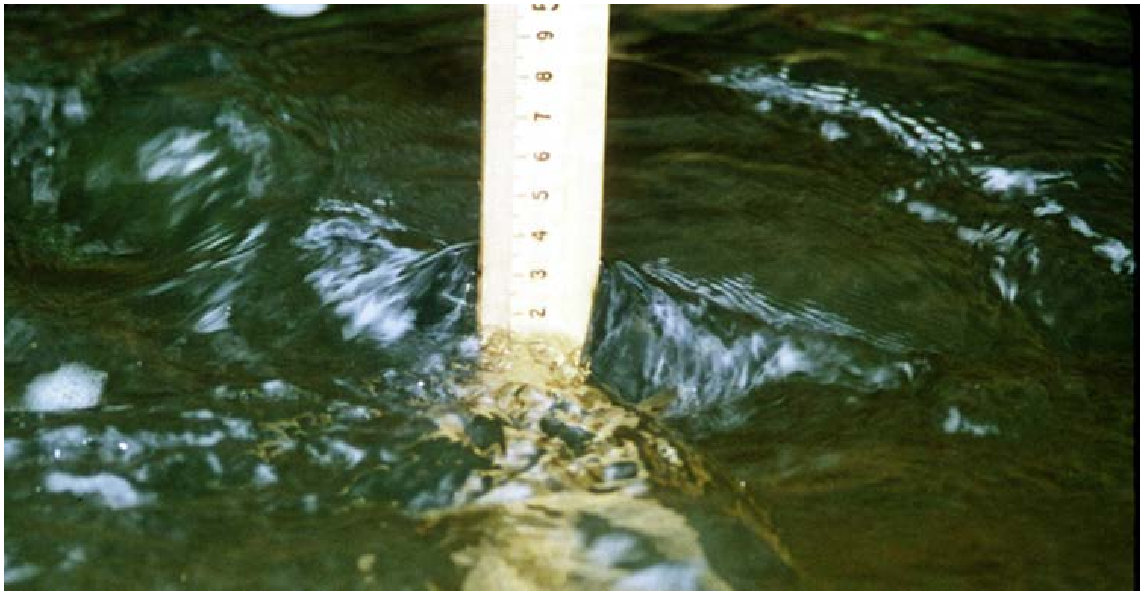

Figure 5. A point measurement of hydraulic head.

3.4.3 Technique 3: Distance/Time, Floating Objects and Visual Estimation

Where flows are too slow to create sufficient hydraulic head to enable accurate measurements (< 2 mm HH), crews can use floating objects to estimate velocity. A formula can be applied to convert velocity into a measure of discharge (Appendix 2).

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 (smooth and unobstructed) flow and similar width and depth across the channel. This is typically located close to the crossover points where the maximum depth of the stream is in the middle of the channel.

The length measured (in metres) needs 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 (measured distance). 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. Three separate trials should be recorded on the field sheet.

3.5 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 6). The specific location to place the tape measure is at the point where the stream channel begins to spill into the stream bank 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. Record the channel width, or bankfull width, in metres on the field sheet.

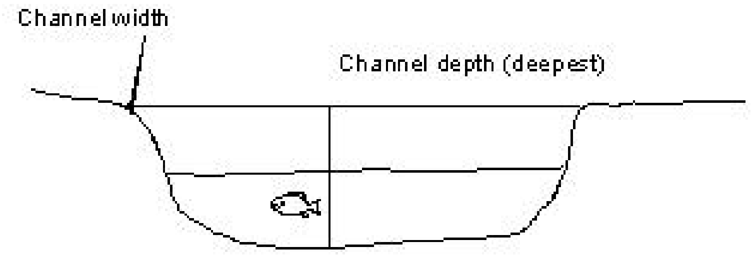

Figure 6. Measuring bankfull width and depth.

Leaving the tape in the same location, locate 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) (Figure 6). Record the channel depth, or bankfull depth, in metres on the field sheet.

3.6 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 that zero (“0”) is a value that must be recorded. If there is a blank space where a “0” should be, 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.

Finally crews need to be familiar with the objectives of the module and the techniques used such that they will be able to obtain data when suboptimal conditions are encountered at a site. In these situations crews may deviate from the standard procedures to obtain measurements, provided data quality is not affected. For example:

- If a site is braided (e.g. an island is present in the middle of the channel) methods may be applied to each of the channels. Discharge calculations can then be added together to obtain the total value
- If a site is too shallow to obtain measurements, crews may move to another area that is more appropriate, or they can temporarily constrict the stream by placing a log or board in the channel to enable data collection (e.g. concentrate flow).

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See S6: OSAP Data Management for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications as well as to obtain an update on the availability of Aps for use in data acquisition in the field.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The rapid assessment survey for stream discharge and perched culverts has gone through several iterations. The initial input for this module was provided by Marc Hinton. Expansion of the module and the development of the linkages to volunteer implementation strategies benefitted from Joyce Chau and Sarah Hogg's input as well as comments from the many citizen volunteers that have applied this module.

6.0 REFERENCES

Stanfield, L. (Editor). 2005. Ontario Stream Assessment Protocol. Version 7, Fish and Wildlife Branch. Ontario Ministry of Natural Resources, Peterborough, Ontario.

Chau, J. and P. Lancaster. 2012. Going with the Flow: An analysis of Check your Watershed Day Data, 2006-2010. Available at: http://www.ecospark.ca/monitoringthemoraine/resources

Appendix 1

Example of a Reconnaissance Discharge Survey Form

Reconnaissance Survey:
Check Your Watershed Day

Form Link: 699848

28631

GRCA

Stream Name: WILmOT CREEK

Stream Code: Wm1

Watershed Code: 2HB-02

Sample: 1

Survey Zone: 1

Date (dd-mm): 18-07-2009

UTM Zone: 17

Source of UTM Coordinates: GPS ☒ GIS ☐ OBM ☐ Other

Crew Leader (init. & last name): S SmITH

Discharge Approximates Baseflow yes ☒ no ☐

Site Code: A1C1

911 #: 899

Stream Dry? ☒ Perched Culvert? ☒

Easting: 699848.2

Northing: 4885350.1

Perched Ht (mm): 300

Wetted Width (m): 0.0

Bankfull Width (m): 3.1

Bankfull Depth (m): 0.8

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	0		.		.	1	.	
2	0		.		.	2	.	
3	0		.		.	3	.	

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

DR235

Site Code: A1C2

911 #: 1150

Stream Dry? ☐ Perched Culvert? ☐

Easting: 699485.1

Northing: 4867500.2

Perched Ht (mm): 0

Wetted Width (m): 1.2

Bankfull Width (m): 2.1

Bankfull Depth (m): 0.91

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	4	0	.		0.0	1	.	
2	5	0	.		.	2	.	
3	2	0	.		.	3	.	

Site Description: 24 IN CULVERT 70m SOUTH OF 1356 OCHONSKI ROAD. STANDING WATER, NO FLOW.

DR233

Site Code: A1C3

911 #: 1152

Stream Dry? ☒ Perched Culvert? ☒

Easting: 699762.5

Northing: 4886216.7

Perched Ht (mm): 250

Wetted Width (m): 0.0

Bankfull Width (m): 2.1

Bankfull Depth (m): 100

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	0	0	.		.	1	.	
2	0	0	.		.	2	.	
3	0	0	.		.	3	.	

Site Description: DRY STREAM. REVISIT SITE.

DR 234

Comments (please incl. names of crew members)

Recorder

Entered/ Scanned

Verified

Corrected

Reconnaissance Survey:
Check Your Watershed Day

Form Link 699848

28631

GRCA

Site Code W-062

911 # 2245

Stream Dry? ☐ Perched Culvert? ☒

Easting 690569.2

Northing 4867249.1

Perched Ht (mm) 420

Wetted Width (m) 0.8

Bankfull Width (m) 1.9

Bankfull Depth (m) 0.85

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1			.		.	1	4.5	17
2			.		.	2	4.5	19
3			.		.	3	4.5	18

Site 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.

DR372

Site Code W-063

911 # 1345

Stream Dry? ☐ Perched Culvert? ☒

Easting 690008.2

Northing 4867249.3

Perched Ht (mm) 600

Wetted Width (m) 0.5

Bankfull Width (m) 0.9

Bankfull Depth (m) 0.25

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	15		0.5	5	.	1	.	
2	20		0.5	7	.	2	.	
3	8		0.5	8	.	3	.	

Site Description

24 IN CULVERT AT NORTH EAST CORNER OF SQUIRES ROAD AND CONCESSION 6.

DR371

Site Code A1C4

911 # 511

Stream Dry? ☒ Perched Culvert? ☐

Easting 690465.5

Northing 4865469.2

Perched Ht (mm) 0

Wetted Width (m) 0.0

Bankfull Width (m) 0.0

Bankfull Depth (m) 0

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1			.		.	1	.	
2			.		.	2	.	
3			.		.	3	.	

Site Description

12 IN CULVERT 100m NORTH OF CONCESSION 6 ON SQUIRES ROAD. NO DEFIND CHANNEL. SWALE ON BOTH SIDES OF THE ROAD.

DR370

Additional Comments

STARTED SURVEYING AT 1000 AND FINISHED AT 1145. ONE LANDOWNER ON OCHONSKI ROAD ASKED TO BE EMAILED WITH RESULTS OF THE SURVEYS AND WAS INTERESTED IN VOLUNTEERING IF THIS IS DONE AGAIN. SAMIAM@HOTMAIL.COM

NO DR CODE

Appendix 2 - Converting Data to Measures of 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. Each of these queries are currently available as part of the summary discharge report in FWIS.

Technique 1: Volume / Time

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

Technique 2: Area / Velocity, Hydraulic Head

When hydraulic head is used, it must first be converted to velocity using the formula[5]:

$$\text{Velocity (m/s)} = 0.625\sqrt{(0.02*HH)}$$

Then velocity is multiplied by the wetted width and the depth to obtain the measure of discharge.

$$\text{Discharge } (m^3/s) = (\text{velocity})(\text{wetted width})(\text{depth})$$

However, both the hydraulic head and depth measurements have to be corrected for the edge effects (i.e. while we make 3 observations we do so in 4 panels).

So for the example at site W-060, the measurements are as follows:

hydraulic head = 6 mm, 8 mm, 5 mm and 0 mm*
depths at the hydraulic head = 40 mm, 60 mm and 50 mm
wetted width = 0.8 m

The mean hydraulic head measurement across the stream channel is 4.75mm.

$$HH = (6mm + 8mm + 5mm + 0mm)/4 = 19mm/4 = 4.75mm$$

The velocity is 0.185m/s.

$$\text{Velocity} = 0.625\sqrt{(0.02*HH)} = 0.625\sqrt{(0.02*4.75mm)} = 0.625\sqrt{0.095}m = 0.193m/s$$

---

[5] This formula accommodates the differences in measurements, such that the observed hydraulic head measurements are entered as is, and represents the original formula published in OSAP with a correction factor (0.625) 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.

The standardized depth measurement is 0.0375m.

Depth = (40mm + 60mm + 50mm + 0mm*)/4 = 150mm/4 = 37.5mm = 0.0375m

The discharge is therefore 0.0055 m^3/s or 5.5 L/s.

Discharge = (Velocity)(wetted width)(depth) = (0.185m/s)(0.8m)(0.0375m) = 0.0055m^3/s or 5.5 L/s.

*Note: the inclusion of 0mm for hydraulic head and depth accounts for the fact that there were only three measurements but there were four panels

Technique 3: Time / 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.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 5

Measuring Stream Discharge Quantitatively[1]

TABLE OF CONTENTS

APPENDICES

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[1] Authors: L. W. Stanfield, M. Hinton and S. Jarvie

1.0 INTRODUCTION

This module contains instructions for measuring discharge in wadeable streams using the Area Times Velocity Method and the Volume/Time Method. This module can be completed individually, or in conjunction with any of the modules that use a “transect” to collect data. The volume by time method can be readily applied in any survey that targets road crossings and other areas where culverts are likely to be perched.

The amount of water within any stream channel is an important attribute to aquatic biota. Changes in discharge reflect both the natural hydrologic cycle and anthropogenic alterations to this cycle. It is essential to have information about flow conditions in order to understand how changes in flow are related to development and weather patterns.

The data collected are useful for long-term monitoring and impact assessment studies. These procedures can be used for characterizing baseflow conditions or for determining a point-in-time response to a storm event. When applied throughout a storm event, a stage response curve can be developed and used to calibrate the Rapid Assessment Methodology for Hydrologic Response to Storm Events (S4.M6).

If the study objective is to assess causes of stream instability, it is recommended that the bankfull profile (S4.M3, Bankfull Profiles and Channel Entrenchment) and at minimum the substrate component (3.6.6 Substrate Particle Size Distribution) of S4.M2, Point Transect Sampling for Channel Structure, Substrate and Bank Conditions also be evaluated.

The methods described in this module have been modified from Gore (1996) to provide a balance between precision and efficiency. These methods are detailed in manuals produced by Water Survey of Canada (Terzi 1981) and the United States Geological Survey (Rantz 1982). The manuals generally recommend that more panels be sampled per transect than this module and contain information about site selection, study design and data interpretation. If sites are intended as long-term gauging stations, refer to these manuals as the standard.

The methods described in this module are suitable for streams which have:

- A maximum depth of less than 30 cm along the transect (greater depths require an additional velocity measurements at each observation point)
- Sufficient depth to enable the current meter to work effectively at most locations on a transect or
- Have discharge low enough that it can be captured in a measuring device (e.g. bucket).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people (a surveyor and a recorder). Survey time varies with the precision required (number of panels sampled) but typically takes anywhere from 15 to 90 minutes to complete.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment list is required:

1. Discharge Measurements Form: Non-Point Transect Methods and Diagnostic Indicators of Channel Stability field form (on waterproof paper if possible)
2. Pencils
3. Wooden metre sticks
4. Tape measures (30 m or longer)
5. Flagging tape
6. Spikes or tent pegs (four, 25 cm long) or bungee cords
7. Two spring-loaded clamps with rubber edges (to hold tape)
8. Calculator (waterproof, or in resealable bag)
9. Calibrated current meter[2]
10. Buckets, assortment of sizes (10 – 25 L)
11. Stopwatch
12. Funneling or ramping device to direct water into bucket

Optional equipment includes a tool kit (hammer, duct tape, wrench, screw drivers).

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

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[2] Although several designs and models of current meter exist, this method specifically describes the use of Price AA and mini (Pygmy) vertical axis flow meter. Other current meters can be used provided they are suitably calibrated and used according to their instructions.

3.0 FIELD PROCEDURES

The module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers, and S1.M2, Screening Level Site Documentation or S1.M3 Assessment Procedures for Site Feature Documentation. At each site, fill out the site descriptors (e.g. ’Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample #’ and ‘Date’) and record the names of the ‘Crew’. Record whether the ‘Discharge Approximates Baseflow’ for the survey date[3] on whichever field sheet is being applied for the site: the Rapid Stream Discharge Form (Appendix 1), or the Transect Discharge Form (Appendix 2), by marking either ‘Yes’ or ‘No’ with an ‘X’. Record any comments about the site’s suitability for obtaining a measure of discharge in the ‘Comments’ box.

The Volume/Time Method (Section 3.1) is used at sites with low discharges that have either a drop structure or sufficient head to enable a drop structure to be temporarily installed. The Area Times Velocity Method (Section 3.2) is used in all other circumstances.

3.1 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. Repeat this procedure until three similar times (<10% difference from the average) are obtained (the same volume of water is collected for each of the three measurements). Record the volume and the times on the Rapid Stream Discharge Form (Appendix 1).

There is often leakage and/or spillage associated with this technique that can be minimized by using various tools (e.g. plastic bags[4], funnels, larger measuring device). The amount of water that is missed should be visually estimated and recorded in the appropriate category on the data form.

---

[3] Baseflow can be defined as the portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion or other human activities (William *et al.* 1997). The baseflow conditions exist when there is no evidence in the stage discharge hydrograph of any recent storm events. A more in-depth definition is available in the Appendix 2 of S4.M10.

[4] In small shallow channels a plastic bag may be held on the bottom of the cross-section and opened for a short period to capture the flow.

3.2 Measuring Discharge Using the Area Times Velocity Method

For this method fill out the transect identification information i.e. ‘Transect #___of ___’ on the Diagnostic Indicators of Channel Stability field form. This method can be conducted at one of the transects used in S4.M3, Bankfull Profiles and Channel Entrenchment, preferably where the flow is most uniform.

It is important to have a calibrated current meter[5] and the following sampling conditions at each transect (adapted from Rantz 1982):

- Water depth is greater than 0.1 m at all observation points along the transect
- Flow is uniform, constant over time and greater than 0.1 m/s at all observation points
- Flows are free of eddies, slack water and excessive turbulence, approximating laminar in the sample area
- The streambed is relatively uniform and free of obstacles (e.g. boulders, heavy aquatic growth or mid-channel islands within 5 m of the transect).

Where these criteria are not met, first consider whether minor modifications (e.g. relocating an upstream rock or moving to an area with less aquatic growth) may correct the problem. Second, if velocity is heterogeneous, consider whether the discharge can be measured by increasing the number of panels. Finally, the transect can still be established if the area that does not meet the above criteria is relatively small (i.e. less than 10% of the cross-sectional area). For example, large velocity variations (and shallow depths) near the stream edges are common, yet quantifying flows in these areas with accuracy may be of minor importance if the proportion of flow in these sections is only a small fraction of the total discharge. Where these point observations cannot be measured using a velocity meter, the hydraulic head can often be used as a coarser measure of the velocity (see below).

The spacing of observation points and the intensity of sampling at each point will influence the accuracy of the discharge estimate. Guidance on spacing is provided in Table 1. Use as many panels as necessary to capture the variance in velocities in the channel. Project managers must determine the desired accuracy of the survey, as this influences the number and duration of velocity measurements. For further information consult the Hydrometric Field Manual – Measurement of Streamflow (Terzi 1981).

---

[5] Current meters should be regularly checked to ensure that impellors are intact and spin freely and evenly. Refer to specifications stipulated by the manufacturers.

3.2.1 Setting up the Transect:

Transects should be established perpendicular to the general direction of flow. To set up the transect, stake both ends of a tape measure into the banks so that it is reasonably level and taut.

Measure and record the active channel width (see definition below) to the nearest 0.1 m on the Diagnostic Indicators of Channel Stability field form. Divide the active channel width by the number of observation points (Table 1) to determine panel width. Sampling will be conducted at the mid-point of each panel (see example below and Figure 2). Mark the location of each observation point on the tape measure and record the 'Horizon. Loc (m)' to the nearest 0.05 m.

Table 1 - Relationship Between the Stream Width and the Number of Panels to Sample for Low Variance and High Variance Sites

Channel Width (m)	Number of Panels to Sample	
	Transects with Low variance in velocity	Transects with High variance in velocity
> 3.0	minimum 8*	minimum 10*
1.5 – 3.0	5	8
1.0 – 1.5	3	6
< 1.0	2	4

* Add one panel for every 2 m increase in stream width i.e. 9 m wide = 11 (low variance) or 13 (high variance) panels.

Active Channel

The active channel is the area between the two outermost banks, which includes all active flow (i.e. moving water) at the time of the survey. The transect boundaries are at the bank-water interface (i.e. where the water meets the land; when undercuts are present, see Figures 4 and 5 in S4.M2).

Rules for defining the active channel:
1. Side channels or braids are included if both the inlet and outlet occur within the sample site.
2. Only the mouth of a tributary is included, i.e. the transect does not extend over a bank.
3. Backwater pools (wet areas adjacent to the active channel that are fed by intergravel flow) are included if they are located within the high flow channel, are located below the top of bank, and there is visible flow from the pool into the stream.
4. Mid-channel bars and islands are included in the cross section (Figure 1).

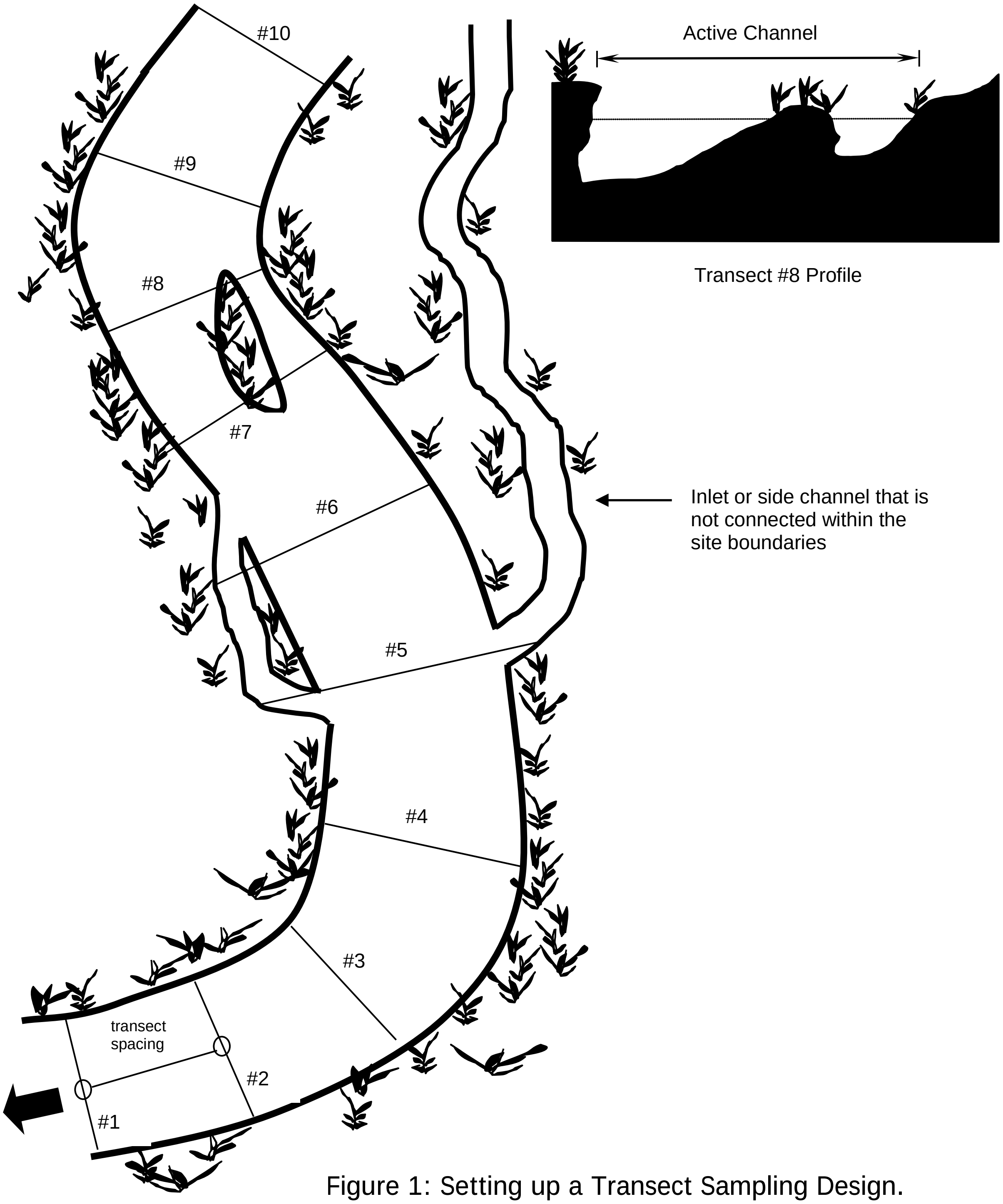

Figure 1: Setting up a Transect Sampling Design.

The thalweg can often be used to assist in determining the appropriate orientation of the transect (angle relative to channel). Transect lines 5 and 6 cross a side channel that is connected within the site and 8 crosses an island. These are considered a part of the active channel. Transect line 5 crosses a side channel that is not connected within the boundaries of the site; and this side channel is therefore not considered to be part of the 'active channel'.

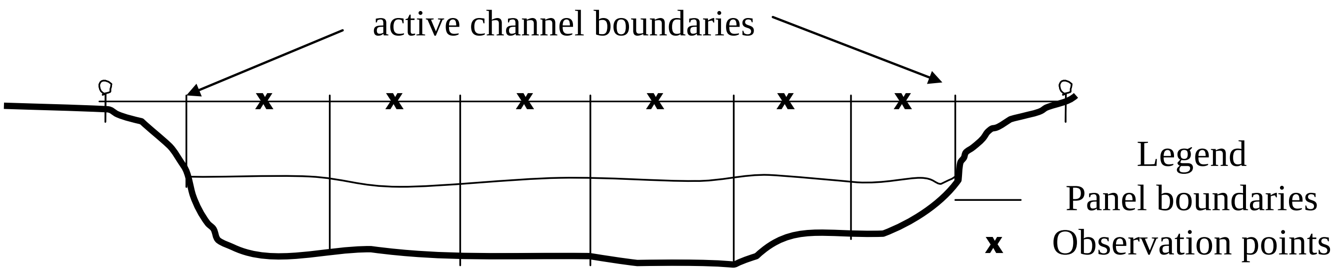

Figure 2: Setting up a Transect Line and Locating the Active Channel

Observation Point Calculation Example

For a stream that has an active channel width of 2.9 m wide, and low variance in velocity, five panels are sampled. The point spacing would be 2.9/5 = 0.58. This number actually represents the boundary of a set of panels that transect the stream, with each observation point located in the centre of each panel. To determine the actual location of the observation points, divide the first panel in half, and for each additional location add 0.58. The first observation point would be at 0.29 m (i.e. 0.58/2 = 0.29). The second point would be at 0.29 + 0.58 = 0.87 m. The complete list of observation points is 0.29, 0.87, 1.45, 2.03 and 2.61 m.

Note: Observation point locations are dependent on whether the tape extends beyond the bank water interface. For example if the left bank water interface occurs at 1.5 m on the tape then the first observation point for the above example would be at the 1.79 m mark on the tape.

The following data are collected at each observation point. Use the most efficient sampling strategy to obtain the data.

3.2.2 Measuring Water Depth

At the observation point, stand the metre stick on the stream bottom and measure the water depth in mm to the nearest 5 mm. Record this depth on the Diagnostic Indicators of Channel Stability field form (Appendix 2).

3.2.3 Measuring Water Velocity

Set the height of the velocity sensor to 0.4 times the depth of the water from the stream's pavement layer and record this 'Observation Depth (mm)' to the nearest 5 mm (i.e. if water depth is 200 mm, the sensor would be placed at 0.4 x 200 = 80 mm from the stream bottom).

The current meter rod should be held vertical and the operator should stand far enough downstream so that the velocity readings are not affected. Once the flows have stabilized, measure the velocity for 60 seconds and record the velocity over that period[6]. Depending on the unit used, record either the average velocity ('Velocity (m/s)') or the number of rotations ('Turns/Min'). **Ensure that the number of rotations is converted to a velocity measure using the calibration table for that particular meter and record this on the field form as soon as possible.**

If water depth is insufficient to obtain a quantitative measure of velocity at an observation point, measure the hydraulic head and record this in the 'Turns/min' column. Mark this with an asterisk and record in the 'Comments' that this refers to a hydraulic head measurement. To measure hydraulic head, orient the wooden ruler at the observation point so that it is vertical and the **wide side with the markings is facing away from the current** (see Figure 3). Avoid standing in front or too close behind the ruler as this can obstruct the flow. The ruler will create a barrier to flow causing the water to climb up the front of the ruler. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 3) in mm as observed or rounded to the nearest 5 mm. 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). Measure the maximum height difference observed over a 3-5 second period.

Use the following formula to estimate velocity (v) in m/s from hydraulic head (HH, measured in mm):

$$v = 0.625\sqrt{0.02(HH)} \qquad \text{(modified from Rantz 1982)}$$

Therefore, if the hydraulic head was measured as 15 mm, the estimated velocity is approximately 0.625 $\sqrt{0.30}$ or 0.34 m/s.

---

[6] Where flows are stable/consistent, or extremely low, it may be feasible to sample for less than 60 sec. In these situations make sure to sample for at least 30 sec. If the unit records in turns/min, don't forget to normalize the value recorded to 1 minute.

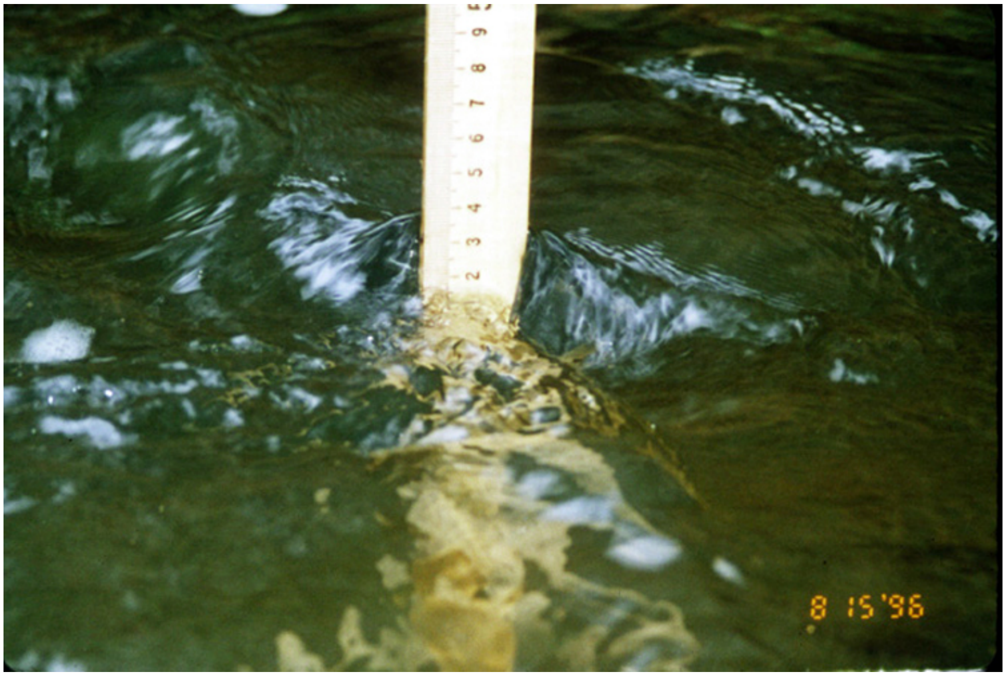

Figure 3: A Point Measurement of Hydraulic Head
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which can be recorded as 19 or 20 mm (rounded to nearest 5 mm).

3.3 Tips for Applying this Module

All depth measurements (water, hydraulic head) can be either recorded as observed (e.g. 18 mm) or can be rounded to the nearest 5 mm (e.g. 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

Tie several pieces of flagging tape loosely on the tape measure that can be slid to each observation point.

Do not forget to use the protective brake or travelling pin on the current meter when in transit and to remove these prior to use in the stream. Keep the current meter well lubricated and turning freely.

Make sure the tape is reasonably level and taut. Clamps or a bungee cord can be used at the handle ends of the tape measure to tighten the tape. Once the tape has been stretched, lock the handle in place and anchor the bungee cord to the nearest solid object.

Always double-check the spacing of the observation points before starting to record the data.

Mark all field equipment with bright paint or flagging tape to increase visibility and prevent loss.

A top setting wading rod will save a great deal of time in setting up the rod to take the velocity measurements.

Make sure that all fields have data recorded before taking down the tape measure.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications as well as to obtain an update on the availability of any applications (Apps) for use in data acquisition in the field.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The quantitative measure of stream discharge module benefitted from suggestions of Andrew Piggott and Jamie Duncan. Ryan Stanfield generated the correction formula for converting hydraulic head measures to velocity.

6.0 LITERATURE CITED

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Appendix 1

Example Rapid Stream Discharge Survey Form, Volume/Time Data

Rapid Stream Discharge Survey

Stream Name: ROSLYN CREEK

Discharge Approximates Baseflow: yes ☒ no ☐

Stream Code: RSC1

Watershed Code:

Sample: 01

Survey Zone:

Date (yyyy-mm-dd): 2016-07-02

UTM Zone: 17

Source of UTM Coordinates: GPS ☒ GIS ☐ OBM ☐ Other

Crew Leader (init. & last name): H ROSS FDOW

Site Code: FIRSTGD

911 #:

Stream Dry? ☐ Perched Culvert? ☒

Easting: 690485.0

Jumping Ht (mm): 250

Perched Ht (mm): 280

Wetted Width (m): 1.5

Northing: 4867500.0

Bankfull Width (m): 2.2

Bankfull Depth (mm): 900

% LOST: 0

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
			.		.	1	20.0	35
			.		.	2	20.0	32
			.		.	3	20.0	33

Site Description: ACCESS EASIER ON LEFT SIDE OF STREAM

**Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code:

911 #:

Stream Dry? ☐ Perched Culvert? ☐

Easting: .

Jumping Ht (mm):

Perched Ht (mm):

Wetted Width (m): .

Northing: .

Bankfull Width (m): .

Bankfull Depth (mm):

% LOST:

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
			.		.		.	
			.		.		.	
			.		.		.	

Site Description:

**Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code:

911 #:

Stream Dry? ☐ Perched Culvert? ☐

Easting: .

Jumping Ht (mm):

Perched Ht (mm):

Wetted Width (m): .

Northing: .

Bankfull Width (m): .

Bankfull Depth (mm):

% LOST:

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
			.		.		.	
			.		.		.	
			.		.		.	

Site Description:

**Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface*

Comments (please incl. names of crew members):

Recorder	
Entered/ Scanned	
Verified	
Corrected	

Appendix 2

Example Diagnostic Indicators of Channel Stability Field Form, with Velocity Data

The crew determined that the site was 5.25 m wide and there was minimal variance in the depth and velocities across the profile. Therefore, nine (minimum 8, + 1 observation point because the stream is 2 m wider than 3 m) equally-spaced observation points were established. The transect was set up such that Point-transect Sampling for Channel Structure, Substrate and Bank Conditions (S4:M2) measurements could also be conducted. The tape was set up at 1.5 m from the left bank. Note that the depth of water was insufficient to use the velocity meter at the 10th measurement mark. Therefore hydraulic head was measured here as identified by the asterisk and notation in the comments. Velocity was later determined for this observation using the formula provided earlier in the module.

Bankfull Profiel/transect Discharge

Mandatory Fields In Grey
Must be filled out for processing

Transect No. 1 of 1

Page No. 1 of 1

Date (yyyy-mm-dd) 2010-08-10

Stream Name WILMOT CREEK

Discharge Approximates Baseflow yes ☒ no ☐

Stream Code WMI

Site Code 3CDW

Sample 1

Record only on the 1st transect.

Site Length (m) 44.2

Transect Spacing (m) 4.91

Discharge Approximates Baseflow?

☒ Yes ☐ No

Obstructions to Flow
(Check all applicable types)

☒ None Present ☐ Armouring
☐ Trampled Banks ☐ Inlets
☐ Wood Deflectors ☐ Other
☐ Inorganic Deflectors

Others

Indicators Used to Locate Bankfull Level

	Left Bank	Right Bank
Inflection Point	☐	☐
Bank Material	☐	☐
Top of Point Bar	☐	☐
Vegetation	☐	☐
Min. Width:Depth	☐	☐

Others
L
R

Entrenchment
Entrenchment Height = 2 x Max. Channel Depth

Entrenchment Width = horiz. distance from the location of the Max. Channel Depth to the bank at the Entrenchment Height

Record either the Left and Right width or the Total Width

Left Entrenchment Width (m) .

Right Entrenchment Width (m) .

Total Entrenchment Width (m) .

Transect & Point Layout
Use this table to determine the number of measured points per transect, given the minimum stream width.

Minimum Width (m)	Low Variance in Velocity or Depth	High Variance in Velocity or Depth
> 3.0	8+1 every 2 m	10+1 every 1m
1.5 - 3.0	5	8
1.0 - 1.49	3	6
< 1.0	2	4

Point Spacing = $\frac{\text{Active Channel Width}}{\text{Points per Transect}}$

1st Point = Point Spacing / 2 (from left bank)

Active Channel Width (m) 5.3

Point Spacing (m) 0.58

Channel Profile

Ht. Represents Bankfull? ☐ Yes ☐ No

Velocity Measurements
(Recommended depth ratio from stream bottom is 0.4 m)

	Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
Left BFD		.					
Right BFD		.					
Max. Chann. Depth		.					
Left Active Chann.		1.50		0	—	—	.
Right Active Chann.		6.74		0	—	—	.
Observ.	01	1.79		300	180	—	0.0
	02	2.37		405	210	—	1.220
	03	2.96		515	309	—	2.060
	04	3.54		310	205	—	1.880
	05	4.12		235	141	—	1.590
	06	4.71		190	120	—	1.680
	07	5.29		160	96	—	1.880
	08	5.87		175	100	—	1.540

Velocity Measurements

Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
09	6.45	5	50	—	—	0.550*
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.

Comments

OBSERVATION POINT 09 TOO SHALLOW, HYDRAULIC HEAD MEASURED INSTEAD

Crew Leader (init. & last name) J BEAL

Crew	Recorder	Entered Scanned	Verified	Corrected
AC, SB	AC	SB	AC	SB

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 6

Crest Stage Gauges: Rapid Assessment of Response to Storm and Drought Events[1]

TABLE OF CONTENTS

Appendices

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes a low-cost method (using a crest stage gauge or CSG) for measuring the maximum or minimum (by subtraction) depth of stream flows that occur between two visits. This provides information on responses to flow events (rainfall or snow-melt) or by tracking decreases in stage over time, the response to drought. The measures can be converted to the area of a channel occupied by flow during the period of time between visits to a site, but this requires additional data collection and some calculations. In addition, temporal measurements enable the preparation of a stage height graph (depth of water over time) and indicate how quickly the system responds and recovers from a storm event (flashiness). Flashy streams have fast response times, high peak flows and are more prone to erosion problems such as scouring, undercutting and bank collapse. Comparisons can be made among sites on the same stream or to reference locations in order to detect impacts.

This approach is complementary to approaches which provide continual measures of stage height such as are employed at traditional water survey gauging stations or technologies such as pressure transducers. In fact several studies have used CSG’s at locations where pressure transducers are employed as a validation mechanism for maximum stage depth.

Measures of stage height can be converted to estimates of stream discharge by developing a stage response curve for each site. This is achieved by using module S4.M5, Measuring Stream Discharge Quantitatively, under varying flow conditions that include high flows and developing a line of best fit between the stage and discharge measures. Alternatively, stage response can at minimum be converted to a measure of the cross-sectional area of channel occupied by water at the peak stage discharge. This is achieved by linking the CSG measures to a detailed cross-sectional profile of the stream channel (S4.M3, Bankfull Profiles and Channel Entrenchment) (see Stanfield 2009 for details). Measures of wetted channel area can be converted to measures of discharge by estimating the average velocity using Manning’s equation (see Manning 1891 and Stanfield 2008 for details). Finally, Stanfield and Jackson (2011) took this one step further and related measured flows to local rainfall events and quantified landscape factors that influenced the flashiness of streams. Options for collecting this data are described and the database has been designed to accommodate this information for future analysis.

This module can be used on any stream where the crest stage gauge can be anchored and protected to withstand a storm event.

2.0 PRE-FIELD ACTIVITIES

A typical crew consists of two people and survey time varies with the number of readings. Each reading takes approximately 1 minute to perform. Installation of the crest stage gauge (PVC pipe) requires 10 to 30 minutes.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment list is required:

1. Water level record (ideally on waterproof paper) for individual or group readings
2. Pencils
3. Metre stick
4. Clear plastic pipe (approx. 4 cm diameter), cut to a minimum height of bankfull depth + 0.5 m
5. 2 pieces rebar (3 foot long minimum)
6. 4-6 tie cables
7. 1 hammer for putting in rebar
8. 1 plastic bottle or other capping device
9. 1 meter stick
10. Flagging tape or other marker to identify reference pipe
11. Tape measure and 2 stakes
12. Talcum-based baby powder (i.e. hypoallergenic)
13. Water and rag for dampening inside of pipe and cleaning

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

The module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. At each site, fill out the site descriptors (i.e. 'Stream Name', 'Stream Code', 'Site Code', 'Sample #' and 'Date'). These data should also be recorded in the appropriate fields on the Water Level Record field sheet.

The crest stage gauge used in this module consists of a clear pipe that is coated on the inside with talcum powder (Figure 1). The powder dissolves as the water rises, leaving a mark on the pipe at the maximum depth attained during an event. Conversely, if water levels drop over time the observed water level will be lower than the mark on the pipe when it was installed. If the device is being deployed to generate a stage response curve, the sampling should follow a time schedule dictated by the hypothesized shape of the curve for a stream.

The crest stage gauge can be installed at any time and left in place throughout the study. Stream responses can be measured several times during a season with each storm event being a separate sample comprised of multiple readings. Drought responses can also be recorded over time as these are indicated as the change (decrease) in water depth between two observation points. The survey results from each hydrologic event represent a sample for this module. For example, regardless of whether sampling occurs once or multiple times during a storm event, all of the data are recorded as one sample (see Appendix 1). Multiple observations recorded during a single rain or drought event are considered replicates.

Figure 1 - Crest Stage Gauge attached to both rebar and a tree

3.1 Overview of Sampling Procedures

Step 1: Ensure that site documentation information is completed to the degree of detail required by the study being conducted (Section 1).

Step 2: Install a crest stage gauge (CSG) in an appropriate location within the site (e.g. that provides protection from debris/vandals) and has uniform channel depth and bank heights (i.e. close to a crossover). Label one of the rebar stakes as a reference bar. Wet the inside of the CSG using a rag and coat it with baby powder.

Step 3: Take initial measures of the CSG including; current water depth and distance from the reference rebar to the top of the CSG. If stream response is to be converted to a measure of area of wetted channel, conduct a detailed cross-sectional profile of the channel at the CSG location following methods described in S4.M3: Bankfull Profiles and Channel Entrenchment.

Step 4: Once an event has occurred or is in progress, return to the CSG to capture the response in the stream during or following an event (e.g. rainfall, melt or drought) as dictated by study design. Record the stream response and existing water level conditions as well as the distance of the top of the CSG to the reference rebar. Reset the CSG.

Step 5: If required, record the appropriate measure of the event condition. Examples include the depth and duration of rainfall; number of days without rainfall; depth and duration of snowmelt.

3.2 Installing the Water Level Gauge

Prepare the clear plastic CSG for installation by drilling four 6 mm holes on two sides of the bottom end of the pipe. This will ensure the free flow of water into the pipe and prevent it from becoming plugged with sediment or debris. Plastic pipe can be purchased from central vacuum supply companies and generally comes in 8 foot lengths. Pipe length is determined by the stream type but should exceed bankfull height by at least 0.5 m.

Place a label with information about the CSG's purpose, owner, contact information and the station's unique site code near the top of the pipe.

Select a location where flows are constricted and a similar bank profile exists on both sides of the stream. If multiple locations within the stream meet these criteria, try to select a sheltered location that offer the CSG protection from debris flows etc. Attach the CSG to an existing structure such as a tree or fence post and/or drive at least two pieces of rebar (or other stakes) into the substrate at a sufficient depth to stabilize the CSG. Rebar should be placed at right angles to the flow (Figure 1). It is not critical that the CSG be perfectly vertical provided subsequent measurements are taken using a ruler held vertically. Tie the CSG firmly to the rebar stakes using zip ties and pliers. If the stream is expected to have high sediment loads, a 1 cm gap should be left between the stream bed and the bottom of the pipe and or drill holes can be placed ; this will reduce the potential for the pipe to become clogged and impede water from entering the pipe.

Mark one of the stakes (or place a mark on a tree, fence post, etc.) to identify the reference height (top of rebar). This mark is used to confirm that the CSG has not moved vertically in the time between visits. Clean and dampen the CSG with water and a wet cloth tied to the end of a stick as long as the pipe (e.g. a meter stick). Wait 10 to 20 seconds or until the inside is damp but not dripping and squirt a talcum-based baby powder into the pipe (sold as hypoallergenic baby powder). Note that cornstarch-based powder should not be used as slugs and worms are attracted to the powder and will remove it from the inside of the pipe. Once powder is applied, place a cap (e.g. plastic water bottle) over the pipe to keep precipitation from dissolving the powder. The cap should fit snugly but not be so tight as to create a vacuum. Plastic water bottles, particularly those that are hourglass shaped work well for this purpose. If possible, slide one side of the cap between the stake and the CSG to help keep it in place.

3.3 Initial Crest Stage Gauge Readings

Take the following initial measurements (see Figure 2):

1. Total length of the CSG pipe (mm).
2. Vertical distance from the top of the CSG to the top of the reference stake or mark. If the top of the CSG is below the reference point, record the distance as a negative number (e.g. -150 mm).
3. Vertical distance from the bottom of the CSG to the current water level (include the measurement to the stream bed if the stream is dry and record a negative depth if the water level is below the bottom of the CSG). If the stream is dry record the water depth as -99 (i.e. it is dry and you can't measure this attribute).

Hint: *It is much easier to manage the data (not have to remember whether it is +ve or –ve) if all pipes are set up so that the stake is below the pipe.*

Record each of these measurements to the nearest 1 mm on the 'Water Level Record Field Sheet for CSG Installation' (Appendix 1).

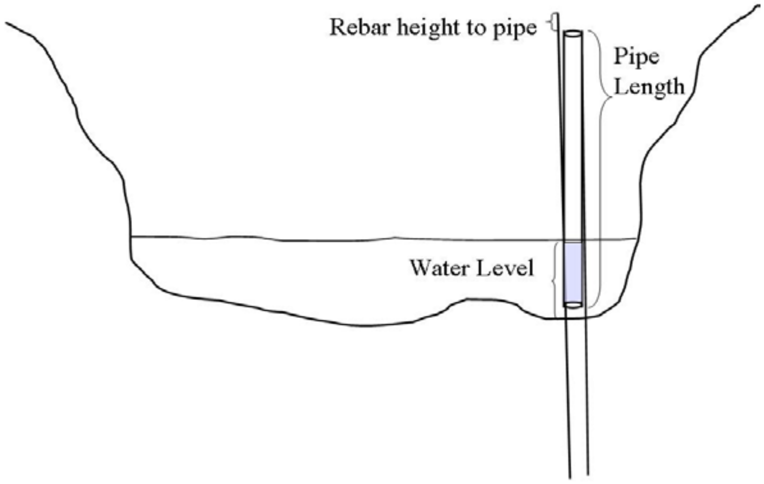

Figure 2: Initial measures to be taken on installing a crest stage gauge.

3.4 Determining and Documenting the Hydrologic Response

The study design will dictate the timing of subsequent samples. Upon revisiting the site, measure the stream response by taking a measurement from the bottom of the tube to the middle of the line that demarcates the stage height (i.e. the extent of dissolved powder) (Figure 3). Measurements are made at the mid point of the CSG to accommodate differences in water levels between the front and back of the CSG (e.g. hydraulic head). Note that above this line the powder may appear to be “clumped”. This occurs when water rises up the sides of the CSG but as no lateral flow through the pipe exists powder does not dissolve. Also record the distance from the top of the CSG to the top of the reference mark.

Once a reading has been taken from the CSG, check to ensure it is still secure and take any steps to re-secure it if necessary[2]. Clean and reset the CSG with powder as described above then measure and record the current distance from the bottom of the pipe to the water line and distance from the top of the CSG to the reference mark. In most instances this measurement will not have changed from the previous observation.

Figure 3: Example of Crest Stage Gauge with response

Record all data to the nearest millimetre.

The following data must be recorded for each sampling event: ‘Date (YYYY/MM/DD)’, ‘Time (24hr clock)’.

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[2] Note: if the readings are being used to generate wetted area of stream per event, make sure the reference rebar itself does not move, or if it must be moved, then re-measure the distance from the reference point to the tape height.

3.5 Data Recording and Capturing or Rainfall data

The field sheets have been designed to meet both a single intensive survey and a spatially extensive survey. Regardless of the study design, fill out one field sheet per site for the initial installation of the CSG. This sheet would also be filled out again in the event that the CSG must be reinstalled or moved. Then each time the CSG if revisited and measurements taken the 'Water level Record Field Sheet' is filled out (see Appendix I). The field sheet can be used for more than one site of records, but is designed to capture data associated with a single storm event.

Future use of the data will greatly benefit from having also captured the amount of rainfall associated with a storm or drought event. Rainfall data can be obtained by either:

- Placing a rain gauge in an open area adjacent to the site
- Estimating rainfall based on weather reports from Environment Canada or some other reliable source
- Calculating rainfall from proximity analysis of known records (see Stanfield and Jackson 20011 for a local example).

Record the rainfall as well as a description that includes intensity and duration on the field sheet.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 TIPS FOR APPLYING THIS MODULE

Mark all sampling equipment to reduce the potential for tampering/vandalism.

If possible, place the CSG in shade to reduce condensation and the potential for streaking, or dissolving of the powder.

Make sure caps fit snugly but do not prevent air exchange.

Have a selection of rebar/stake lengths so that the rebar can be driven far enough into the stream bed to provide support and still leave a sufficient length to tie the CSG to the rebar at several locations.

Make sure to mark the site code on the CSG for ease data recording and to prevent errors.

Mark the reference rebar for consistency of repeat measurements.

Place the CSG higher off the stream bed and consider putting more holes in the pipe in high silt

6.0 ACKNOWLEDGEMENTS

The initial concept and first module for estimating the hydrologic response to flow changes using crest stage gauges came from Bruce Robertson and Jim Buttle and was the basis of this module until version 9. The methodology was revised in 2008 to provide the current approach and it benefitted from the input of Sarah Ross and Mike Berenz.

7.0 LITERATURE CITED

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Appendix 1

Example Field Sheets for Initial Observations and Events

Water Level Record Field Sheet for CSG Installation

Page _1_ of _1_

Stream Name WHITEMANS CREEK	Stream Code WHM	Date 2009/07/23	Crew S. SALAR, S. TRUTTA

Site Code	CSG length (mm)	Reference rebar height[1] (mm)	Distance from bottom of CSG to water level (mm)	Distance from reference pt. to tape[2] (optional)	Comments: (justify negative numbers)
WHM1	1010	37	25	229	
WHM2	1225	-125	32	325	TOP OF CSG IS BELOW THE REFERENCE REBAR
WHM3	1001	78	-15	118	WATER LEVEL IS BELOW THE LEVEL OF THE CSG
WHM4	1500	226	0	-115	REBAR BELOW BANKFULL,WATER LEVEL AT CSG BASE
WHM5	1350	35	-99	195	DRY STREAM

Notes: 1 If CSG is lower than the rebar record as a negative number
2: If rebar is lower than the bankfull height (tape measure) record as a negative number.

Water Level Record Field sheet for CSG Event Data Sheet

Page 1 of 1

Stream Name WHITEMANS CREEK	Stream Code WHM	Date 2009/07/31	Crew S. SALAR, S. TRUTTA

Event Identification RAINFALL ONE	Event Description HIGH INTENSITY THUNDER STORM	Rainfall Amount (mm) 65	Rainfall Source RAIN GAUGE

Site Code	Sample	Replicate	Time: (2400)	Height bottom of tube to response height (mm)	Height rebar to top of tube (mm)	Reset height bottom of tube to water level (mm)	Reset height rebar to top of tube^1 (mm)	Comments (readability, reliability, cap on, etc.)
WHM1	1	1	1030	59	37	35	37	
WHM2	1	1	1050	310	-123	45	-123	
WHM3	1	1	1100	1001	85	15	78	RESET PIPE AND TIGHTENED TIES, ADDED TWO NEW TIES
WHM4	1	1	0930	1500	226	750	-115	STREAM STILL HIGH, CONTINUE TO CHECK
WHM4	1	2	1110	1315	226	750	226	
WHM4	1	3	1230	916	226	750	226	
WHM4	1	4	1430	626	226	750	226	
WHM4	1	5	1700	108	226	750	226	
WHM4	1	6	1915	5	226	750	226	

Note: 1. if rebar higher than tube record as negative number.

Appendix 2

Measuring Cross Sectional Profiles

In many situations study designs will dictate that the CSG data be converted to a measure of the wetted cross sectional area of channel occupied by water for each event. This requires a detailed profile of the channel that can be referenced back to the CSG stage measurements through the reference rebar or other mark. Details regarding these measurements are provided in S4.M3, Bankfull Profiles and Channel Entrenchment.

The cross sectional profile of the channel is carried out at right angles to the flow and at the location of the CSG (Figure A2-1) with the caveat that **the tape measure must be extended across the bank at a height equal to or greater than the highest anticipated flows during the study period** (often exceeds bankfull height). Ensure that the tape is kept level during the survey as deviations could introduce errors in measures of cross sectional area[3]. Measure the depth of the channel at every inflection point in the cross-sectional profile such that no more than a 5 cm change in stream bed elevation occurs without being captured. This represents the most detailed level of application of S4.M3, Bankfull Profiles and Channel Entrenchment. The data is used to determine the area of the channel that is wetted during each hydrologic event (Figure A2-2).

To tie the observations to the CSG readings, measure the distance to the tape from the reference rebar (TR in Figure A2-2). In making these measurements, it is important to note whether the reference rebar is above or below the tape height. In keeping with the convention mentioned earlier, record a **positive** number for the height of rebar if it is above the tape. If the rebar is below the tape record the distance to the tape as a **negative number**.

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[3] Use of a laser level provides an easy means of facilitating this task.

Figure A2-1: Conducting a bankfull profile at a crest stage gauge within a headwater stream

For each event, the dry channel height is determined as follows (Figure A2-2):

$$DC = PL - (S + RP + TR)$$

Equation 1

TR (distance between tape measure and reference point) must be adjusted for each event to account from movement between samples. To do this subtract the difference in the RP ($RP_{beginning}$ –RP_{event}) from the TR (i.e. (TR – ($RP_{beginning}$ –RP_{event}))).

TR Adjustment Example: If the initial TR was 230 mm and the reference heights were 205mm when the bankfull profile was measured and 207mm for a hydrologic event, the TR value used to calculate dry channel depth for the event would be 232 mm or (230mm-(205mm-207mm)).

The area of wetted channel for each event is calculated by subtracting the area of the stream that remains dry from the overall cross-sectional area. This should be calculated one “panel” at a time. For details of this approach and example algorithms for extracting the data using Excel see Stanfield (2009).

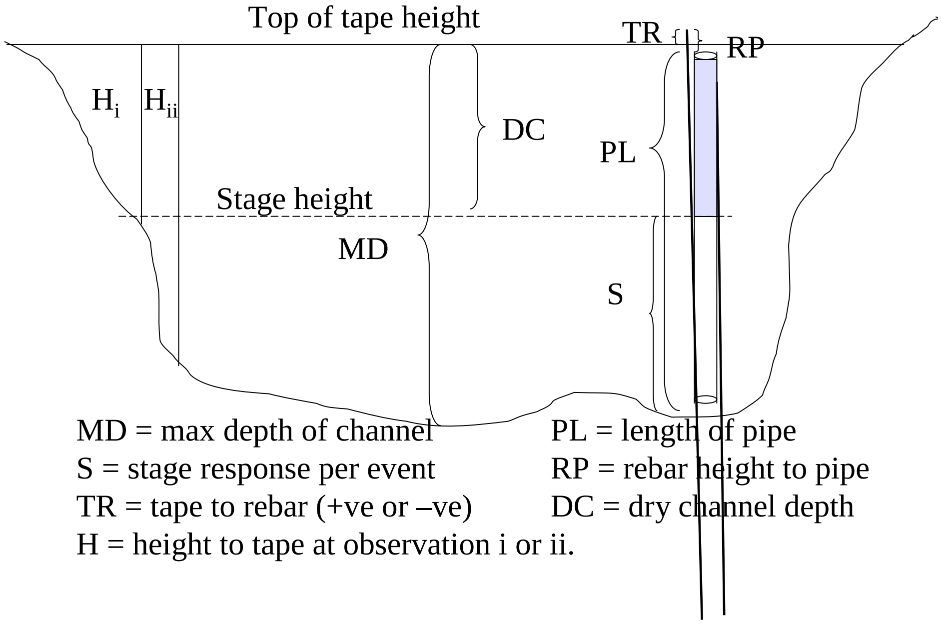

Figure A2-2: Field measurements necessary for linking CSG measures to channel profiles. Ensure that all data are obtained upon installation of the CSG.

Appendix 3

Quantifying Precipitation for an Event

If linking stream response to precipitation events is a study objective, a reliable measure of the amount and intensity of precipitation that fell in the upstream catchment of the site is necessary (at minimum). Storm events can be highly variable and localized and the amount of runoff reaching the stream varies with soil conditions, geology, land use, catchment size, time of year, etc. Specific needs will vary depending on the desired precision of results however it is recommended that surveyors consider placing rain gauges in the study catchment area to augment weather station data and capture local variation in rainfall. Gauges should be placed at least 30 m from any tree or object likely to intercept precipitation. If the study objectives target more widespread events, precipitation data can be obtained from the Environment Canada web page (http://www.ns.ec.gc.ca/msc/em/land_climate.html).

Record the amount of precipitation (to the nearest mm) and the duration (to the nearest 0.25 hours) for the storm or drought event.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 7

Standardized Procedures for Measuring Site Slope[1]

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APPENDICES

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[1] Author: L. W. Stanfield,

1.0 INTRODUCTION

This module provides instructions for measuring changes in the elevation of the stream bed or water surface between two or more locations within a site. When combined with site length, the techniques are useful for measuring the average slope of the bed and the water surface in a site. The methods are also appropriate for characterizing the variation in bed elevation and water surface gradient within a site if differences in elevation between specific morphologic features (e.g. riffles and pools) are recorded. These methods can be applied to diagnostic surveys that measure small changes in bed elevation, however there are more efficient, albeit expensive, approaches than those described here.[2]

Stream slope provides one measure of the erosive power and sediment transport capabilities of a stream. Changes in slope reflect both the natural physiography of a catchment and anthropogenic alterations to the channel. Variations in stream bed elevation provide a measure of habitat diversity, particularly water depth, and can provide insight into whether channels are aggrading or degrading (i.e. down cutting or depositing) over time. Measurement of the water surface slope is also necessary to convert measures of stage response (S4.M6) to a measure of estimated discharge using Manning's equation (see Harrelson *et al.* 1994, Newbury and Gaboury 1993, Stanfield 2009).

If the study objective is to assess causes of stream instability, it is recommended that the bankfull profile (S4.M3, Bankfull Profiles and Channel Entrenchment) and at minimum the substrate component (3.6.6 Substrate Particle Size Distribution) of S4.M2, Point Transect Sampling for Channel Structure, Substrate and Bank Conditions or the rapid assessment module for substrate (S4.M8) also be evaluated.

The methods described in this module have been modified from Newbury and Gaboury (1993) to provide a balance between precision and efficiency and are suitable for any wadeable streams, although the specific tools used will vary with stream width.

This module provides a more rigorous assessment of stream slope than the rapid assessment methods described in S4:M10: Assessing Headwater Drainage Features.

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[2] High resolution GPS units in tandem with a local base station can be used to generate a complete bed profile to cm accuracy. This approach will be described in further detail in future OSAP modules.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people (a surveyor and a recorder). Survey time varies with the tools used and the sinuosity of the stream and density of vegetation but typically takes anywhere from 15 to 90 minutes to complete.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment list is required:

1. Discharge and Slope Measurements Form: Non-Point Transect Methods
2. Pencils
3. Wooden metre sticks
4. Stadia rod[3]
5. Tape measures (30 m or longer)
6. Surveyor level: This can consist of either a traditional surveyor level (sometimes called a transit) with a telescope and spirit level mounted on a tripod or other technologies such as a laser level and tripod, an abney level, or even a laser level with a range finder[4]
7. Flagging tape
8. Calculator (waterproof, or in re-sealable bag)

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.) and should follow the manufacturer’s instructions for safe use of laser devices.

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[3] Stadia rods come in many forms including versions that can telescope to varying heights. These can also be constructed for use in the field by gluing tailors tapes to or marking boards that are linked with wing nuts. Stadia rods should have 0.5 cm accuracy.

[4] Laser levels work well for short distances between readings, although they are prone to the light being blocked by vegetation or by diffusion in bright sunlight. They also require the use of protective eyewear.

3.0 FIELD PROCEDURES

The module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M3, Assessment Procedures for Site Feature Documentation. At each site, fill out the site descriptors (e.g. ’Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample #’ and ‘Date’) and record the names of the ‘Crew’. At a minimum, elevations should be measured at the bottom and top crossovers of a station. The number of times that the surveyor level needs to be moved will depend on the equipment used, site conditions, and survey goals. Therefore, several options are described for data collection and implementation is left to the crews. Tying all observations to a station benchmark, a large boulder, culvert etc., (see S1.M3) provides an optimal way of ensuring all observations are comparable and also enables comparisons to be made between sampling events. Recording GPS coordinates and bearing for each observation point enables a spatially accurate 3 dimensional survey to be made of the site[5].

3.1 Overview of Sampling Procedures

Step 1: Ensure that site boundaries (S1.M1 - Defining Site Boundaries and Key Identifiers, and Section 3.2 - Identifying the Site Boundaries) have been established. It is recommended that a site sketch be completed and that all measurements be tied in to at least one station marker (refer to S1.M3 - Assessment Procedures for Site Feature Documentation).

Step 2: Select an appropriate location to set up the survey level that provides a level and unobstructed view of the sample area.

Step 3: At the downstream crossover, place the stadia rod on the stream bed in the middle of the channel and measure the level location and the water depth on the stadia rod. Ideally, measurements will also be made to the station marker.

Step 4: Measure the distance up the middle of the channel to the next observation point, whether it is the top of the station or the next stream feature.

Step 5: Repeat step three at this location. The difference in readings from the upstream location and the downstream location indicate the change in bed elevation.

Step 6: To obtain the change in water surface elevation, subtract the water depth from the stadia readings. The difference in readings divided by the distance between locations is the slope used in Manning's velocity equation.

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[5] Record the waypoints in the comments field.

Step 7: If the stadia rod cannot be observed from a particular location, move the survey level to a new upstream location and repeat the process, ensuring that observations from both locations are made to one observation point to calibrate between observations.

Note: If measurements are to be tied in to a station marker, choose the feature that offers the most obvious and permanent location for measuring elevation (e.g. the top of an erratic, the base of a building, road bed) and record the measurements described below for each stadia location. Optional: Record the bearing at each observation after setting the declination on your compass to reflect local conditions. Another option, not presently available on the field sheet is to record the way points of each measurement using a GPS that can later be used in mapping.

3.2 Setting up the Survey Level

Set up and level the tripod upstream of the first observation point. The location should offer an unobstructed view of the downstream crossover and at least one upstream observation point (Figure 1). In shallow systems, the best location for the tripod may be in the channel or on a bar mid-channel.

Position the survey level device on the tripod (see Harrelson *et al.* 1994 or the instructions provided in the device manual). If a laser level is being used, ensure that the unit is above the height of all vegetation in the pathway. Swing the level on the tripod base to ensure it is level in all positions and adjust if necessary.

Leveling the Survey Device

Line the survey devise so that it is in line with two of the leveling screws. Turn both screws in opposite directions (i.e. in or out) until the bubble is in line with the target area. Turn the survey device 90º and turn the remaining screw until the bubble is centered.

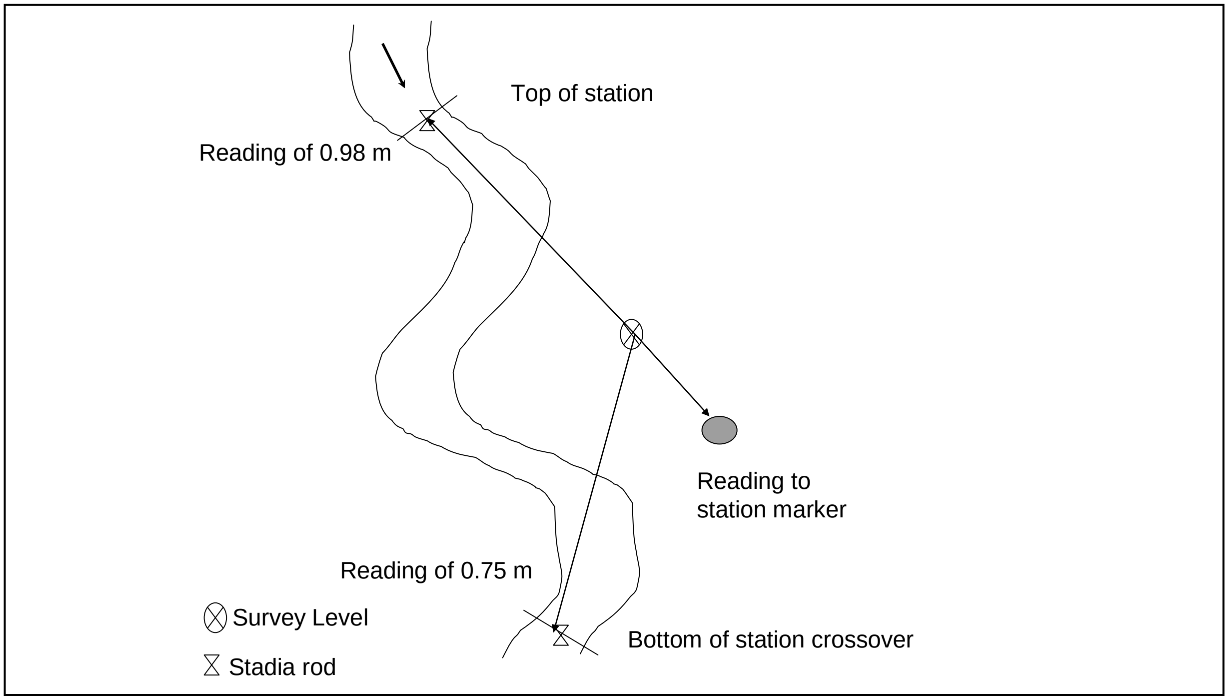

Figure 1: Obtaining site slope measurements from one observation point. Recording observations to the station marker is optional but recommended.

3.3 Measure the Difference in Elevation from Survey Level to Pavement Layer

Place the stadia rod on the pavement layer (Figure 2) of the stream bed in the center of the bottom crossover (ensure the rod is facing the survey level). Record the water depth (to the nearest 5mm) on the stadia rod and measure the height difference between the survey level and the pavement layer of the stream bed. If using a traditional survey level this value will be the intersection of the line in the view finder and the stadia rod. If a laser level is used read the height as the mid point of the beam on the stadia rod.

Pavement Boundary

The pavement boundary represents the bottom of the active flowing channel and is identified as the point where substrate particles form a fairly uniform layer across the bottom (Figure 2). This may be difficult to determine in areas dominated by coarse material. In these instances, put the ruler between the coarse material to the lowest layer of material that is visible.

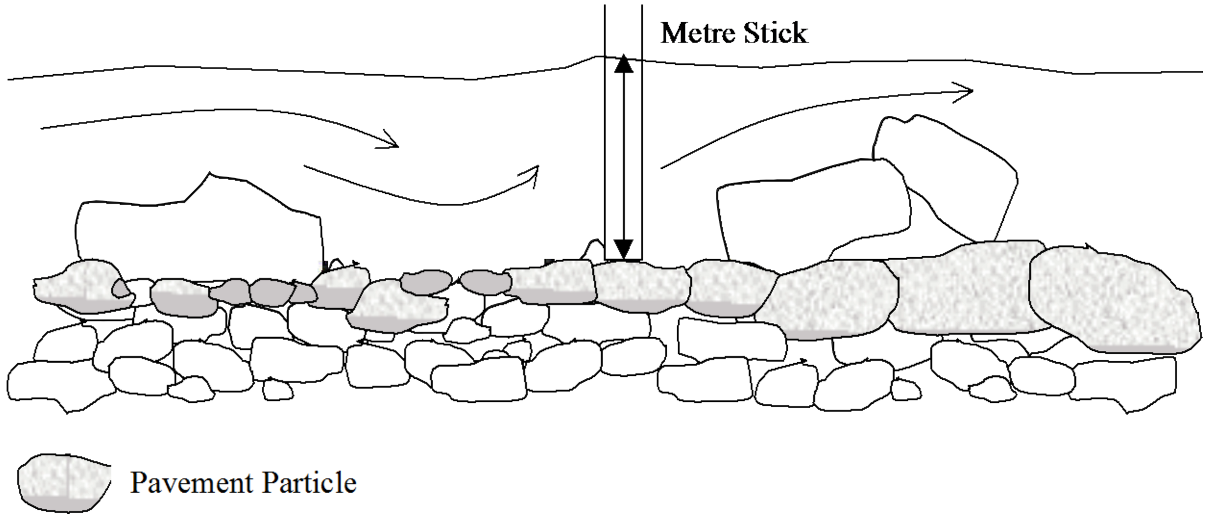

Figure 2: Placement of Stadia Rod on Pavement Layer.

3.4 Locating and Measuring Distance to the Next Observation Point

Identify the location for the next stream bed elevation measurement based on the objectives of the study. For example, a study to capture the longitudinal profile of the stream might locate observation points at specific thresholds for depth changes (e.g. > 0.1 m) or at the maximum depths of hydrologic features such as riffles and pools. The minimum measure is the elevation at the top and bottom of the station (i.e. crossovers) which provides a total drop in elevation through the site.

Measure the distance between the first and second observation points by chaining up the centre of the stream. To do this, one person stands at the bottom of the site in the middle of the stream to mark the starting point and a second person proceeds upstream until the stream changes direction or the next observation point is reached. If the stream changes direction before the observation point is reached, the second person should mark the location and the distance and call for the first person to move up to the new mark. This process continues until the observation point is reached. Record the distance between points to the nearest 0.1 m.

Note: If the next observation point cannot be observed from the current location of the survey level, procedures for tying in multiple survey level stations will need to be employed (see below).

3.5 Measure Stream Bed Elevation at Subsequent Observation Points

Place the stadia rod at the next observation point and turn the survey level so that a reading can be made. Be careful not to knock the tripod when using the level. Record the water depth on the stadia rod (to the nearest 5 mm) and measure the height difference between the survey level and the pavement layer.

If a level with a range finder is used, crews can record the distance from the tripod to the stadia rod for each observation and apply the cosine rule to calculate the straight line distance between observation points.

3.6 Tying in Measures from Multiple Survey Level Points

If the survey level must be moved to obtain additional bed elevation levels the observation from one location must be tied into or corrected to subsequent observations. This is achieved by making multiple observations of the same channel bed location from two different vantage points. In practice, the person holding the stadia rod remains in place while the survey level is relocated to an upstream location and a new reading of the same observation point is taken (Figure 3). The differences between the readings from the first and second readings of this observation point represent the difference in height of the survey level. This must be taken into account for subsequent observations[6]. The process is repeated each time the survey level is relocated, enabling all observations to be corrected to the first survey level height measurement.

Another option for tying in observations is to incorporate the use of the station benchmarks, including bearing. Note, use of a high quality GPS, especially with a base station will enable bearing to be collected after the fact using GIS.

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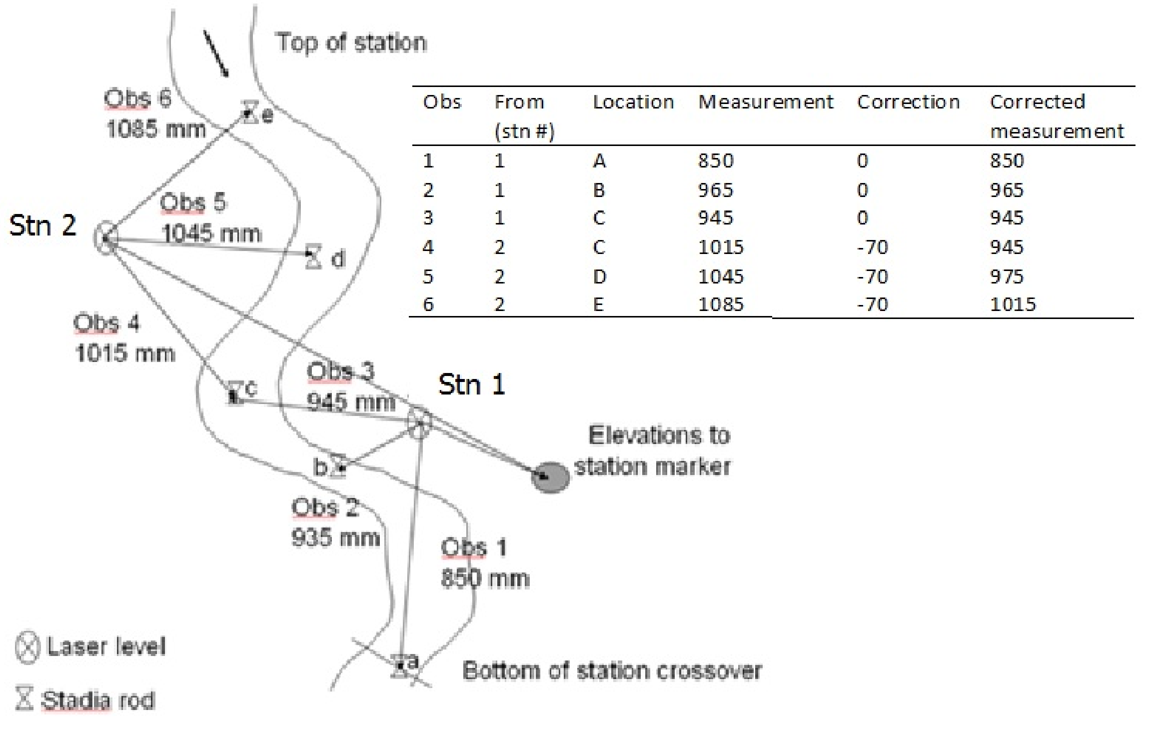
[6] The change in bed elevation at any two observation points is calculated as: elevation_x = survey obs_x-survey obs_0 where 0 is the downstream observation point. Once more than one sample location is included the survey observation must first be corrected by subtracting or adding differences in elevation between observations to subsequent records. In the Figure 3 example, the second survey level was placed 70 mm higher on the land than the first one, as determined by subtracting observation 4 from 3 (1015-945 = 70). This would be repeated on subsequent moves of the survey level, if required.



Obs	From (stn #)	Location	Measurement	Correction	Corrected measurement
1	1	A	850	0	850
2	1	B	965	0	965
3	1	C	945	0	945
4	2	C	1015	-70	945
5	2	D	1045	-70	975
6	2	E	1085	-70	1015

Figure 3 - Obtaining Measurements from Multiple Survey Locations. Note the difference in measurements between observations 3 and 4 provide the correction factor for subsequent observations. See the field sheet in Appendix I for how to record such data.

3.7 Use GPS, GIS and other Technology to determine slope

As technology advances more options become available for measuring slope. Range finders with laser levels, GPS technology and a GIS paired with a Digital Elevation Model (DEM) can each be used to measure slope. However, the accuracy of these techniques varies considerably. Make use of this technology where appropriate, applying the same principles described above to make the measurements. For example, a range finder can be used in similar ways as a clinometer (see M4.S10) but with more accuracy and the additional benefit of measuring length simultaneously. With this example, readings would be recorded in the “stadia rod” boxes on the Slope Measurement field sheet (Appendix 1). Record the types of equipment used to obtain the slope measurements by marking an X in the appropriate boxes on the Site Slope Field Form. GPS technologies are improving, but are likely only effective in larger rivers where changes in elevation are more pronounced and where access to more satellites improve the accuracy of the method.

3.8 Tips for Applying this Module

This technique can be applied to develop a profile of the site by taking measurements at each change in bed elevation and at about every one channel width along the site.

If surveyors are using a laser and range finder, recording the bearing and distance to each observation point from the level enables the cosine rule to be used to calculate the straight line distance between observation points.

Remember higher points on the ground give lower readings on the stadia rod. If you are generating a stream profile from downstream to upstream, don't forget to invert the observations, otherwise it appears as though the stream is flowing upslope. From the example, observation point 2 is actually plotted as -85 mm.

This technique can easily be linked to observations collected using other modules (for example S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions) by measuring differences in bed elevation between transects.

Mark all field equipment with bright paint or flagging tape to increase visibility and prevent loss.

Make sure that all fields have data recorded before taking down the tape measure.

Transport the laser level inside a waterproof container and consider placing the entire unit inside a clear plastic bag.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at:

http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The standard approaches for measuring site slope benefitted from input from Scott Jarvie, Mark Desjardins, Scott Finucan and Doug Forder.

6.0 LITERATURE CITED

Harrelson, C.C., C.L. Rawlins and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Techniques. USDA Forest Service Report RM-245 (available on line)

Newbury R. W., and M. N. Gaboury. 1993. Stream analysis and fish habitat design: A Field Manual. Co-Published by Newbury Hydraulics Ltd., the Manitoba Habitat Heritage Corporation and Manitoba Natural Resources, Gibsons, British Columbia (available on line at www.newbury-hydraulics.com)

Stanfield, L. W. 2009. Understanding the factors that influence headwater stream flows in response to storm events. University of Toronto, Masters Thesis. 75 pp. + appendices.

Appendix 1

Example Site Slope Field Form

The data record on this field sheet reflects the information in Figure 3. The survey level is set up at two stations. Observation 1 measures the bottom of the site level (850 mm) and is tied into the station marker which is 400 mm higher than the bottom of the station. Observation 3 is repeated from both survey stations in order to determine a correction factor for the next set of observations together. Station 2 is 70 mm higher than station 1 so in the calculations of differences in bed elevation, 70 mm is subtracted off all observations made from station 2. If additional stations are set up, subsequent corrections must account for the cumulative differences in heights between stations. For example, if a third stations is measured to be 1060 mm at observation point 6, (that is 25 mm lower than station 2) all subsequent observations would be corrected to -45 mm (-70+25). Note, corrections can be either positive or negative differences. In this example the total change in bed elevation at this site is 165 mm (1015-850).

Site Slope Field Form

Page 1 of 1

Stream Name WILMOT CREEK	Site Code WM1	Site Code 3CDW	Date (yyyy/mm/dd) 2005/06/12

Crew Leader
S. SALAR

Crew Members
S. BYE, J. CODE

Equipment Used
☐ Survey Level ☒ Laser Level ☐ GPS ☐ Range Finder ☐ GIS

Description of Station Marker or Benchmark (if used):
BASE OF WILMOT CREEK FISHING CLUB BUILDING, NORTHEAST CORNER (SEE SITE DESCRIPTION).

Comments

Obs. Num.	Loc. Iden.	Instream Observation Points					Station Markers (if used)				Comments
		Distance from Previous Obs. (m)	Water Depth (mm)	Stadia Rod Reading (mm)	Corrected Difference (mm)	Bearing (Deg)	Distance to Station Marker (m)	Stadia Rod Reading (mm)	Corrected Difference (mm)	Bearing (Deg)	
1	1	------	---	850	0		20.2	650	0	49	BOTTOM CROSSOVER
2	2	3.6	126	935	935		------	------	------		
3	3	10.2	300	945	945		------	------	------		
4	3	------	---	1015	------		32.8	815	95	53	MOVED TRIPOD
5	4	38.6	230	1045	975		------	------	------		
6	5	42.2	350	1085	1015		------	------	------		UPSTREAM CROSSOVERR
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 8

Rapid Assessment Methodology for Instream Substrate Sampling[1]

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[1] Authors: S.E. Hogg and L. W. Stanfield

1.0 INTRODUCTION

This module describes techniques for conducting screening level assessments of substrate composition throughout an entire site. The techniques used are a cross between a traditional Rapid Assessment Methodology (RAM) and a standard survey approach in that crews use rapid assessment approaches to locate sampling points and then apply a standard approach to measure substrate composition. As such, this approach can generate an accurate assessment of the proportion and sizes of substrate particles throughout a site.

The point-transect approach used in this module improves repeatability over conventional non-point transect visual assessments (Hawkins *et al*. 1993, Stanfield and Jones 1998). While this methodology is defensible and variance can be quantified, data collected using this tool is vulnerable to sampler bias because the sample locations are selected visually. As such crews must be diligent about minimizing bias in both the location of observation points and in the selection of particles to be measured, if data are to be an accurate representation of the substrate composition of the site.

As these methods are vulnerable to sampler bias it is recommended that project leaders incorporate both a training strategy and a calibration exercise to quantify bias where sample sites are located in highly variable substrate conditions and/or where subtle biases have the potential to impact on study findings. Follow the procedures provided in S4.M1, Rapid Assessment Methodology for Channel Structure, if this is the case for your study. Finally, as most surveyors will also collect stream width and depth data while conducting these surveys, the methods described in other modules are also provided here and space is provided for these “optional” measurements on the field sheet.

This module is best applied in studies that have one of the following objectives:

- A study of fish habitat conditions for which substrate composition is a critical factor but resources are limited. In this instance crews will use the instream habitat measures described in S4.M1, Rapid Assessment Methodology for Channel Structure and supplement these measures with the more accurate evaluation of substrate composition provided by this module.
- To supplement other surveys of streams (e.g. geomorphology, hydrology, benthos) to provide accurate descriptions of substrate, but for which the minor bias associated with sample location is not considered important.

If more spatially explicit and unbiased results are required, a full point-transect method should be considered (S4.M2 - Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions). Further, the methodology is readily extended to include the bankfull channel by extending the transect or by collecting complementary data from the non-wetted channel area.

2.0 PRE-FIELD ACTIVITIES

A typical survey of a site should take between 10 to 20 minutes. A two-person crew is recommended for safety. Field surveys should follow a training program (see Appendix 1).

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1, Site Identification and Documentation)
- Equipment check

The following equipment is required:

1. RAM Substrate Field Forms on waterproof paper
2. Pencils
3. Metre stick and small ruler
4. Tape measure or hip chain
5. Maps

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

This module assesses the substrate and sediment transport characteristics of the site, within the context of the type of parent material available to the stream. In order to understand the relationship of parent substrate materials and bedload transport, measurements and comparisons are made between **maximum particle** and **point particle** sizes. Interpretation of the survey data is dependent on the type of stream channel being surveyed.

For sediment transport purposes, there are three types of channels commonly found in Ontario – bedrock, alluvial and detrital. Bedrock streams can either be erodible (shale) or not (granite). Alluvial streams have parent material of either fine (sand), medium (gravel), or coarse (cobble) particulate materials. Detrital streams ae typically of low gradient, have high volumes of wood and therefore low erosive power and store large volumes of detritus, commonly referred to as gavia feces. In these systems there is generally long periods of time between flows that modify the channel through bedload movement. As such it may be sufficient to simply walk the banks and apply a visually based rapid survey to record the amount of area occupied by gavia feces. If the entire site is detrital consider using the rapid assessment module (S1.M1 Rapid Assessment Methodology for Channel Structure).

Procedures outlined below include defining site boundaries, recording site information, and measurement of channel features, bank conditions and substrate.

3.1 Recording the Site Identification Information

The module should be done in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and S1.M2 - Screening Level Site Documentation or S1.M3 - Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available.

3.2 Defining the Site Boundaries

The site boundaries are defined as per S1.M1. If no accurate data on site length are available, record the approximate length of the site (±3 m). This is accomplished by either chaining up the centre of the stream (most accurate) or by pacing up the channel or the banks, depending on site conditions. Record the site length on the Site Identification Form, mark with an asterisk (*), if anything other than chaining was used to obtain this measurement, and include an explanation in the 'Comments' section indicating that the site length was estimated. On the RAM Substrate Field Form (Appendix 1), record the appropriate unique identifiers for the site (see S1.M1).

3.3 Setting up Transects and Observation Points

The number of transects required and the number of observation points per transect is determined by the minimum width of the site. If the stream is greater than 3 m wide throughout the site, use 10 transects and 6 observation points per transect; otherwise estimate the stream width at the narrowest location and refer to Table 1. Transects should be evenly spaced along the site.

Beginning at the first downstream transect, visually locate the appropriate number of observation points along the transect (Figure 1). Point substrate measurements are made directly below the observation point and maximum particle size measurements are made within a visualized estimated 30 cm ring centered on the observation point (referred to as the 'observation area').

Table 1: Relationship Between the Minimum Stream Width and the Number of Observation Points Required per Transect

Minimum Stream Width (m)	Number of Transects	Number of Observation Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.5	15	3
< 1.0	20	2

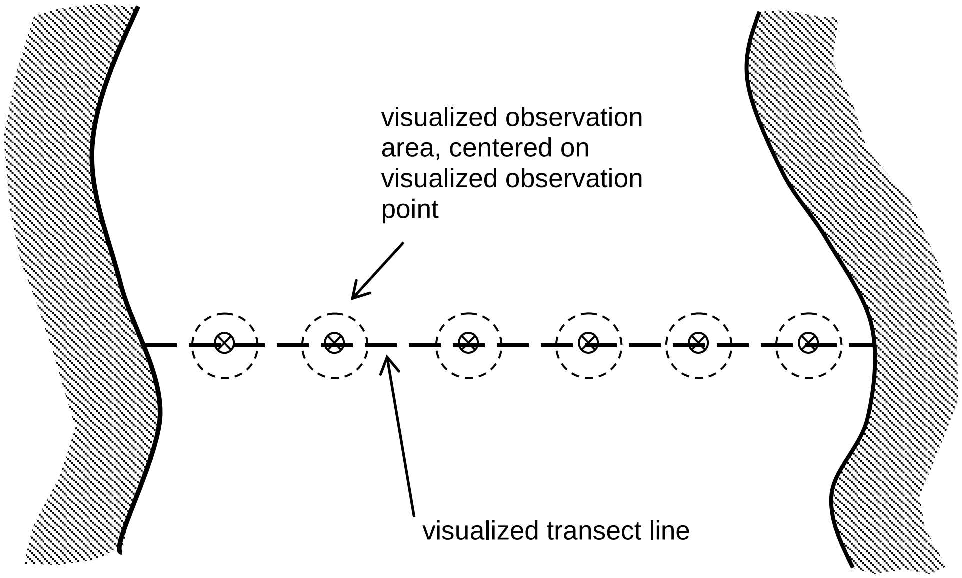

Figure 1: ‘Observation Areas’ (30 cm diameter) and Transect.

3.3.1 Substrate Measurements

At each observation point measure the size of the point particle and largest particle that is within or is touched by an imaginary circle that is centered on the observation point and has a diameter of 30 cm. If in doubt use your ruler to see if a particle is greater than 15 cm from the observation point. If the presence of a deep layer of organic material (gavia feces) prevents the stream bottom from being accessed, record the point and maximum particle sizes as having gavia feces (8888).

Dealing with Bedrock and Hardpan clay

If either bedrock or hardpan clay are picked as a point particle then the maximum particle would be the largest particle movable by the stream within the cover ring. Conversely, if particles are picked and hardpan clay or bedrock is present in the observation area, record the largest particles that are movable by the stream. It may be that no other materials are present, in which case bedrock or hardpan clay would be recorded for both measurements. In some bedrock and hardpan clay streams there will be a fine (opaque) layer of silt that has been trapped by algae or slime that covers the bedrock. Ignore this fine layer in the determination of substrate particle size.

3.3.1.1 Point Particle

At each of the visualized observation points, a substrate particle should be selected by looking away and extending an index finger until a substrate particle is touched. Measure the particle along its median axis (Figure 2); for very large particles measurements may be taken in the stream. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Rapid Assessment Methodology for Instream Substrate Form; otherwise record standard sizes found in Table 2 in dot tally format. Remove any undecomposed organic material (e.g. leaves, sticks), before making substrate measurements. Decomposed organic material should be classified as silt.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

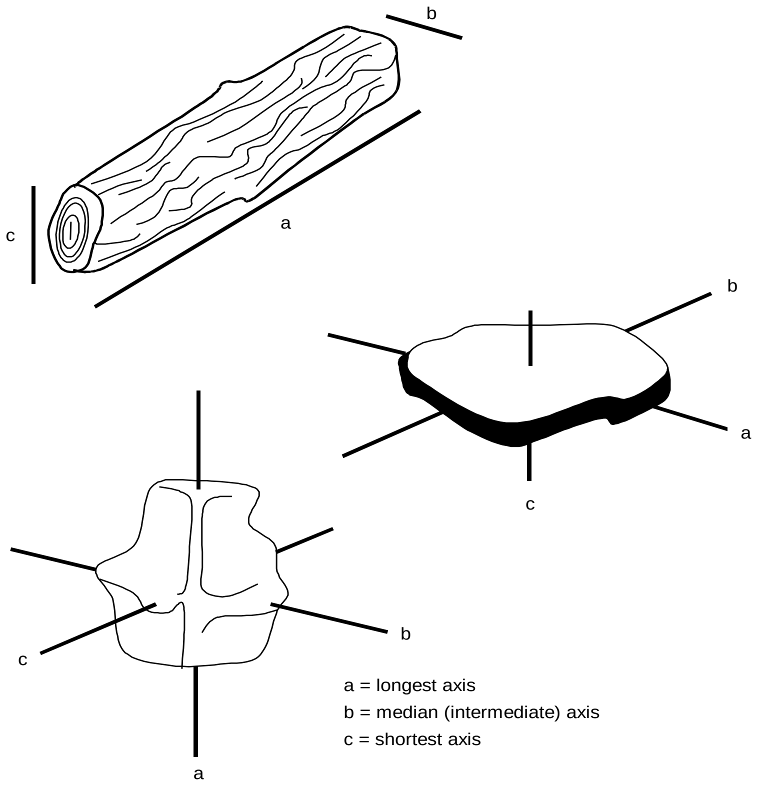

Figure 2: Measuring the Median Axis of Cover and Substrate.

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

3.3.1.2 Maximum Particle

Select the largest particle within the visualized observation area (i.e. 30 cm circular sampling area) and measure its width along the median axis following the same procedures described above.

Note: In some situations large boulder can extend across several observation points, being counted each time that it is appropriate.

Hint: If there is a mixture of smaller particles within the 30 cm ring, such as silt/sand or clay/silt, catalogue point particle size as the smaller particle size (e.g. silt (0.05)), and the maximum particle size as the largest particle size (e.g. sand (0.10)). This is to avoid biasing the sample.

Table 2: Substrate Descriptions and Size Categories.

Material	Description	Size to be Recorded
'Unconsolidated Clay'	Very hard packed when dry and sticky when wet	'0.01'
'Consolidated Clay'	Hard even when wet, slippery, gray in colour, often laminated	'0.011'
'Silt'	Feels soft like a powder or flour	'0.05'
'Sand'	Gritty, sizes >0.05 and < 2 mm	'0.10'
'Bedrock'	Exposed bedrock	'1111'
'Concrete'	Human made materials such as concrete or asphalt	'2222'
'Gavia feces'	Dense mat of floating detritus that generally fills the entire water column	'8888'
Measured particles	Between 2 mm and 1000 mm.	Median axis
'Large Boulders'	> 1000 mm but not attached to bedrock	'1001'

3.3.2 Wetted Width and Mean Water Depth

Measuring the 'Wetted Width' and the 'Mean Water Depth' provide supplementary data for interpreting the stream power at a site. These optional measurements are taken at the bottom of the site (i.e. at crossover point).

Measure and record the wetted width of the stream in the box marked 'Wetted Width (m)'. Measure and record to the nearest tenth of a metre. At the same crossover estimate the average water depth by either recording the depth in the middle of the channel, or by taking several measurements across the stream with a metre stick, or a wading rod and averaging them. Record the water depth to the nearest 5 mm (e.g. a water depth of 17 mm can be recorded as either 17 or 15 mm).

3.4 Tips for Applying this Module

Crews using this module should have experience with the point-transect methodology.
It is strongly recommended that crews be trained and have enough field experience to ensure repeatability.

Project managers should establish a training program for crews at the outset of the study and a follow-up assessment to ensure that data are acceptable (See S4.M1 Appendices 1 and 2).

Data should be recorded while proceeding up the stream and then summarized before leaving the site.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The impetus for the rapid assessment survey for substrate was Rachel Marten and earlier conversations with Cam Portt and John Parish.

6.0 LITERATURE CITED

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Stanfield, L. W. and M. L. Jones. 1998. A Comparison of Full-Station Visual and Transect-Based Methods of Conducting Habitat Surveys in Support of Habitat Suitability Index Models for Southern Ontario. North American Journal of Fisheries Management 18: 657-675.

Appendix 1

Example Rapid Assessment Methodology for Instream Substrate Field Form

Rapid Assessment Methodology for Instream Substrate Form

Stream Name WILMOT CREEK	Stream Code WM1	Site Code 3CDW	Sample 1	Date (yyyy/mm/dd) 2005/06/08

Wetted Width (m) 5.1	Mean Water Depth (mm) 55	Comments USED 12 TRANSECTS, 5 OBSERVATION POINTS EACH

Record standard substrate particles using a dot tally under the Standard Sizes section. Substrate particles ranging from 2mm – 100 mm must be measured along their median axis and recorded in the Measured Particles section.

Substrate Measurements

Standard Sizes

Material	**Description**	Count *(use box tally)*			
		Substrate Particles	Total	Maximum Particles	Total
Unconsolidated Clay	Very hard packed when dry and sticky when wet	☒ •	11	• •	2
Consolidated Clay	Hard even when wet, slippery, gray in colour, often laminated				
Silt	Feels soft like a powder or flour	☒	10		
Sand	Gritty, sizes >0.05 and less than <2mm	☒☒ • • • •	24	• •	2
Bedrock	Exposed Bedrock	•	1	• • •	3
Large Boulders	> 1000 mm but not attached to bedrock			•	1
Measured Particles	*Between 2mm and 1000 mm*	*Measure median axis and record under 'Measured Particles'*			

Measured Particles

Substrate Particles						Maximum Particles					
24	68	16	35	3	12	48	160	182	212	60	78
98	140	12	32	56	21	65	200	306	82	205	86
24	64					204	314	104	256	214	524
						54	68	251	356	125	137
						217	421	123	323	421	57
						98	84	76	124	185	201
						162	213	79	142	136	215
						46	82	304	145	62	97
						104	186	245	211		

Crew Leader S. SALAR	Crew J.J, S.B, H.K	Recorder H.K	Entered H.K.	Verified S.S.	Corrected H.K.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 9

Instream Crossing and Barrier Attribution[1]

TABLE OF CONTENTS

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[1] Authors: Stanfield, L. W., Kelsey, I., R. Sitch, and A. Skinner.

1.0 INTRODUCTION

Natural or man-made constrictions in streams create unique conditions that can affect flows, sediment transport and fish migration. Historically, Ontario's stream crossings and barriers have been inventoried by multiple agencies and the data have not always been collected consistently or been shared. Under the Lakes and Rivers Improvement Act (LRIA), the Ministry or Natural Resources (MNR) is responsible for the safe management of all dams in the province, and that they are operated in a manner which provides for environmental protection. Dam owners must seek LRIA approval from the MNR for any new dam construction, or for repairs, alterations, improvements or decommissioning of existing dams. The Land Information Ontario (LIO) Dam and Barrier, and the Provincial Dam Inventory (PDI) databases were developed to inventory dams greater than 1 metre in height to support the LRIA. Dams and Barriers is a point data class for use in a GIS with FIPPA compliant attributes and is available for free from LIO. The PDI is a tabular database.

This rapid assessment module is intended to augment the Dams and Barriers and PDI by providing a tool to inventory dams that are less than 1 metre in height as well as other potential barriers and sources of flow constriction that might affect fish and sediment passage. Since many of these constrictions will be associated with road and drainage infrastructure, the module incorporates a section on structure design and state of repair that is intended to assist in the identification of features that are at a higher risk of failure.

Types of features to be inventoried using this module includes:

- Road crossings such as culverts that do not span the width of the valley
- Natural barriers such as rock ledges, sluiceways or beaver dams
- Low head man-made barriers
- Tile outlets and from buried headwater drainage features
- Storm sewer outfalls
- Pond outlets and weirs
- Other features that constrict flows sufficiently to cause upstream ponding.

Features that restrict fish passage have the potential to fragment populations, but also can serve a beneficial role by protecting reaches from invasive species or non-desired competitive interactions. Understanding the role of fragmentation on biota requires a comprehensive understanding of barriers to fish migration in a watershed. Stream constrictions can indirectly affect fish by influencing water quality and habitat conditions within the stream. Impoundments in streams often cause sediment (both suspended and bed material) to be deposited upstream of the feature leading to silt build-up in the ponded area and sediment deprivation downstream. Sediment deprivation downstream of the feature causes an increased rate of stream bank erosion as the sediment-reduced water flowing past the barrier has more energy and scours the stream banks more quickly. This also leads to increased erosion of sediments in depositional areas of the lower stream reaches. Evidence of sediment deposition and scouring indicate a risk of failure (wash-out) of a man-made feature (culvert, bridge, etc.). As well as being costly and inconvenient, feature failures can have catastrophic effects on downstream habitats when large volumes of water and sediment are transported to these reaches.

The intent is to share this information among the multiple agencies responsible for managing these features in order to facilitate efficiencies in surveys and better decisions. The module builds on a recent initiative to develop a standardized protocol for sampling stream crossings on the US side of the Great Lakes (USFWS, 2011). This module does not evaluate detailed information on structure, ownership, liability or flow management. It is suggested that for this detailed information the PDI protocol developed by Water Resources Branch (reference) should be employed. Further, this module should not be considered as an authoritative evaluation of fish passage for specific species.

1.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people (a surveyor and a recorder). Survey time varies with the size and type of feature being evaluated but typically takes anywhere from 10 to 60 minutes to complete. Note, electronic survey equipment that make measurements of distances and gradient changes by one person feasible (e.g. range finders and high resolution GPS units) are becoming more popular and cost effective. If such equipment is available we encourage their use and remind surveyors to ensure data are recorded on the field sheets using the appropriate measurement scale.

Pre-field activities should include:

- A check for existing information to determine where on the river features are known or are likely to exist e.g. road crossings, historical surveys etc.
- Landowner contact for access if not on crown land
- Documentation of site access and appropriate stream identifiers (see Section 1)
- An equipment check
- Reviewing safety requirements

The following equipment is required:

1. Field form, OSAP module and clip board or electronic tablet device
2. Pencils
3. 2 Wooden metre sticks (metric on both sides)
4. 1 short (e.g. 12 inch) ruler
5. Clinometer or survey level

6. Tape measures (30 m or longer)
7. GPS unit
8. Camera and white board/pen
9. Polarized sun glasses
10. Waders

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone, etc.).

1.1 Sample Location Considerations

This module targets specific features where flows are constricted or impounded. A sample site evaluates one unit of stream that drains a distinct drainage area, even if it is braided within the valley. Note that where more than one stream segment outlet is in close proximity, each is treated as a distinct and unique sample site. Depending on the study objectives and landscape, project managers may choose to focus sampling to specific types of features or higher risk areas. For example, users might target:

- All road crossings in a watershed
- Areas of major changes in slope based on a topographic map or GIS
- Ponded areas
- Locations of known outlets or barriers based on infrastructure maps or file records

The module is designed to meet each of these needs and users are encouraged to document the study design considerations used to select sample locations by using the meta-data description module (S0.M1).

This module is complementary to and with minimal additional effort can enhance information on watershed condition when applied in concert with other protocols that are often applied as part of road crossing surveys. Savings occur because site description information, sketches and photos need only be taken once. This module aligns well with both the headwater drainage feature module (S4.M10) and the rapid assessment module for stream discharges and perched culverts (S4.M4).

2.0 FIELD PROCEDURES

This module can be applied at any time of year, provided the feature is visible (i.e. not buried in snow!) and conditions are safe for sampling. Within this module a sample site is a location on a stream network where flow is sufficiently constricted to create a visible difference in channel form between the up and downstream locations of the constriction. The site distance extends up and downstream of this location to at least one crossover in both the up and downstream directions. Where a pond exists, the upstream crossover is assumed to extend to at least the end of the pond.

Where multiple constrictions to flow exist (e.g. culverts) record the general characteristics for the features and then record the physical characteristics of all the features following the guidelines below and the identification guidelines described in Section 3.5.

2.1 Overview of Sampling Procedures

Once a feature has been located the crew will document the:

1. Site location
2. Responsible agent (if known) for the feature
3. Purpose of the feature and the materials it is made of
4. Length and width of each feature
5. Number of drops to the active stream
6. Depth of the plunge to stream bottom of the feature
7. Jumping height and jumping distance for fish
8. Characteristics that influence whether a fish could swim through or across a feature (e.g. water depth, velocity and feature slope
9. Condition of the feature and
10. Evidence of erosion

2.2 Site location Documentation

At each sample site, fill out the site descriptors (e.g. 'Stream Name', 'Stream Code', 'Site Code', and 'Date') and if appropriate the 'alternate site code(s)'. Also record the names of the 'Crew members'. Practitioners are reminded to apply the most appropriate naming convention for site codes as described in S1.M1 (Defining Site Boundaries and key Identifiers) in order to optimize data sharing (see text box below).

Record the Universal Transverse Mercator (UTM) coordinates as determined from either a GIS or using a Global Positioning System (GPS) according to S1.M2. Ensure that the datum is NAD83 and record the 'Zone' 'Easting' and 'Northing'. For more details and other options for recording geo-coordinates see S1.M2 (Screening Level Site Documentation).

Hierarchy of Site Code Naming Conventions

1. Use the primary Site Code identified in FWIS (http://comap.ca/fwis) where available,
2. Where no primary site code exists but a local waterbody identifier code exists, apply this as the primary site code,
3. Document any additional location identifiers (agency site codes, water crossing identifiers etc.,) in the alternate site code field.

Take photos of the downstream looking up, upstream looking down (if feasible) and any structural issues observed. Try to capture the full constriction and plunge, if present, and for the upstream picture try to capture the extent of pooling. Place a white board somewhere visible in the photo without obstructing the view of the site. Label the white board with site code and date. Record a photo number under “Photo #” and any additional information about the photo (e.g. upstream vs. downstream, etc.) under ‘Photo Name’. It is a good practice to rename the files after downloading the pictures to correspond to the site name and description (e.g. streamcodesitenameup or streamcodesitenamedn for the up and downstream photos).

Describe the location of the site such that future users will be able to validate the location recorded using geo-coordinates and possibly drive to the site in the site Descriptions/Access Route following the guidelines provided in S1.M3. Record the street name, emergency access number (if available) of the nearest dwelling, and the approximate distance to the next major intersection. At the bottom of the field sheet, record the crew leader’s initial and last name, the crew member’s initials, and the recorder’s initials.

2.2.1 Feature Responsibility

Since a common objective of flow constriction feature studies will be to mitigate priority impacts or to ensure longevity of features where favorable effects occur, it is useful to document the responsible agent for each feature. It is not the intent of this protocol to be a comprehensive tool for addressing the issues around barrier management. Therefore for the purposes of this protocol crews are simply asked to classify the ownership/responsibility of the barrier as best they can under the categories listed in Table 1. If additional information about the owner of a feature is required by a user of this protocol, then we recommend that a separate form be filled out by the field crews. This private information will not be stored in the FWIS database.

Table 1: Codes and descriptions for responsible agents for each feature

Responsible Agent Code	Category	Descriptions
1	Municipality	Municipal road allowances and operated lands (e.g. parks)
2	Crown	located on provincially managed lands
3	Conservation Authority	
4	Private	Private landowner
5	Commercial	Incorporated entity including farms, businesses
6	Federal	Federal government, e.g. Parks Canada
7	First Nations	On First Nations land
8	Other	record in comments
9	Unknown	Cannot determine without deed search

2.2.2 Feature Purpose

Understanding the purpose of a feature and what service it supports provides perspective on its importance to meeting societal needs on the landscape. Classify the service that a feature provides based on the categories provided in Table 2.

Table 2: Codes, definitions and descriptions for purposes of features

Feature Purpose Code	Definition	Descriptions
1	Road Conveyance	The passage of water under a roadway
2	Storage for wildlife	Whether a beaver pond or a wetland complex the backwater provides habitat for wildlife
3	Industrial Storage	Includes water for use in mining, gravel washing, pulp and paper etc.,
4	Water power	storage for hydro power use in turbines
5	Irrigation storage	Agriculture, golf courses, etc.
6	Mill use	Water used or historically used to power a mill
7	Fish barrier	A barrier to migratory fish passage
8	Storm water pond outlet	Peak flow mitigation and low flow augmentation through storm water ponds
9	Field drainage	Tile drains and other features that collect and concentrate flows through a pipe
10	Entombed outlet	The outlet of an entombed (buried) stream including storm water outlets that do not pass through ponds
11	Other	Record the purpose in comments
12	Unknown	Could not determine

2.2.3 Constriction Type

There are many types of features that either purposely or naturally constrict flows. Record the type of feature that best reflects the one located at each site following the definitions provided in Table 3.

Table 3: Codes, definitions and descriptions for types of features

Constriction Type Code	Definition	Descriptions
1	Culvert	Smooth, round or oval structures that fully engulf the stream
2	Tile	A perforated pipe that collects water through holes in the material and discharges it to an outlet
3	Arch	A “∩” shaped structure that has an open bottom to facilitate substrate movement
4	Constructed Dam/weir	Constructed feature with a wall to restrict flow and sediment movement. Materials differentiate types
5	Rock Shelf	A natural slowly erodible rock shelf that creates a change in bed height up and downstream of a nick point (local change in slope).
6	Gorge/Cascade	A narrowing of the valley walls that creates a funnel through which the stream flows
7	Bridge Abutments	Bridges that contain vertical structures located within the stream channel that constrict flows
8	Ford	A low water crossing for vehicles, typically the stream bed is augmented with materials (e.g. gravel, rocks or rubberized beds) to help support vehicles.
9	Other	Record in comments

2.2.4 Type of Feature Materials

The materials that features are made of vary greatly and influence their stability and longevity. Record the type of material that makes up the feature using the definitions provided in Table 4. Note that two types of material can be recorded as a means of identifying features made with more complex materials (example an earthen dam with a steel front)

2.2.1 Outlet Flow Types

Depending on the type of feature and its purpose, the configuration of the outlet will vary. The configuration influences the flows from the outlet in ways that affect fish attraction and hydraulics that assist fish in migration and in sediment movement. For example, overflow lips that pass equal amounts of water across the feature purposely do not concentrate flows in any one area, while culverts and other rounded outlets tend to concentrate flows to a central point (Figure 1). Indicate and record the flow outlet form for the feature as defined in Table 5.

Table 4: Codes, definitions and descriptions for materials that make up the features

Feature Material Code	Definition	Descriptions
1	Corrugated steel	Waved steel, typically used in culverts
2	Mud and sticks	As in a beaver dam
3	Natural rock	Bedrock or eroded rock material (rocks, boulders, etc.)
4	Sheet steel	Smooth material as in sheets used in piling or as beams
5	Concrete	Poured concrete with no reinforced steel
6	Gabion and rock	Steel wire baskets filled with rock
7	Reinforced concrete	Poured concrete with reinforced steel
8	Earthen fill	Mixed materials consisting of soil and rock material
9	Masonry	Shaped inlaid stones, brick or concrete blocks that may or may not be joined by mortar.
10	Plastic or other flexible material	Typically smooth and associated with tiles and other features that transport water
11	Other	Describe in comments

Table 5: Codes, definitions and descriptions for outlet form type

Outlet Flow Form Code	Definition	Descriptions
1	Stream grade	The feature is set such that it is embedded in the stream and there is minimal difference in flow types and bed materials within and immediately downstream of the feature.
1	Concentrated Pore Point	Water passes over the rim of a feature that is curved in such a way that flows are concentrated in the central part of the outlet (e.g. round culverts, notched spillways and chutes).
2	Partial Diffuser	Flows are concentrated to a < half the width of the feature and at least low flows and concentrated to a horizontal lip that passes downstream. These features can be natural as in Figure 1c or can be a bi-pass feature of dams made of boards or other stop logs.
3	Diffuser	Water flows or will flow, over the lip of a feature that has mostly uniform depth across > half the width of the stream such that flows are diffused (e.g. a bedrock shelf, or dam or dam.
4	Other	Describe in comments

Figure 1 - Outlet Flow Types: a. stream grade, b. concentrated, c. partial diffuser, d. diffuser

2.2.2 Outlet Drop Type

The nature of the way that water outlets a feature greatly influences its pass-ability for fish (Figure 2). This attribute documents the nature of the outlet that receives the water once it passes the "lip of the feature (e.g. edge of culvert, top of dam etc.). Select the code from Table 6 that best represents the nature of what water hits once it passes the lip of the feature as it proceeds downstream.

Table 6: Codes, definitions and descriptions of the feature outlet drop type

Drop Type Code	Definition	Descriptions
1	Stream grade	There is no difference in the elevation of the stream bed within and outside a feature. E.g. the bottom of a feature is at or below the downstream stream bed (Figure 2c)
2	Rip-rap	Water from the feature outlets onto rip-rap before moving downstream (Figure 2a)
3	Apron	Water drops onto a concrete (Figure 2b) or natural (Figure 1c) smooth apron before moving downstream.
4	Pool drop	There is a drop in elevation at the outlet and water hits a deeper part of the stream that is the result of stream bed scouring (e.g. Figure 1b, 1d)

5	Chute	Bed elevation is similar but there is a strong velocity gradient at the outlet that is the result of water being forced through a physical constriction. (e.g. Figure 1a)
6	Other	Describe in comments

Figure 2: Example of outlet drop types: a. rip rap, b. apron, c. stream grade

2.2.7 Substrate in the bottom of the water transport channel

The type of material within the water transport areas of the feature provide information about both the types of bed load material being passed by the feature and whether there are likely to be velocity breaks that might enable fish passage. Record the dominant material type found within the area of the feature that would typically transport water using the codes in Table 7.

Table 7: Codes, definitions and descriptions of the dominant substrate type found within the features water transport areas.

Substrate Type Code	Definition	Descriptions “The most common substrate type by area is”
1	None	Less than 10% of the water transport area is covered with any substrate and is therefore smooth
2	Silt or Clay	< 0.06 mm median diameter and feels smooth to the touch
3	Sand	> 0.06 and < 2 mm median diameter
4	Gravel	> 2 and < 65 mm median diameter
5	Cobble	> 65 and < 250 mm median diameter
6	Boulders	> 250 mm median diameter
7	Bedrock	Exposed bedrock

2.2.8 Number of Drops

Some dams/barriers such as older gabion-style structures consist of many drops instead of a single drop (e.g. Figure 2b has two drops and Figure 1c has at least 2 drops). A drop is a solid structure that creates a water fall across a river that has air pockets between the fall and the structure. Record the number of drops or steps from the structure crest to the plunge pool.

2.2.9 Presence of Human Grates and Beaver Cones

Many pipes and culverts are covered by security grates on either end of a feature to restrict access from humans or at upstream to prevent large logs etc., from entering the pipe. Such grates can also impact on fish and animal use of the feature for migrating. Similarly, beaver cones are used to reduce the effect of beaver activity at culverts in areas where beavers are problematic. These are placed on the upstream side of culverts. Record whether no grate or cone is present (0), or whether a human grate (1) or a beaver cone (2) is present on the field sheet in the box titled “Grate”.

2.3 Physical Dimensions of the Feature

The dimensions of a feature are a reflection of the capacity of the river in which it operates and the engineering that created the feature. These physical characteristics directly influence its ability to pass water, sediment and fish that will vary under low and high flow conditions. In the following sections crews will document the width, height of each feature at the low and bankfull flow levels. The depth of any plunge will be recorded as well as the dimension of any potential jumping pool that might facilitate fish jumping. Record the slope and length of the feature along which fish would be required to travel as a means of evaluating the passability of the feature to fish at other flow levels. All width and length measurements are in metres (m) and all depth measurements are in millimetres (mm).

2.3.1 Perched Height

At the outlet or tightest point of constriction of the feature, place a metre stick vertically on the stream bed and measure the height to the lowest or deepest part of the “crest” of a feature (Figure 3). The crest may be the bed of a culvert or dam or it may be the bottom of a pipe. Some features may have a terraced, U, or V shaped crest. The measurement is made to the deepest location (e.g. the bottom of the V) on the crest. Where the feature is perched above the stream, the measurement is synonymous with a measured “perched height” from other OSAP modules (see S4.M4 - Rapid Assessment Surveys for Discharge and Perched Culverts). Where there is a lateral distance between the stream bed and crest, a second ruler or stick can be used to help with the measurement (Figure 4). The measurement is made regardless of water presence. Measure the height to the nearest 5 mm.

Figure 3: Measuring perched height and jumping height

If the feature is dry, only record the perched height. Record these measurements to the nearest 5 mm.

2.3.2 Jumping Height:

The jumping height is the distance from the lowest part of the culvert (its center) to the water surface (Figure 3). Record this as the 'Jumping Height' (mm).

2.3.3 Jumping Distance:

Measure the distance from the furthest upstream location of the **hydraulic jump** to the crest of the feature (see box below). Surveys conducted under low flow conditions will necessitate that crews infer the location of the hydraulic jump based on the depth and configuration of the stream bed below the feature. There will often be a sorting of bed materials and a change in depth at the hydraulic jump. Use these criteria to identify the location where a fish would emerge from the stream as the jumping distance. Where the feature empties onto diffuse materials such as rip rap or boulders chose the location with the deepest plunge pool to make this measurement, as fish would likely prefer to jump from this location first (see Figure 2a). Measure the distance from the hydraulic jump to the top of the feature (Figure 4b) to the nearest 0.1 m.

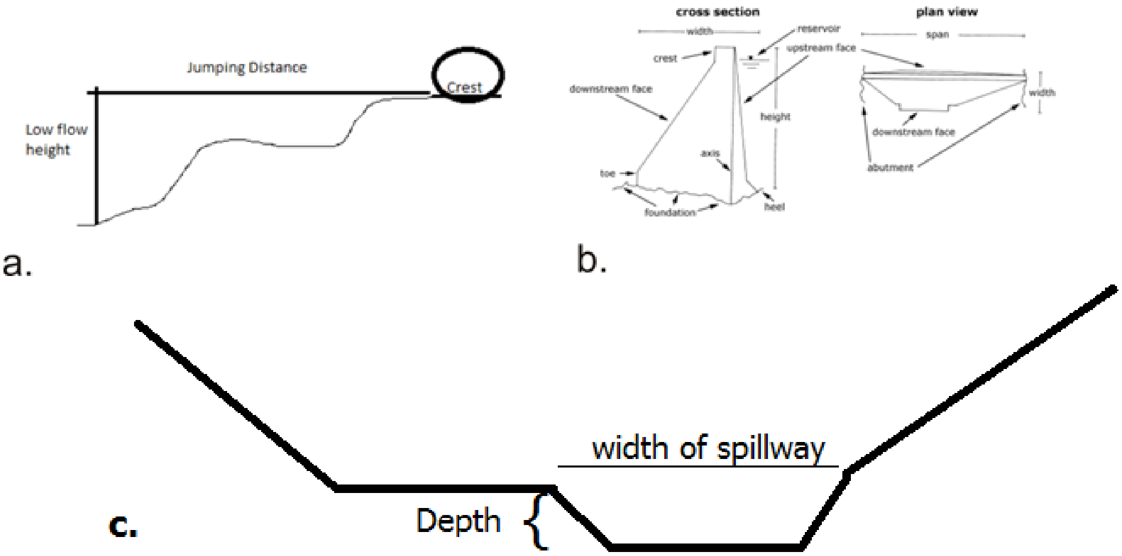


Figure 4: Measuring low flow height at terraced features: a. feature with an irregular spill pad (e.g. boulders), b. dam with a concrete spill pad. The width in the cross secton of figure b. approximates the jumping distance. Note the notched crest on the plan view of figure b identified as the 'downstream face' and the spillway in figure c indicate where feature width would be measured for all features that pass water through a trough. The feature depth is the height of the crest or spillway. ***Source of figure b:http://simscience.org/cracks/advanced/grav_anat1.html***

Hydraulic Jump

A hydraulic jump is generated when high velocity water meets lower velocity water forcing the water into a circular flow that creates a boil on the downstream side of the feature. Fish use the upward motion of the flow to propel themselves upward in an effort to clear the source of the jump (Figure 5a). For a fish to successfully clear the feature the location of the hydraulic jump must be a sufficient distance from the top of the feature. The point of measurement for the hydraulic jump is the exit point of the upward flow of water, which is also the forward location of the boil (see Figure 5b).

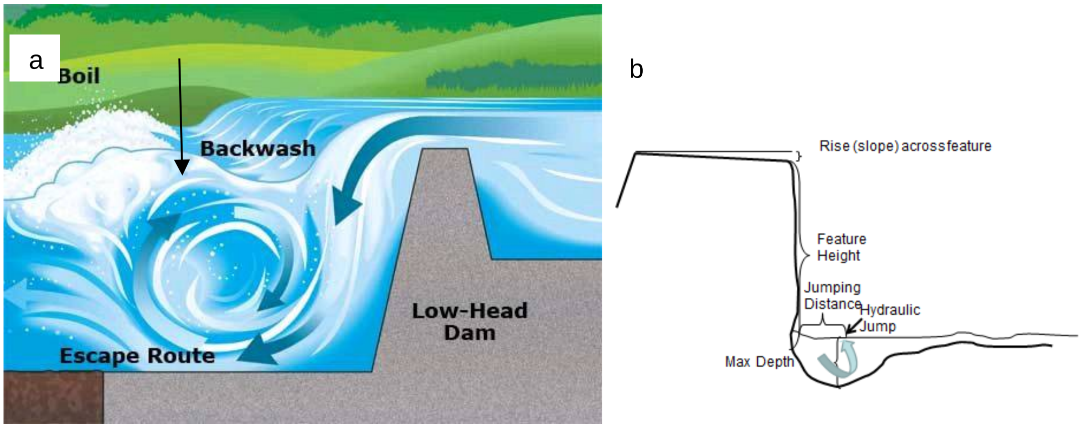


Figure 5: Identification of a hydaulic jump (a) and the location of where to make physical measurements of a feature (b). The insertion point of the arrows indicates the location where the hydraulic jump emerges in both figures.

2.3.4 Feature/Culvert Width and Depth:

The width and depth of the feature through which the constricted flows pass under low flow conditions is recorded. For features that are wider than the river, this will be the width and depth to the crest of the spillway (see Figure 4b). This will be the maximum width of a culvert. Measure this width to the nearest 0.05 m. For example an 18 inch diameter culvert is recorded as: 0.48 m in the Feature/culvert box for width (see Appendix I)..

2.3.5 Water Passage Length:

Assuming an animal can access the crest of a feature, the animal would need to move upstream until the end of the constriction, or where velocities again decrease. Where feasible, record the length of the constricted flows (e.g. culvert length). Lengths will vary with each type of feature, but as a guideline one can expect the following:

- 2 lane road: 9 m
- 4 lane road: 18 m

Record feature water passage lengths to the nearest m.

2.3.6 Water Passage Slope:

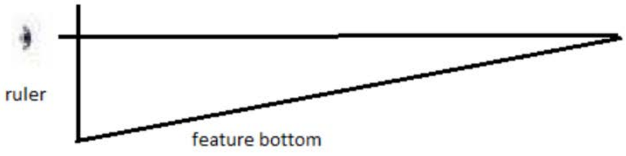
The slope of the area will directly affect velocities through the constricted area of flow. Slope can be estimated based on the water passage length and the change in elevation along the feature. Change in elevation can be measured using, in order of accuracy: a survey level, laser level, clinometer, or by eye (visual). Project managers must decide the degree of accuracy required for this module and crews must record the method used using the codes defined in Table 8. Most surveyors will employ either the visual or clinometer method for this rapid assessment module.

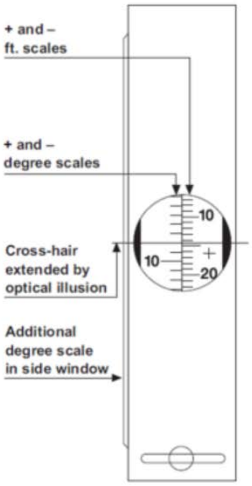
Table 8: Slope Measurement Method Codes

Passage Slope Method Code	Method Used
1	Visual
2	Clinometer
3	Laser Level
4	Survey Level
5	Other

To measure longitudinal slope use a ruler focus a parallel line to the end of the feature. Use a second ruler to measure the height from the downstream side to the point where the measurement is level with the end of the feature. Measure the vertical height to this location (Figure 6) and record the **difference in mm to the nearest 5 mm** under “Passage Rise”.

Alternatively, and especially for road crossings, use a clinometer. With this approach, two surveyors stand side by side and the surveyor with the clinometer (who will be downstream) finds a focal point on the second surveyor that is at a comparable height with their eye (e.g. second surveyor's nose). Following this, the surveyor holding the clinometer lines the clinometer with the focal point on the upstream second surveyor and reads the difference in elevation i**n degrees** from the clinometer (Figure 6). Be sure to record the **degree** change value (the one on the left in most clinometers). Other options for surveyors that require more accurate measures of slope (e.g. surveyor rod and laser level) are provided in module S4 M7 – Measuring Stream Slope. When applied at culverts surveyors can stand on either the bottom lip or top of the culvert depending on which is exposed and intact (i.e. not crushed) to make this measurement. Record the observed ‘Rise’ values and the method applied (‘Rise Mt’), to ensure the correct units are stored in the database (i.e. mm or degrees).





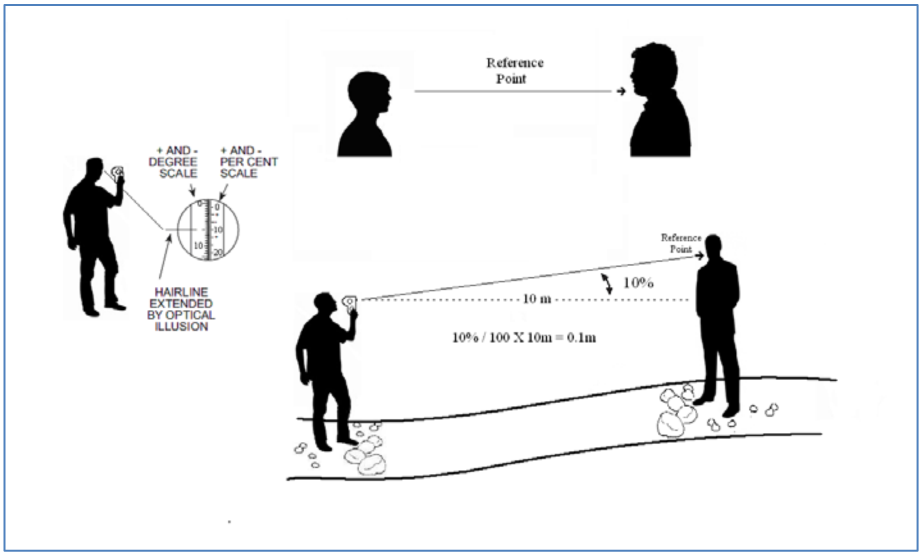


Figure 6: Using a clinometer to measure slope. Note the clinometer reading here indicates a difference in elevation of 8º and 5º in the upper and lower examples respectively.

2.3.7 Water Passage Velocity and Depth:

Where flows exist at a feature the existing velocity and depth provide an indicator of the likelihood that a fish could pass the feature. Place a metre stick (or smaller ruler) parallel to flow at the deepest point in the feature and measure the depth of water. Turn the ruler to be at right angles to the flow and measure the hydraulic head (Figure 7). Record both numbers to the nearest 5 mm in the “feature depth” and “HH” boxes.

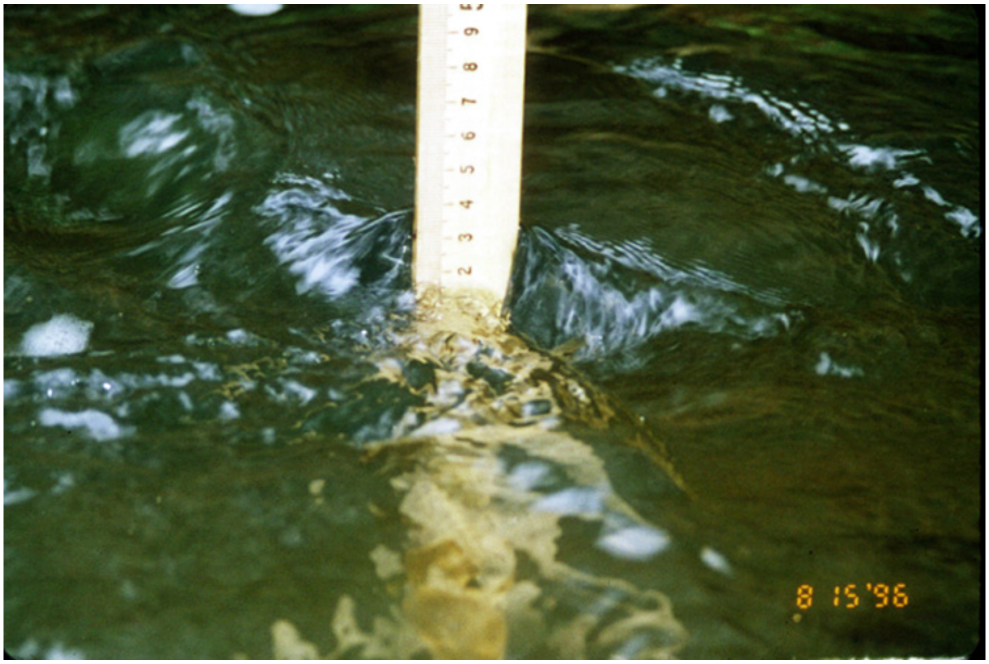


Figure 7: Hydraulic Head Measurement.

The upstream reading is measured as 35 mm, the downstream as 16 mm; therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

2.3.8 Plunge Pool Measurements

Plunge pool information is important to assist in determining whether a feature is passable to fishes. In addition to the water depth at the exit point of the plunge pool that can be calculated by subtracting plunge height from jumping height in the database, the maximum pool depth available to fish effects the size and type of fish that might be able to migrate past the feature. On the downstream side of a feature, record the maximum depth of the first pool located downstream of the feature. Measure and record this in the box titled “Max Pool Depth” to the nearest 5 mm.

2.3.9 Storage and Plunge Pool Width Measurements

With many constrictions in flow a head-pond is created that acts as a deposition area for substrate. To evaluate the degree to which flows are impeded by the constriction a comparison is made between up and downstream storage widths. Record the maximum storage width observed in the feature prior to the first upstream crossover (Figure 9). Where there is a head-pond or wetland, it is unlikely that crews will be able to physically measure the storage width upstream of the feature. In this instance, since the measurement compares the magnitude in the differences between the up and downstream areas, the measures can be made with a range finder, visually or with a GIS. Record the Storage Width:Upstream to the nearest 0.5 m.

Make the same measurement downstream of the feature by determining the widest part of the channel in the area immediately below the feature and prior to the first downstream crossover and record this in the Storage Width: Downstream field. Note the measures are accurate to within 1 m although tenths of a meter are provided to accommodate very small streams.

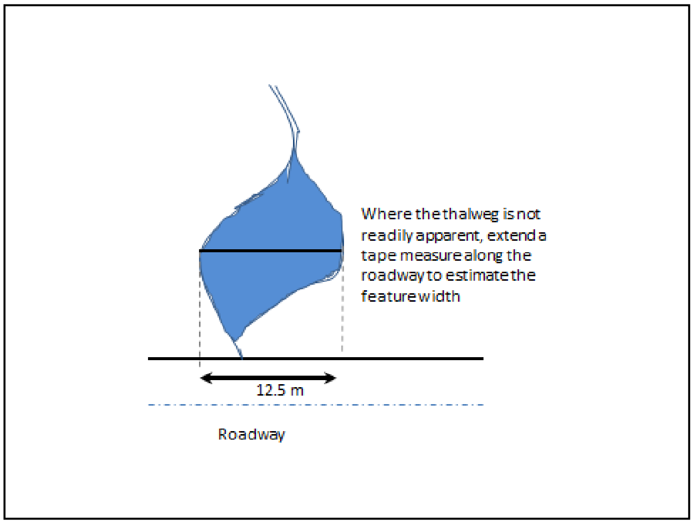


Figure 9 - Measuring the width of the head-pond at a barrier

2.4 Inventorying multiple features associated with a single stream segment

Where multiple features exist at a constriction (e.g. multiple culverts, outflows etc.), begin at the furthest left feature while facing upstream and document the physical characteristics of each constriction following the guidelines described above (see example field sheet).

Apply the directions for documenting the feature physical properties to each of the features individually, numbering them always following a **left** to **right** principle as defined while looking upstream (Figure 8). If more than four features are present at a site, use a second field sheet ensuring the unique identifiers (Stream Code, Site Code and date) are recorded on the header to link the data. This information will be manually entered into the database.

Figure 8 - Twin perched "PVC" culverts. Note: culvert 1 has a short jumping distance (approx. 50 mm) while culvert 2 has a longer (approx. 250 mm) jumping distance.

3.0 INFRASTRUCTURE STATE

Manmade structures require maintenance to function and crews can qualitatively assess the general state of repair of these features and provide photographs that once shared can help agencies identify priorities for infrastructure work. This qualitative description is not meant to be an assessment of structural condition of the feature.

3.1 Triage Feature Condition

Surveyors can offer initial insights into the general state of a feature relative to its vulnerability to failure. This is not intended to provide an assessment of the engineering state of a feature. Rather, surveyors are requested to simply document any obvious concerns that might affect the ability of the feature to pass fish or provide a source of sediment to downstream reaches as a result of erosion/failure. Select the code that most effectively defines the state of the feature from a structural perspective following the criteria provided in Table 9. In some situations the feature will obviously be in imminent danger of failure, usually as a result of several factors. Classify these features as category 88 and inform the responsible agency ASAP.

Table 9: Condition Categories for Infrastructure with respect to water passage

Condition Code	State	Definition
1	No evidence	no evidence of damage to a feature or a build-up of materials that might block flows and result in failure
2	Minor evidence	Minor evidence of aging (e.g. rust, fraying of sides etc.), but no major issues observable that might suggest imminent failure of the feature.
3	Plugged	A substantial loss (> 10%) of water passage capacity is lost due to the deposition of material in the feature.
4	Crushed	Manmade structures are prone to becoming crushed by vehicles or during high flow events.
5	Perforated	Features often become perforated providing access by water to the bermed material with the possibility of erosion from this source. (e.g. rust holes through culverts, pierced dams)
6	Unknown	Cannot effectively assess
88	Imminent failure likely	Evidence of multiple issues that could lead to imminent failure of the feature in the near future.

For culverts, estimate the percent of the area of exposed material that shows signs of rust, recording this number as an average for both ends of the feature in the ‘Culvert % Rust’ box.

If evidence of deposition or “plugging” is present (Figure 10), measure the depth of the material (mm) and record in the field plug_depth. Plugging does not apply to culverts and bridges that are purposely embedded in a stream so as to allow natural substrate and flow conditions to occur (see Figure 1a for an example). There must be evidence of flow blockage for a feature to be considered ‘plugged’.

For crushed features record the width of the remaining opening (mm) where water must pass. If more than one issue is identified add the codes for all issues observed and record the number in the “Feature Condition” field. For example if a culvert is both plugged and perforated, record an “8” in the box (3+5).

Figure 10 - Plugging of a corrugated feature that greatly reduces the flow capacity.

3.2 Evidence of Erosion within or around a constriction feature

Where a constriction occurs in erodible materials, erosion to either the up or downstream walls may be present that make the feature vulnerable to failure via a “washout” (Figure 11). Document the presence and extent of erosion observed in both the up and downstream banks associated with the feature using the codes in Table 10. Note localized erosion caused by human access is not considered here, although this type of erosion can exacerbate natural conditions.

Table 10: Evidence of erosion codes. To be applied to the upstream and downstream areas.

Erosion or deposition Code	State	Definition
1	None to minimal	No or little evidence of erosion or deposition
2	Moderate erosion	localized evidence of erosion, but does not immediately threaten the structure
3	Extreme erosion	Extensive down-cutting or back-cutting that threatens the long-term viability of the feature
4	Unknown/not applicable	Cannot or inappropriate to assess

F

Figure 11. Examples of extreme erosion due to both down-cutting and back-cutting

3.3 Photographs and Sketches of Feature

To augment the information assembled on the feature, a photograph and sketch should be collected and made available. If all the required information for this project is already available for a particular feature, a field trip to take a photograph of the feature site will be left to the discretion of the surveyor.

3.4 Tips for Applying this Module

If sampling near road crossings, look for numbered tags (typically placed at the top of rebar) in proximity to culverts that provide local identification identifiers that can be applied as either a primary or alternate site code identifier.

If working near any infrastructure on a stream such as a bridge or dam, look for any identification codes/numbers that identify the feature and can be used as a site code and a possible station marker (see S1.M3).

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to share provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The stream crossing and barrier attribution module is a true result of a collaborative effort with several individuals contributing significantly to its development; including: Dave Cote, John Hanna, Ian Kelsey, Michael Kuluski, Audie Skinner, Ryan Sitch and Paul Staples.

6.0 LITERATURE CITED

CO/MNR. 2007. CA Dam Inventory Project Technical Guidance Document. Version 1.4, 22p.

USFWS 2011. Great lakes road stream crossing inventory instructions. A joint publication of the U.S. Forest Service, U.S. Fish & Wildlife Service, Michigan DNR, Wisconsin DNR, Huron Pines, Conservation Resource Alliance, Michigan Technological University. http://conserveonline.org/workspaces/streamconnect/documents/map-and-assess-potential-barriers

Appendix 1

Example Instream Barrier Field Form

Stream Crossing and Barrier Attribution

Stream Code HB1

Site Code HB357

Zone 17

Easting 643427

Northing 4865382

Date (y y y m m d d) **2** 0 1 6 0 5 2 8

Time (24 hr) Hr : min 1 0 2 5

Stream Name HUMBER RIVER

Alternate Site Code(s) YR132

Access Route
200 M NORHT OF HWY 7, 60 M EAST OF SAND ROAD
ROAD CROSSING

Site Description
TRAIL ON EAST SITE OF CROSSING

Optional Measurements

Water Temp C	Air Temp C	pH	Conductivity (Ns)	Turbidity (NTV)	Dissolved O_2 (mg/l)C
12	18	7.1	850	——	——

Number of Features 2

Photo #	Photo Name
102	HB357_DSTRLUP
103	HB357_UPSTLDN

					Outlet							Water in Feature/Culvert			Feature/Culvert								
	Respon-sible Agency	Pur-pose	Feat. Type	Mater-ials	Flow Type	Drop Type	# Drops	Subst-rate	Perch Ht. (mm)	Jump Ht. (mm)	Max Pool Depth (mm)	Depth (mm)	Width (m)	HH (mm)	Width (m)	Depth (mm)	Feature Length (m)	Jump Dist. (m)	Rise MT	Rise (mm or º)	Plug Depth (mm)	Feat. Cond.[1]	Culverts % Rust
1	2	1	1	3	2	1	1	3	0	0	15	5	0.15	0	0.46	450	9	0	2	3	255	7	30
2	2	1	1	3	1	4	1	1	250	220	300	10	0.20	15	0.46	450	9	0.3	2	3	0	1	10
3																							
4																							

Perch height: depth from stream bed to lip of feature;
Jumping height: depth from water surface to lip of feature

Note 1: Record the additive values of feature condition for categories 3, 4 and 5.

Comments
CULVERT 1 APPEARS TO HAVE BEEN DAMAGED BY A VEHICLE COLLISION

Erosion Amount 2

Erosion Categories
1. *Minimal*
2. *Moderate*
3. *Extreme*
4. *Can't assess*

Grate/ Cone 0

No =0
Human = 1
Beaver = 2

Storage Width *(m)*

Upstream	Downstream
3.5	2.2

Crew Leader (initial & last name) A DUMBRILLE

Crew Initials SR, HD, JM

Recorder RD

Responsible Agent

1. Municipality - e.g., road allowances
2. Crown: located on provincially managed lands
3. Conservation Authority
4. Private landowner - non-commercial
5. Commercial- including farms, businesses
6. Federal government, e.g., Parks Canada
7. First Nations
8. Other, record in comments
9. Unknown

Main Purpose

1. Road Conveyance
2. Storage for wildlife
3. Industrial Storage
4. Water power
5. Irrigation Storage
6. Mill use
7. Fish barrier
8. Flow mitigation
9. Field drainage
10. Entombed outlet
11. Other
12. Unknown

Constriction Type

1. Culvert
2. Tile
3. Arch
4. Constructed Dam/weir
5. Rock shelf
6. Gorge/cascade
7. Bridge abutments
8. Ford - instream crossing
9. Other

Feature Material

1. Corrugated Steel
2. Mud and sticks
3. Natural rock
4. Sheet steel
5. Concrete
6. Gabion and rock boulders
7. Reinforced Concrete
8. Earthen Fill
9. Masonry/inlaid stones
10. Plastic or other flexible material
11. Other Describe in comments

Outlet Flow Type

1. Stream Grade – minimal difference in bed elevation
2. Concentrated pore point (e.g., culvert, spillway
3. Partial Diffuser –reduced width flat overflow
4. Diffuser- uniform depth across > half width of stream
5. Other

Outlet Drop Type

1. Stream grade
2. Rip-rap
3. Apron
4. Pool - water drops into pool
5. Chute - strong velocity gradient
6. Other

Dominant substrate in feature

1. None
2. Silt or clay (smooth)
3. Sand (> .06-2 mm)
4. Gravel (2-65 mm)
5. Cobble (65-250 mm)
6. Boulders (>250 mm)
7. Bedrock

Slope measurement method

1. Visual
2. Clinometer
3. Lazer level
4. Survey level
5. Other

Standard Width Conversions	
10”	25 cm
12”	30 cm
18”	46 cm
24”	60 cm
36”	91
48” – 4’	122
60” – 5’	152
72” – 6’	182
84” – 7’	213
96” – 8’	244

Feature Condition Categories

1. No Evidence of issues - no evidence of damage
2. Minor Evidence of issues - example surface rust
3. Plugged - part or all of the feature infilled
4. Crushed – some part is crumpled
5. Perforated – rusted holes and other escapes for water
6. Unknown

Erosion Codes

1. None or minimal
2. Moderate - feature integrity not immediately threatened
3. Extreme - feature integrity threatened
4. Unknown - can’t effectively assess

Responsible Agent
1. Municipality - e.g., road allowances
2. Crown: located on provincially managed lands
3. Conservation Authority
4. Private landowner - non-commercial
5.Commercial- including farms, businesses
6. Federal government, e.g., Parks Canada
7. First Nations
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9. Unknown

Main Purpose
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1. Stream Grade – minimal difference in bed elevation
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5. Other

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1. Stream grade
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4. Pool - water drops into pool
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Feature Condition Categories
1. No Evidence of issues - no evidence of damage
2.Minor Evidence of issues - example surface rust
3. Plugged - part or all of the feature infilled
4. Crushed – some part is crumpled
5. Perforated – rusted holes and other escapes for water
6. Unknown
88. Imminent Failure Likely

Erosion Codes
1. None or minimal
2. Moderate - feature integrity not immediately threatened
3. Extreme - feature integrity threatened
4. Unknown - can’t effectively assess

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 10

Constrained Headwater Sampling[1]

Contents

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[1] Authors: L. Stanfield, L. Del Giudice, E. Bearss and D. Morodvanschi

1.0 INTRODUCTION

This module describes a rapid assessment method for characterizing the amount of water and sediment transport and storage capacity within headwater drainage features (HDFs). Additionally, this module provides a means of characterizing the connectivity, form and unique features associated with each HDF. A HDF is a depression in the land that conveys surface flow. In some instances flows are concentrated through pipes along these depressions to speed this natural process. An objective of this module is to provide standardized datasets to support science development and monitoring on both the interim guidelines for headwater drainage features (TRCA and CVC 2013) and to evaluate existing mitigation strategies. An initiative is also underway to evaluate how these data can help understand the cumulative contributions of individual headwater drainage features on the downstream watershed state (see Stanfield et al., 2013).

While theoretically this module could be applied to any type and size of HDF, for practical purposes, the intent is to sample those features that are sufficiently large to capture enough flow so that sand particles could be transported. For most areas of the province, a headwater drainage feature would have a catchment of at least 2.5 ha in size. The intent of this module is to provide a means to assess all features that are:

- Relatively permanent on the landscape, meaning that if they are altered (e.g. ploughing), the drainage channel will re-emerge in subsequent runoff events;
- Have sufficient seasonal flow to have the potential to move bedload;
- Have a drainage area that can be calculated using a digital elevation model with approximately 5 metre resolution.

Rivulets and other temporary features are not intended to be assessed with this module.
This module is best applied at stream crossings where the crossing structure (road, railway, trail beaver dam, etc.) causes a constriction in flows during high flow events to facilitate an assessment of sediment transport/deposition. Such locations also facilitate ease of access. Study designs will dictate the process to be followed to identify specifically where field crews will sample (e.g. road layer intersection with water layer or Arc-Hydro) which should be documented using the Study Design Meta-Data Documentation Module (S1.M4). Data collected at perennially flowing streams are less reliable and their relevance declines as feature catchment area increases. Locations other than these constrictions can be sampled using this module, but the methods for assessing sediment transport require a constriction in flows.

As a rapid assessment module, methods provide a coarse measure of HDF sediment and water transport and provide no measure of drift. Techniques generally rely on classification using broad categories (e.g. sediment transport) that are intended to facilitate prioritization of HDFs as to potential influence of each feature on downstream reaches. Project managers should consider the cost/benefit of using these approaches and might consider, at a minimum, nesting these methods within a subset of sites where more rigorous, e.g. continuous sampling methods are applied to capture more rigorous data.

This module is complementary with and in some ways overlaps with attributes measured in the Instream Crossing and Barrier Attribution (S4.M9) and the Rapid Assessment Surveys of Stream Discharge and Perched Culverts (S4.M4) modules. Finally, the site feature information section of this module is nearly a complete replicate of the attributes documented using the Assessment Procedures for Site Feature Documentation (S1.M3). The information is replicated here for convenience to reduce the numbers of field sheets used by crews[2]. However, if any of these other modules are or have already been applied at the site, crews need not record the duplicate information.

Finally, information from these surveys targets the primary HDF at a sample location (site: see text box). Project managers have the option of whether to include secondary features such as roadside ditches, tile outlets and storm sewers within the survey design. Inclusion of these secondary features ensures a more complete analysis of the sources of water and sediment transport, but adds considerable cost to collect data on features that because of their size, likely contribute minimally to the overall water and sediment budgets of a watershed.

Primary Drainage Feature

The primary HDF carries the largest volume of flow under storm events and has more erosive power than other features. Secondary feature channels often curve in the downstream direction in contact with the primary channel and have sediment deposits upstream of the outlet.

1.1 Background on HDFs

HDFs have not traditionally been a component of most monitoring efforts, and as such, little is known about their form and function on the landscape. Williams (2006) refers to these types of features as “variable habitats” in recognition of the natural variability they exhibit in form and function. These features may provide direct, both permanent and seasonal, habitat for fish in the form of refuge pools, seasonal spawning and nursery areas or thermal refugia as a result of groundwater discharge. They may also provide indirect habitat for biota by exporting food (detritus/invertebrates to downstream waters (Wiplfi and Gregovich 2002). These features may be important sources, conveyors or storers of sediment, nutrients and flow, and may have an important role for terrestrial and wetland species, as breading grounds and corridors for travel. HDFs include small streams, springs, wetlands, swales and ditches and have variable flow conditions from perennial to ephemeral streams. They include both natural and human modified features that have the generic function of the conveyance of water and sediment (Richardson and Danehy 2007). Regardless of the form of the HDF, new science is suggesting that they play an important role as the interface between land and water for water and sediment transport and as corridors for the migration of biota. For an extensive review and more details on HDF importance, study design considerations

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[2] Channel hardening and straightening have been split; presence of on-line ponds and evidence of channel scouring and erosion have been added.

and more intensive sampling methods see Fritz *et al.* (2006)
http://www.epa.gov/eerd/manual/HISSmanual_full.pdf

2.0 PRE-FIELD ACTIVITES

This module requires a crew of two people (a surveyor and a recorder). Survey time varies with the precision required but typically takes anywhere from 5 to 25 minutes to complete per site. Note that with increasing availability of surveying equipment such as range finders and high resolution GPS units it is becoming feasible for one person crews to be able to measure widths and depths effectively, although for safety concerns we would still recommend a two person crew.

Pre-field activities should include:

- Development of a sampling site map with appropriate site identifiers (see Section 1)
- Landowner contact where appropriate

The following equipment list is required:

1. Headwater sampling field sheet (on waterproof paper if possible)
2. Pencils
3. One wooden and one metal metre stick
4. Camera
5. Tape measure (ideally 30 m)
6. Stopwatch, calibrated buckets, funnel and float for discharge

Optional Equipment

7. GPS unit
8. Clinometer
9. Range Finder
10. Turbidity meter and/or YSI meter
11. thermometer

3.0 FIELD PROCEDURES

Site conditions will dictate the type and amount of information collected. For example, there is tremendous variability in the condition of HDFs that will dictate whether surface transport of water or sediment is occurring and can be measured at a site. It may or may not be possible to collect all the information on the field sheet at the time of sampling. **In the event that any attribute cannot be measured at a site, put a slash through the box, indicating that you tried but could not measure the attribute, rather than (blank) meaning you forgot to measure it. During data entry, this field will be attributed with a Boolean code that reflects the situation.**

In developed areas, the assessment will most often be done at culverts. The number of features and attributes for HDFs may change from upstream to downstream, so separate information is collected for each side of the constriction. One field sheet will be filled out for each site sampled, and information will be collected for the upstream (front page of field sheet) and downstream (back page of field sheet) side of each HDF constriction. It is possible that there will be two culverts in close proximity conveying flows under the road for only one feature. In this instance, treat the culverts as one site, taking the measurements at the structure that transmits the larger portion of flows.

A sample site is defined by a set distance of 20 m upstream and 20 m downstream of the outlet of the primary HDF (Figure 1). All measurements are made from within these boundaries.

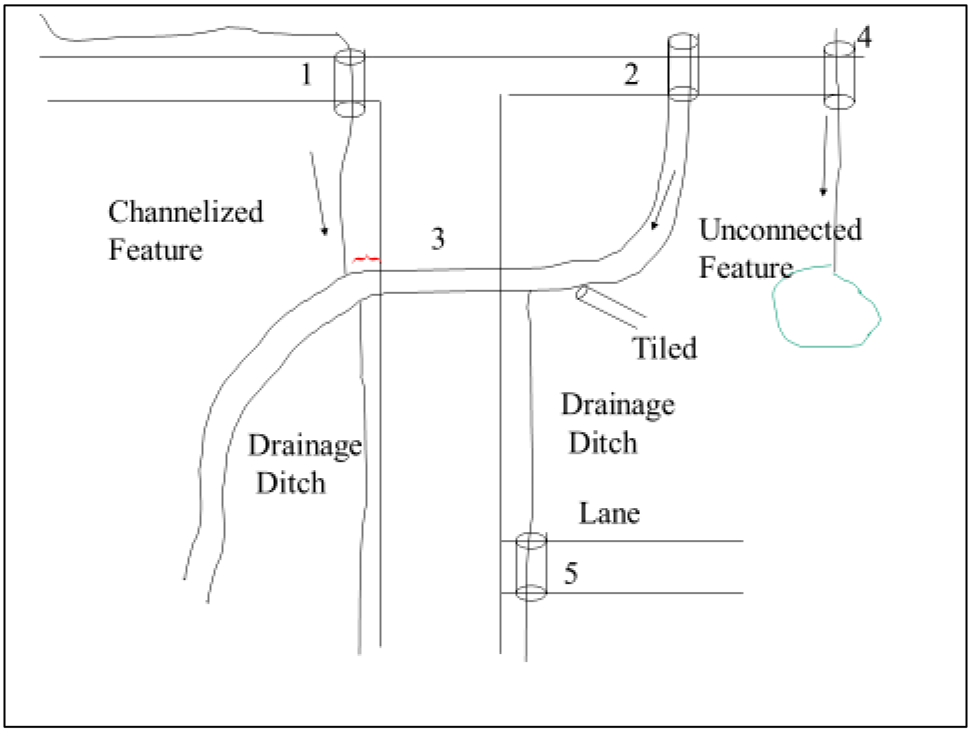

Figure 1: Sample Site survey areas and feature designations. *Note: Sites 1 nad 2 are connectd HDFs and should be sampled. Featrue 3 is downstream of 2 and is optional for sampling. If included in the study, note the secondary tiled feature in the site and the drainage ditch that is only included if the study design dicates. Featrue 4 is an unconnected feature, draining only to a local pond and is surveyed. Site 5 is only sampled if it can be seen that the feature drains more than just road runoff.*

Depending on whether there is water present within the sampled feature and whether it meets sampling objectives, water quality information may be collected following standard procedures as defined by the Ministry of the Environment (Todd, 2006) and as monitoring objectives dictate. Options available on the field sheet include: ‘Water temperature’, ‘Air temperature’, ‘pH’, ‘Conductivity’, ‘Turbidity’ and ‘Dissolved Oxygen’.

3.1 Timing of field Sampling

This module is best applied in the short period of time following a major freshet event, which in Ontario generally occurs during late winter and spring, and before new vegetative growth covers and disrupts any newly deposited sediment. However, in Ontario specific timing of when the sampling should be initiated is quite variable across regions and between years. In some areas, there may be several windows of opportunity before spring growth is sufficient to hinder sampling. Surveyors are directed to develop general guidelines for sampling and be prepared to blitz a study area when the conditions are appropriate. Factors to consider when choosing a sample period are:

- Following an extended warm period that enables frost to leave the ground;
- Surface flows from recent rain or melt conditions have provided sufficient flows to generate at least close to bankfull flows in some HDFs.
- And the main freshet is subsiding to enable safe sampling and the measurement of sediment deposition, erosion levels etc.

It is equally important to know when sampling should be stopped because the characteristics being assessed become unmeasurable or obscured. Such conditions occur when:

- Frost returns to the ground preventing sediment deposition from being measured
- New vegetative growth exceeds approximately 5 cm, and is sufficient to alter the roughness of a channel, obscure sediment deposition and hide HDF feature boundaries.

Generally, this means that sampling should occur between March and the middle of June in Ontario. However, parts of the module may be useful to collect at other times of the year as well in order to provide insight into vegetative growth and low flow conditions and can complement the spring survey data. It may be important to understand headwater conditions at other times of the year and intense summer storms can mimic some of the effects observed from spring freshets. Components of this module, such as site characterization and flow condition, can be completed at any time.

3.2 Site Descriptors and Site Identifiers

The top portion of the field sheet must be completed when collecting either upstream or downstream observations according to S1.M3.

At each site, fill out the site descriptors (e.g. 'Stream Name', 'Stream Code', 'Site Code', 'Sample #', 'Date' and 'Time')[3].

Record the Universal Transverse Mercator (UTM) coordinates as determined from either a GIS or using a Global Positioning System (GPS) according to S1.M2. Ensure that the datum is NAD83 and record the 'Zone' 'Easting' and 'Northing'.

On the front page (upstream side) of the field sheet, describe the Site Descriptions/Access Route following the guidelines provided in S1.M3. Record the street name, emergency access number (if available) of the nearest dwelling, and the approximate distance to the next major intersection.

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[3] For unconnected HDFs apply the naming convention that reflects the larger watershed that the features lies within.

At least one photo should be taken for the upstream side and one photo for the downstream side for future reference. Place a white board somewhere visible in the photo without obstructing the view of the site. Label the white board with site code, date and indicating upstream or downstream orientation. Record a photo number under “Photo #” and any additional information about the photo (e.g. upstream or downstream, etc.) under ‘Photo Name’. It is a good practice to rename the files after downloading the pictures to correspond to the site name and description (e.g. streamcodesitenameup or streamcodesitenamedn for the up and downstream photos).

At the bottom of the field sheet, record the crew leader’s initial and last name, the crew member’s initials, and the recorder’s initials.

3.3 Upstream Section

There may be more than one headwater drainage feature entering the culvert on the upstream side. For example, you may have more than one defined channel upstream, or a tile outlet may enter the HDF within the site boundaries (see Figure 1). You may need to do a walk-about to locate and identify all the features within the site. Roadside ditches that only convey local drainage from the roadway are included only if the study design dictates, since these features will not have a calculable drainage basin. Many apparent ditches are in fact channelized waterbodies (see Figure 1 for illustrations) which have drainage areas that extend upstream of the road. Record the number of features found within the site boundaries in the box provided and record the feature number sequentially from the closest to your left to the furthest on your right (see Figure 2). Record any additional information in the ‘Upstream Comments’ box at the bottom of the sheet.

3.3.1 Distance and Bearings

Record the distance to the nearest 0.5 metres and bearings to the nearest degree for each HDF within the site. Take the bearing of the general direction of the dominant feature flow pathway and to each subsequent feature relative to where it discharges into the dominant feature (the confluence point). The bearing for the primary feature is up the main valley of the feature. To accomplish this stretch a tape measure from the center of the culvert or other outlet to the feature. Bearings are measured from the middle of the culvert (or other feature) to the end of the tape (i.e., crew member). These measurements together will ensure that on returning visits, the assessors will be able to identify and locate a feature that may be hidden by thick vegetation when surveys are conducted in the later summer months.

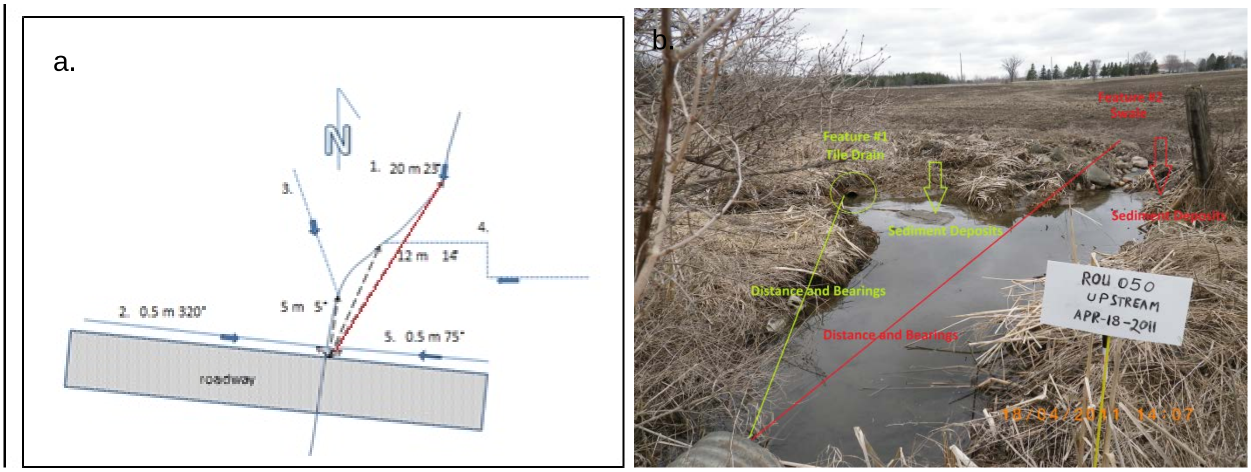

Figure 2: Examples of distance and bearings measurements to the primary (red lines) and secondary HDFs, numbered sequentially from the closest left side of the outlet.

Note: All measurements are taken from the center of the outlet to the confluence of the feature with the primary HDF. Example a, has 4 secondary inlets (no. 2-5) while example b has one (yellow line).

3.3.2 Upstream Longitudinal Gradient

Measure the longitudinal gradient of the site (preferably to a minimum of 20m of the site length). Avoid placing equipment on minor inconsistencies in grade and include all the major elevation changes (e.g. channel heads, cascades or weirs) within the site to obtain a representative measure of slope (see Number 1, Figure 2 for direction for where to make measurements). Record the distance between the two measurement points to the nearest metre, the change in elevation to the closest 10 millimetres (or degrees if using a clinometer) and indicate the method used to measure the slope as defined in Table 1 in the box provided under “Upstream Longitudinal Gradient”. For more details on measuring slope using a laser or survey level see module S4 M7 – Measuring Stream Slope.

Table 1: Longitudinal Gradient: Method Codes

Longitudinal Gradient Method Code	Method Used
1	Visual
2	Clinometer
3	Laser Level
4	Survey Level
5	Lidar
6	Other

To measure longitudinal gradient, using a clinometer you must first find a reference point/location on the receiver person. Face each other in close proximity and determine where on their body your eyes are level with them (see Figure 3). Next, stretch a measuring tape out between crew members to the top or bottom of site, and again look at the reference point, this time while looking through the clinometer. Have each crew member stand in similar locations (e.g. on a riffle) with a clear view between the viewer and the target. Most surveyors will stand on the base of a culvert while making this measurement. Be sure to record the **degree** change value (the one on the left in most clinometers).

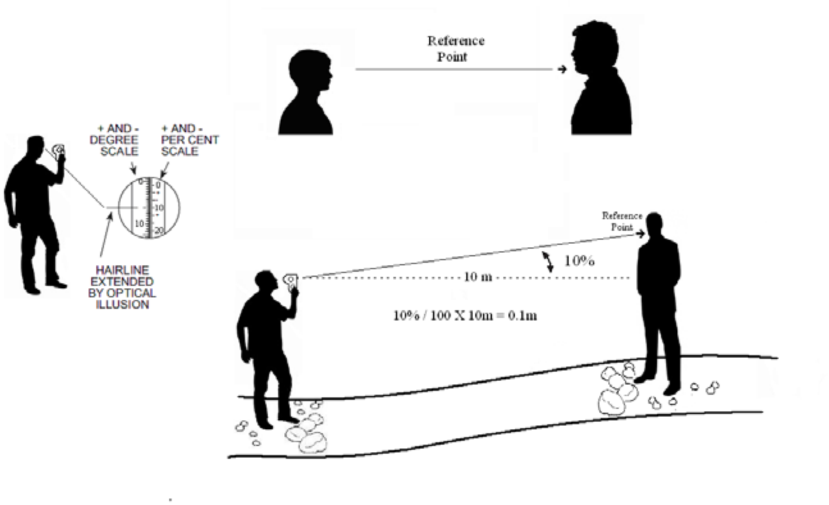

Figure 3: Using a clinometer to measure slope.

Hint: You can calibrate your eye level by standing on level ground with another crew member. Then sight this point on the crew member's body when measuring slope (e.g. eye level or top of head). Having the target crew member hold a metre stick horizontally across the reference point on their body will make lining up the clinometer easier. In this example the value to be recorded is 15º.

3.3.3 Feature Type

The form of the HDF is a key factor in assessing its function. Categorize the feature type according to the Table 2 definitions and record the appropriate feature type code under 'Type'. Flow is only used in determining feature type when separating defined natural channels from wetlands. Natural (infilling) and unnatural processes (dredging, damming) act on HDF channel conditions. If there is a defined channel, even if the banks are poorly defined or absent because the of dense wetland vegetation, the feature is considered a defined natural channel. Where more than one feature type is present within the site boundaries, record the 'dominant' form by aerial coverage within the site boundaries (e.g. 20 m) on the field sheet.

Table 2: Definitions of types of headwater drainage features

Feature code	Feature Type	Feature Definition
1	Defined natural channel	Channel banks and sorted substrates are visible; there is no evidence that the drainage feature has been historically dredged or straightened.
2	Channelized or Constrained	Channel banks and sorted substrates are visible and there is evidence that the stream has been historically dredged or straightened. In some instances the channel is constrained by filling, such that access to the flood-plain is no longer available.
3	Multi-thread	Multiple channels for one flow source; multi-thread channels are subdivided at low-water stages by multiple midstream bars of sand or gravel. At high water, many or all bars are submerged.
4	No defined feature	A topography with no identifiable depression to convey water and no facultative wetland species are present. Water is transported through overland or sheet flow.
5	Tiled	An outlet from a buried stream or tile drain is visible. There may be a defined channel downstream of the outlet caused by scouring.
6	Wetland	Feature with sustained water storage function. Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. Obligate wetland species will be dominant (e.g. cattails).
7	Swale	A shallow trough-like depression that carries water flow during rainstorms or snowmelt and has ill-defined banks. Water conveyance is the primary function for the purposes of this definition. Flow not sufficiently sustained to cause substrate sorting or prevent instream vegetation from establishing, and water storage not sustained to promote obligate wetland vegetation (e.g. cattails). Bed may contain facultative wetland plants (e.g. reed canary grass).
8	Roadside ditch	A watercourse that only conveys road runoff. It does not extend upslope of the road that could generate a catchment
9	Pond outlet	Flow is from the outlet of an on or offline, irrigation, storm- water or other pond. Indicate the type of pond present in the comments field.

3.3.4 Flow Conditions

The observed flow conditions in HDF can be highly variable depending on timing relative to the spring freshet, recent rainfall, soil moisture etc., (see Williams 2006, Stanfield and Jackson 2011). Future use of the data will require a classification based on the degree to which flows reflect “spring baseflow” conditions. This can be challenging to ascertain, but with experience crews can classify the degree to which flows reflect either, spring baseflow, a low level freshet or a spate. Indicate on the field sheet which of the categories in Table 3 best reflects the flow influence on the observation date.

Table 3: Definitions of flow influence

Flow influence Code	Description	Observation
1	Baseflow	The feature is dry or flowing at a rate and condition consistent with only subsurface contributions of flow.
2	Freshet	Flows are elevated but within the bankfull channel
3	Spate	Flows are at or above the bankfull channel

Classify the amount of water flowing within each upstream HDF according to the criteria provided in Table 4:

Table 4: Definitions of Flow Conditions

Flow Conditions Code	Description	Observation
1	No surface water	The feature is dry.
2	Standing water	The feature has standing water, but there is no visible flow. Channel often alternating between standing water and dry.
3	Interstitial flow	Flow is observed in the pavement layer of substrates only.
4	Surface flow minimal	There is flow within the HDF that is estimated to be less than 0.5 litres per second.
5	Surface flow substantial	There is flow within the HDF that is estimated to be more than 0.5 litres per second.

If surface flows are classified as substantial (category 5), then, wherever the most convenient and accurate measure of flows can be obtained, follow the procedures and hierarchy of methods below to obtain an estimate of flow. The hierarchy is as follows:

1. Volume by time: If all of the flow passes over or through a structure such as a perched culvert so as concentrate flows to a central location, place a container so as to capture all the flow and measure the time to fill it takes to fill the container to a known volume. Repeat this measurement three times, recording the volume collected and time to fill to the nearest second.

2. Hydraulic Head: For streams with relatively uniform; low roughness beds; well confined channels, and velocities that exceed approximately 0.1 m/s in the thalweg, measure the depth and hydraulic head at three equally spaced locations across the stream, (Figure 4). Ideally these measurements would be made at or close to a cross-over, or within a culvert, but choice of the appropriate location will vary. Also record the wetted width of the stream to the nearest 0.01 m. **Record the depth measures to the nearest 5 mm and hydraulic**

head measures to the nearest mm. for those less than 10 mm and nearest 5 mm for any heights greater than 10 mm.

3. Distance by time: Where velocities are insufficient to generate at least a 1 mm hydraulic head, measure the amount of time for a floating object to travel a set distance of stream. Conduct these measurements at any location where flow is relatively uniform and free of debris. In many instances local conditions will dictate where the measurement can be made. Repeat the measure three times.

4. Estimated Discharge: For streams where none of the above procedures can be applied, or for which access cannot be attained estimate the discharge to the nearest 0.1 l/s. Note that the ability to estimate discharge changes as volume increases. As discharge exceeds about 2 l/s accuracy will decrease to ± .5 l/s". This is recorded on page 2 of the field sheet.

If there is more than one HDF upstream then measure flow conditions from each feature individually and the accumulated flow from **all** the features on the downstream side. If there is only one feature identified upstream then the flow can be taken either up or downstream of the constriction point wherever the most accurate location to record flow may be. In some cases you may need to improvise in order to collect flow measurements (e.g. at multi-thread channels, channels that are too narrow or highly covered). If you feel that this is not possible without compromising the integrity of the results, take the measurement in the culvert. Record any variations from the protocol in the comments section.

Hydraulic Head

Hydraulic head is measured by placing a wooden ruler on the stream bed so that it is vertical and the **wide side with the markings is on the downstream side of flows**). The ruler will create a barrier to flow. Measure the maximum height difference observed over a 3-5 second period between the front and back of the ruler (Figure 4). 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.

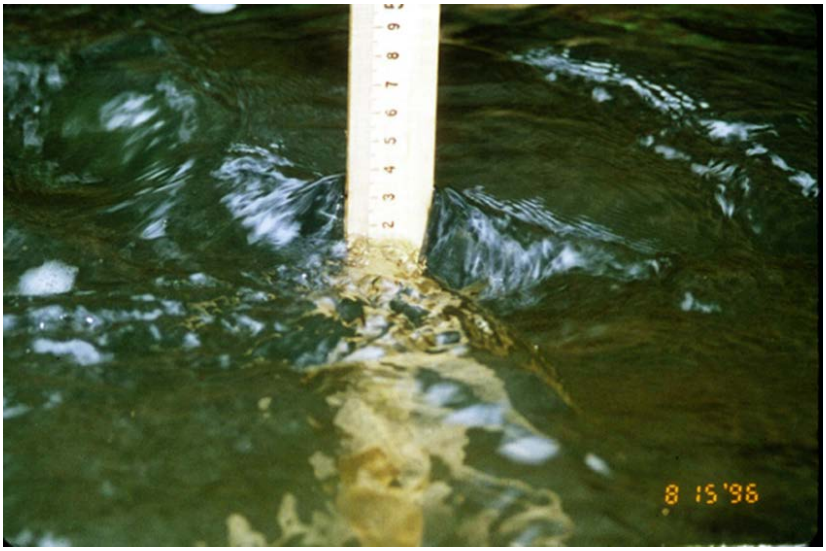

Figure 4: Measuring a 15 mm Hydraulic Head

3.3.5 Sediment Transport to Feature from Adjacent Lands

Examine the areas in the vicinity of the HDF site and note whether there is evidence of sediment transport moving into the feature laterally from the adjacent lands. Adjacent lands are considered all lands upslope of the feature limits. This information will assist in determining whether there is evidence that soil is being eroded from adjacent lands and being conveyed by the HDF. Match the type of sediment transport present to the definitions provided in Table 5, and record these observations in the “Sediment Transport-Adjacent” field. Note: some categories such as tile outlets and instream bank erosion are unlikely to be found outside of the feature, but one table is used for convenience.

Table 5: Sediment transport codes and descriptions.

Adjacent Land Sediment Transport Code	Description	Observation
1	**None**	No evidence of sediment transport
2	**Rill**	A narrow and shallow incision into soil resulting from erosion by overland flow or surface runoff that has been focused into a 'thin thread' by the soil surface texture of roughness. Generally, rills are less than 0.2 m deep.
3	**Rills and Gully**	Both rills and gullies present on the land that input into the HDF
4	**Gully**	A landform created by running water eroding sharply into soil, typically on a hillside. Gullies have steep sides and either U or V shaped valleys. They are greater than 0.2 m deep, but can be metres to tens of metres in depth and width. When the gully formation is in process, the water flow rate can be substantial, which causes the significant deep cutting action into soil and lack of vegetation growth.
5	**Outlet Scour**	Tile outlet drains and other entombed HDFs outlet to a stream through a pipe with sufficient erosive force to cause bank and/or bed erosion immediately downstream of or around the outlet. Sediment deposits found within the HDF can be directly linked to this source of sediment Figure 6a).
6	**Sheet Erosion**	Soil particles are detached and transported as a result of raindrop impacts or by water flowing overland without the formation of rills and gullies. Often this is the precursor of the more obvious rill erosion. Typically associated with tillage on long gradual slopes and low rates of water infiltration (Figure 6b).
7	**Instream Bank Erosion**	Flows or livestock access have generated sediment from within the channel itself that is now available for transport downstream (e.g., bank slumping).
8	**Other**	Describe in comments

Figure 5: Outlet erosion (a), sheet erosion (b)

3.3.6 Sediment Transport to Feature from <u>within the Feature</u>

Sediment generated within the feature can also be transported downstream. Use the codes in Table 5 to record whether there is any evidence of erosion that originates within the high flow channel or areas where hydric soils extend beyond the tbankfull channel in which the HDF flows. Record the most appropriate code in the “Sediment Transport-Feature” field.

3.3.7 Evidence of Sediment Deposition

Assessing the amount of recent sediment deposited in a channel provides an index of the degree to which the feature could be transporting sediment to downstream reaches. The volume of new sediment deposits is an indicator of the amount of sediment transported by the HDF. Examine the hydrologically active area (i.e. valley that transports higher flows) of the HDF and note if a fresh (i.e. this year) layer of sediment has been deposited over the substrate or previous year’s vegetation (see Figure 6 examples). If sediment deposits are evident, lightly push a metal ruler or metre stick into the ground until resistance is met by either old vegetative material or compacted soils. Measure this depth in at least three different locations and record the category that represents the average depth of new sediment according to Table 6. Evidence of excessive sediment deposition might indicate the need for more detailed follow-up surveys.

Table 6: Definitions of sediment deposition categories. All measurements are made at deposition areas (e.g., point bars) that are within the active channel.

Sediment Deposition Code	Description	Observation
1	None	No evidence of sediment deposition
2	Minimal	An average of less than 5 mm of new sediment deposits
3	Moderate	An average of 5 to 30 mm of new sediment deposits
4	Substantial	An average of 31 to 80 mm of new sediment deposits
5	Extensive	An average of greater than 80 mm of new sediment deposits

Figure 6: Examples of HDF's with varying amounts of sediment deposits.

3.3.8 Feature Width

The width of a HDF provides a measure of its ability to convey or store water. Water conveyance is positively associated with the width of the bankfull channel, while water storage capacity is positively associated with the overall width of the feature, as defined by the extent of hydric soils.

In many instances the hydric soils associated with the feature extend beyond the bankfull level into the riparian zone.

Table 7 provides guidance to assist with defining the feature width boundaries in various HDF types. Where access or safety concerns prevent an accurate measurement, estimations can be made (see Figure 7 for one example). For larger features width can be measured using ortho-images and GIS. The FWIS also has these capabilities. Record the 'feature width' to the nearest tenth of a metre, although the accuracy of the measurement is considered to be one metre.

Table 7: Guidance for how to define Feature Width boundaries of various HDFs

Feature Type	Feature Width

Wetland	The wetland boundary will be where vegetation is 50% wetland species (e.g. cattails, willows, etc.) and 50% terrestrial species. Transitions to upland vegetation will usually be evident.
Swale	The swale boundary will be the top of the depression or conveyance channel. It is often demarcated by a change in vegetation (e.g. reed canary grass to upland vegetation species.
No Defined Channel	Not possible to measure. Record 0.
On-line Pond	Measure the width of the pond at its widest point.

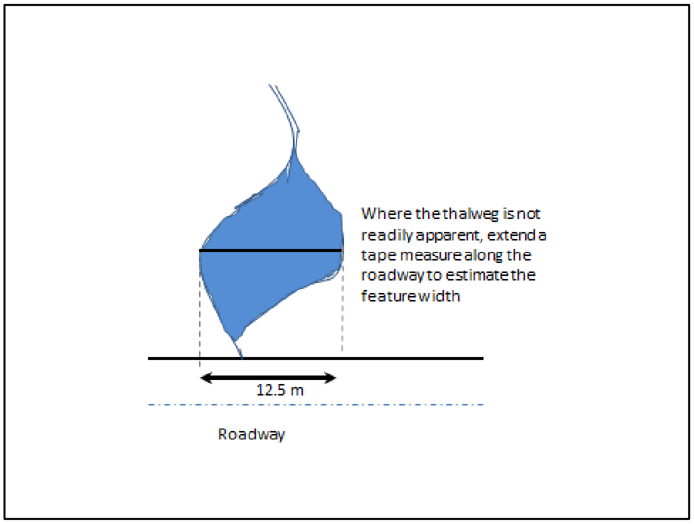

Figure 7: Estimating feature width where access is restricted or thalweg is indeterminate.

3.3.9 Measurement Method:

With so many options to determine feature and bankfull widths a “Width Method (MT)” field is provided to offer a means of documenting the method used to make these measurements. Record the category that represents how the measurements were taken (Table 8). When possible physically measure a feature at a crossover or if necessary at a mean of three locations (for oddly shaped features e.g. multi-thread channels).

Table 8: Width Method Codes

Width Method Code	Description	Observation
1	Cannot Measure	No definitive boundaries (e.g. defined banks, vegetation, soil)
2	Bankfull	Defined channel, measured at top of bank, ideally from one crossover
3	Average Width	Average width of feature, measured at a representative location or if highly variable the mean of 3 locations
4	Estimated	Defined feature boundaries but width is estimated visually
5	GIS	Measured using ortho-image from a GIS for wetlands or ponds
6	Measured and GIS	A combination of field measurement for bankfull and GIS for feature width

3.3.10 Bankfull Width:

To measure bankfull width, 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 8). More detail on how to consistently identify the bankfull level is available in S4.M3 (3.1.2 Identifying the Bankfull Level). The specific location to place the tape measure is where the stream channel begins to spill onto the adjacent floodplain 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. Take the measurements at a location that represents the "average" bankfull width at the site; avoid unusually wide or narrow spots. This is best applied at the location where the thalweg (main concentration of flow) is in the middle of the channel at bankfull flows. If the bankfull width is highly variable within the site, take and record a true average bankfull width. Record the individual measurements in the comments field. Record the 'bankfull width' to the nearest tenth of a metre.

3.3.11 Bankfull Depth

At the deepest part of the channel (generally the middle of the stream), measure the height from the feature bed to the tape measure (depth to top of bank) (Figure 8). Record the bankfull depth to the nearest 5 millimetre in the field marked BF depth.

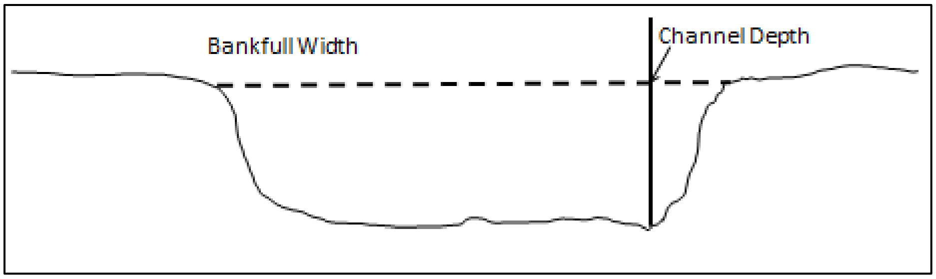

Figure 8: Measuring bankfull width and depth.

3.3.12 Channel Entrenchment

The degree to which flows are contained within its floodplain during high flow events is a measure of entrenchment. Channel entrenchment is defined as a ratio of the width of the floodplain relative to the bankfull width. For consistency the measurement is standardized to a vertical depth of two times the depth of the maximum depth of the channel at bankfull flows (Rosgen 1996). Channel entrenchment is typically measured on the primary channel at the same time that bankfull width and maximum channel depth are measured. To obtain the measurement, double the maximum channel depth and stretch a tape at right angles to the primary feature until it intersects with a bank. This distance represents the entrenchment width. This can also be calculated incrementally (see Figure 9).

Entrenchment width is used with bankfull width to assess channel confinement. If the entrenchment width is > 2 times the bankfull width the stream is considered unentrenched. For efficiencies, entrenchment need not be measured on streams for which the ratio is > 3. By definition surveyors record a width of 41 to indicate that the entrenchment ratio is > 3.

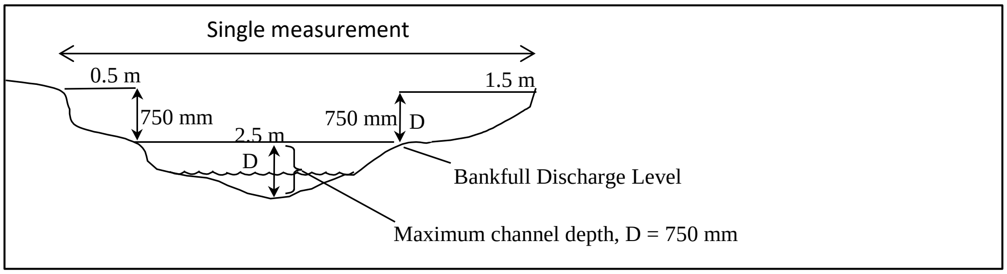

Figure 9: Channel Entrenchment.

Note: in this example there is a a channel width of 2.5m and entrenchment width of 4.5 m for a confinement ratio of 1.8m (i.e., confined channel).

3.3.13 Feature Roughness

Feature roughness will provide a measure of the amount of materials within the bankfull channel that could slow down the velocity of water flowing within the primary HDF "channel". Examine the extent of areal coverage of materials that could obstruct or diffuse flow through the entire site length of the primary HDF channel as defined in Section 3.0. Materials that provide roughness include: vegetation and sticks >20 cm long, boulders,rocks and logs (> 10 cm median diameter axis). Record the roughness of the channel for both the up and downstream sections of the site according to the following categories (Table 9):

Table 9: Definitions of Feature Roughness Categories

Feature Roughness Code	Description	Observation

1	Minimal	Less than 10% of the areal coverage of the channel substrates contains materials that diffuse flows.
2	Moderate	10-40% of the areal coverage of the channel substrates contains materials that diffuse flows.
3	High	40-60% of the areal coverage of the channel substrates contains materials that diffuse flows.
4	Extreme	More than 60% of the areal coverage of the channel substrates contains materials that diffuse flows.

3.3.14 Riparian and Feature Vegetation

For some types of HDFs the vegetation within the feature plays a significant role in flow and sediment movement and provides wildlife habitat. The vegetation can be quite different than what is found in the riparian corridor. For example, without the confined channel, a feature type that is a wetland could have substantial vegetation. For these and pond features the riparian zone classification is carried out at the edge of the wetland. Record the type of vegetation found within the feature, i.e., within the area that is below the "bankfull channel" in the Feat_Veg box. Note that the classification is hierarchical, ensuring that all riparian zones meet one criterion, only. Use the categories defined in Table 10 for both attributes. A feature with wetland as the type of riparian vegetation generally only occur where the feature is defined as a natural (1) or a channelized/constrained channel (2) (see Figure 10 for an example). With these features, under low flow conditions, there will be distinct banks that enable flows to be concentrated in the channel.

Characterize the dominant vegetation type of the riparian zone on the right and left banks, using the following assessment zones, measured from the stream bank: 0-1.5 m, 1.5-10 m, and 10-30 m and definitions provided in Table 10 and illustrated in Figure 11. Remember, the right and left banks are always assigned looking upstream. Measurements begin at the edge of the feature (e.g. top of bank or at the edge of a wetland or swale). *Dominant* is the most commonly observed type by areal coverage of the canopy over the entire feature length. If it is not obvious which type is dominant, measure the area (total length and width) of each type, to sort out conflicts.

Figure 10: Example of wetland riparian vegetation on a naturally defined channel.

Figure 11: Vegetative zones for determining riparian vegetation.

In this example types are meadow, lawn and lawn for zones 0-1.5; 1.5-10 and 10-30 m respectively and there is no vegetation within the feature.

Table 10: Definitions of Riparian Vegetation Categories

Riparian Vegetation Code	Description	Observation
1	None	Over 75% of the surface area within the 30 m wide buffers of each side of the HDF has no vegetation; includes hard surfaces such as roads and buildings
2	Lawn	Grasses that are not allowed to reach a mature state due to mowing
3	Cropped Land	Planted or tilled in preparation for planting of agricultural crops; plants typically arranged in rows (due to machine-planting); may be subject to periodic tillage
4	Meadow	Less than 25% tree/shrub cover; characterized by grasses, forbs and sedges.
5	Scrubland	More than 25% and less than 60% trees and shrubs interspersed with grasses and forbs (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height)
6	Wetland	Dominated by water tolerant wetland plants including rushes, and water tolerant trees or shrubs.
7	Forest	More than 60% of the canopy is covered by the crowns of trees

3.3.15 Upstream Site Length

In some cases, it will not be possible to assess the entire 20 m section in the upstream areaboth areas. In these instances, measure or estimate the site length and record to the nearest metre in the box labeled “Approx Site Length”. Record a ‘41’ to indicate that the feature continues past the 40m site boundary.

3.4 Downstream Section

There are several attributes of HDFs that are only relevant on the downstream side of a constriction. These characterize conditions that influence sediment and water transport and the passage of fish and invertebrates to up and downstream areas. First, only one feature can be present on the downstream side. If for example, there are two culverts with two features that merge to form one feature downstream within the 20 m distance, then treat both features as distinct. The fact that the feature length is < 20 m will be recorded on the field sheet (see below). Second, whether the feature is connected to the surface drainage network determines whether sediment and flows will influence downstream reaches. Third, constrictions often result in down cutting which may create barriers to upstream fish migration. The following subsections describe how to assess channel connectivity and whether the feature is potentially a fish barrier.

The downstream section will contain many of the same components as upstream, including ‘Feature Type’, ‘Flow Conditions’, ‘Evidence of Sediment Transport’, ‘Evidence of Sediment Deposition

Volume’, ‘Width MT’, ‘Feature Roughness’ ‘Bankfull Width’, ‘Feature Width’, ‘Riparian Vegetation’, ‘Longitudinal Gradient’ and ‘Channel Entrenchment’. Refer to the ‘Upstream Section’ above when completing these parts of the downstream field sheet as the procedures are the same. Also include any relevant comments for the downstream side under ‘Downstream Comments’.

3.4.1 Downstream Feature Length

In some cases, it will not be possible to assess the entire 20 m section downstream because the feature may merge with another stream or feature (pond, tile, etc.). In these instances, measure or estimate the site length and record to the nearest 0.5 metre in the box labeled “Approx. Site Length”. Record a ‘41’ to indicate that the feature continues past the 20 m site boundary. This number is used in several OSAP modules to indicate the distance is beyond the threshold for measurement.

3.4.2 Presence of a Barrier to Fish Migration

A perched culvert occurs when the bottom of the culvert is above the stream bed and results either from improper installation or stream erosion. Perched culverts may prevent fish from accessing upstream waters. Fish barriers can also occur at other constrictions such as dams, which are treated as though they were culverts for field measurements (e.g. the lip of the dam).

For sites where perched culverts exist, measure the distance from the bottom of the culvert to the stream bed and record as the ‘Perched Height’ (mm) on the field sheet. Also measure the distance from the lowest part of the culvert (its center) to the water surface and record this as the ‘Jumping Height’ (mm) (Figure 13).

If the feature is dry, only record the perched height in the jumping height box. Record these measurements to the nearest 5 mm.

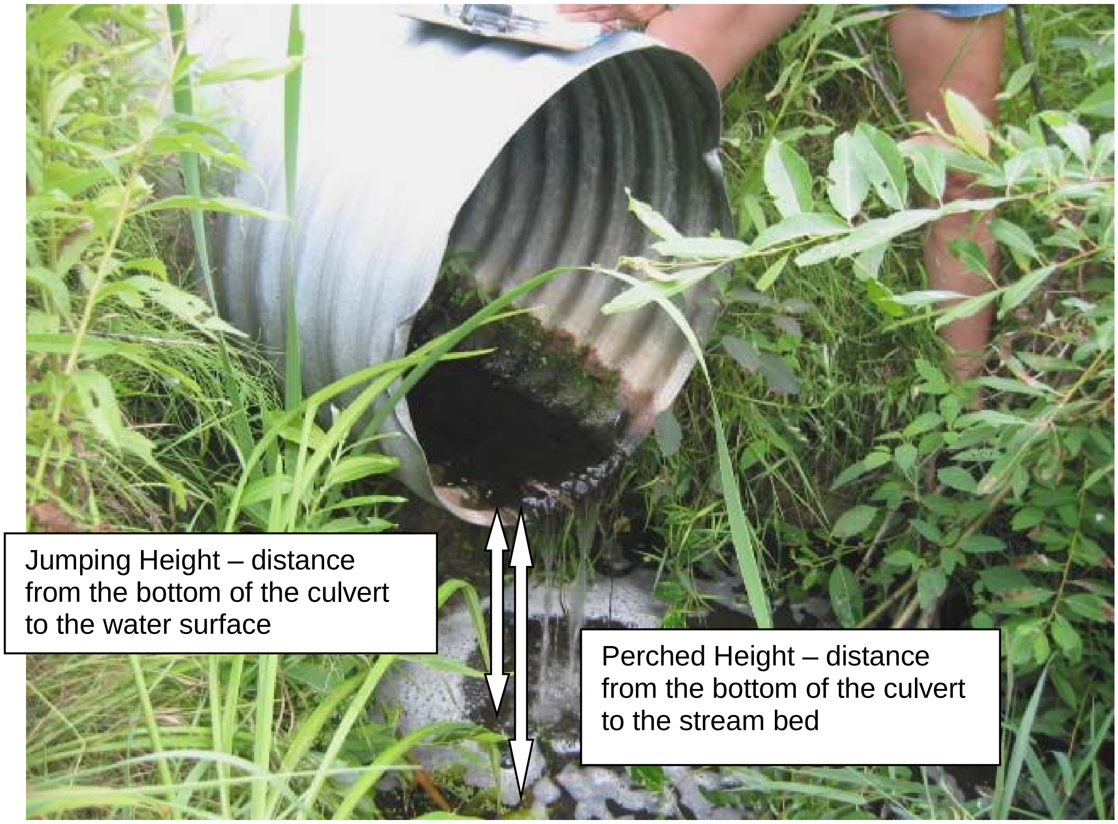

Figure 12: Measuring depth to bed of perched culvert and jumping height for fish

3.5 Full Site Conditions

There are several attributes that are assessed over both the up and downstream portions of a site. Watch for and record these conditions as they are observed and check the final results at the completion of the survey.

3.5.1 Site Features

Document the site features or land use activities that could influence the HDF condition, both within and beyond the 40 m site boundaries, by recording one of the following options (Table 11) that best describes the presence and characteristics associated with adjacent or upstream land use activities and important features listed in Table 12**.** Note the evidence categories are hierarchical, with the last field indicating the crews are uncertain whether a feature is present due to lack of time or knowledge to assess. In the 'Comments' field, describe the features and land uses observed. Make sure to put a number in each field as otherwise it will be assumed that the features presence was not assessed. Other features observed near the site should be documented in the 'Comments' field at the bottom of the page.

Table 11: Categories of evidence of a site features presence near a site

Code	Category	Description

Code	Category	Description
1	‘Ongoing and Active’	There is evidence of the feature at the time of the site visit
2	‘Historical Evidence’	There are signs that the activity has occurred in the past
3	‘No Evidence but Reported’	It has been historically reported, but no obvious physical signs exist
4	‘No Evidence’	There is no current or historical evidence of this activity
5	‘Unknown’	The feature has not been sufficiently evaluated.

Table 12: Definitions of site feature attributes

Site feature	Diagnostic Indicators
‘Potential Contaminant Sources’ (Point or Non-point)	Point or non-point sources: Look for outlets from storm sewers, tile drains, or industrial discharge pipes. Note any obvious signs of discharge at the site (odor, staining, sheen, etc.).
‘Major Nutrient Sources Upstream’	Algal blooms or dense growth of aquatic macrophytes are indicators of upstream nutrient sources. If present, look for potential sources such as sewage treatment plants, processing plants, intensive agricultural operations (e.g. chicken ranches, livestock, feed lots) upstream of the site.
‘Channel Hardening	Hardening is indicated by rip-rap, armour stone, or gabion baskets.
Dredging of Channel (Straightening)	Straightened channels will often have dredged material piled adjacent to the stream, or will be atypically straight relative to the valley gradient.
‘Barriers and Dams in the Vicinity of the Site’	Often visible from roads or air photos; historical evidence includes elevated floodplains with an atypically flat gradient throughout the reach. There may also be evidence along the banks (e.g. elevated culverts, fallen timbers or old bridges that have been buried).
On-line ponds upstream	Any pond with an outlet to a channel that does not have a bypass channel around the feature. This includes those in headwater areas that are groundwater fed with an outlet.
‘Springs or Seeps at the Site’	Abundant watercress in the stream; differences in stream temperature between sections (record temperatures in comments); a rust-coloured deposit on sediments surrounding the groundwater discharge zones in areas with high mineral content.

Site feature	Diagnostic Indicators
Evidence of channel scouring/erosion	Presence of undercut banks, entrenched or incised channel, bare or slumped banks
Evidence of the application of BMPs or restoration	Activities such as fencing, tree planting, livestock watering outside valley etc,

3.5.2 Channel Connectivity

Determine whether the primary HDF is connected or unconnected to downstream reaches of surface water flow using the definitions in Table 13 and the example in Figure 12.

Table 13: Definitions for channel connectivity

Connectivity Code	Categories	Definitions
1	**connected**	A surface water flow connection is apparent from the donating feature to the downstream watercourse with existing or potential overland flow.
2	**Unconnected**	A water flow feature that is not connected to the drainage network except by groundwater infiltration. These features drain to kettle wetlands or ponds etc., that have no outlet to the drainage network except via groundwater.

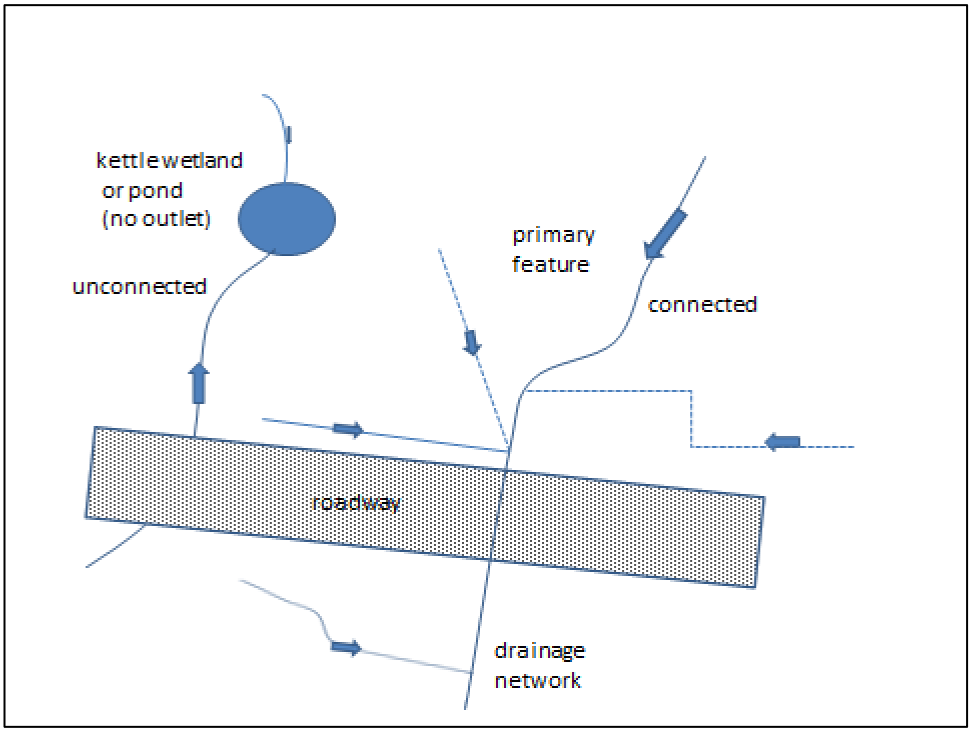

Figure 13: Differentiating connected and unconnected features.

3.6 Tips for Applying this Module

For safety reasons, learn to identify giant hogweed, stinging nettles, water hemlock, and poison ivy.

On every data form, record the standard site identification data and the sample number. Also record the time of sampling as a priority to provide a backup in the event that errors are made with site codes. You will be able to track your route by road and determine where you really sampled.

Make sure that all fields have data recorded before leaving the site.

Record ‘-99’ (‘-999’ for depth) to indicate that a measurement could not be performed.

Finally, record any irregularities in the way the data were collected in the ‘Comments’ field.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management and how to use FWIS.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca/fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

The headwater module was the most challenging of modules to develop, to date. Conceptual development began in 2010 with contributions from Peter Ashmore, Andrea Bradford, Trevor Dickinson, Paul Villard and John Parish. Subsequent edits to the output from this workshop formed the first draft of a protocol that was greatly improved by both review or testing performed by Mari Veliz, Cathy Reeves, Rob Wilson, Jeff Andersen, Jeff McNiece and Geoff Clark, Additional testing of the module was funded by the Lake Simcoe Clean-up Fund and was carried out by Mari Veliz, Evan Bearss, and Daniel Morodvanschi, Sherwin Watson-Leung and John Clayton. Finally, the module was peer reviewed by, Bob Bergman, Jim Buttle, Dave Kreutzweiser, Rob Mackereth, Cam Portt, John Richardson, and Mark Wipfli. Funding for the development of this module was generously provided by Lake Simcoe Clean-up Fund, Peel Region, and York Region.

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Appendix 1

Determining Up and Down Stream

At some locations and particularly where natural drainage has been altered, it can be challenging to determine flow direction. In these situations use the following clues to help determine flow direction:

1. Look at the overall landscape and determine the higher side of the site (use a clinometer to measure when in doubt). The higher side will be upstream.

2. Use a high resolution topographical map to determine the direction of the bends in the up or downstream contours. Contours nearly always bend downstream.

3. Determine if the culvert is perched, the majority of the time the perched end is the downstream side of the culvert.

4. Examine the hydrologically active area (the zone of water flow). Look closely around the feature to see what direction the vegetation has been bent by the force of the water. Dead grass and twigs bent around stationary object will point in the direction of water flow.

5. Delineate the slope of the watershed using a map and the watercourse of other drainage features in the area. This can be used for sites with features with standing water or features like ponds or wetlands on both sides of the culvert.

Appendix 2

Discharge Approximates Baseflow

A stream is flowing at baseflow when it is only under the influence of groundwater and these levels will be higher when the ground is saturated because the water table is higher. Sampling in the spring generally ensures that both baseflow and surface inputs from rain or the spring freshet are more likely to generate elevated measures of flow in HDFs. With small drainage areas HDFs have the potential to return to baseflow conditions much sooner than downstream reaches. Further, rain events are often spatially heterogeneous on the landscape and vary in intensity within a watershed. Therefore, the degree to which specific HDF flows reflect baseflow conditions can be highly variable. Assessing the degree to which a HDF is approximating baseflow requires some knowledge of the return to flow rates in a local area and is best accomplished by comparing flows in several features. Features to consider include:

Spring freshet: A spring freshet is the thawing event of snow and ice that accumulated over the winter months. The size of the watershed, the amount of accumulated snowfall and the consistency of climbing temperatures are factors that can influence the duration of the freshet. Freshet influences can last for several days to several weeks.

Rainfall: Before leaving for the field each day, look up the weather forecast to see if a significant amount of rainfall has accumulated over the past 24 hours and how spatially extensive the event was. Since some areas may accumulate/store more rainfall than others, rain event influences can last from hours to days.

Local geology: Expect that areas with higher relief and more porous soils will return to baseflow more rapidly than HDF on till and clay plains.

Downstream flows: Stopping at downstream crossings to evaluate flow conditions provides a good indication of whether the system is not at baseflow. If the channel is swollen with turbid water, the high flow influences most likely have not passed yet.

Turbidity: Depending on the nature of the watershed, the streams should be running with clearer water at baseflow.

Temperature: HDFs at baseflow will be cooler than downstream areas, particularly when measured at midday or later in the day.

Consider all of these criteria when determining whether the stream is flowing without the influence of surface flows, or is at baseflow.

Appendix 3

Example Headwater Drainage Feature Field Sheet,

Sampling Codes sheet and Field “Synopsis Sheet”

Headwater Drainage Features - Up- and Down- Stream

Stream Code	Site Code	Zone	Easting	Northing	Date (YYYY)	(MM)	(DD)	Time (24hr)
RG1	RUOU08	17	639754	487264	2011	03	30	10:25

Stream Name: ROUGE RIVER

Discharge Approximates Baseflow? ○ Baseflow ☒ Freshet ○ Spate

Upstream Site Length (m):

Access Route: ON BETHESDA ROAD JUST WEST OF # 611. APPROX.
200 M EAST OF NINTH LINE

Site Description: AT ROAD CROSSING

Optional Features

Water Temp (C)	Air Temp (C)	pH	Conductivity (Ns)	Turbidity (NTV)	Dissolved O_2 (ppm)
4	6	___	___	___	___

Number of upstream features: 4

Upstream Roughness: 3

Photo #	Photo Name
438	RUO008UPSTR

Upstream Feature(s)

Feature Number	Distance (m)	Bearing	Type	Flow	Sediment Transport Adjacent	Sediment Transport Feature	Sediment Deposition	Width MT	Feature Width (m)	BF Depth (mm)	Entrenchment Width (m)	Feat. Veg	Riparian Vegetation 0-1.5 m Left	0-1.5 m Right	1.5-10 m Left	1.5-10 m Right	10-30 m Left	10-30 m Right
1	0	344	1	5	1	7	2	2	1.2	370	41	0	4	5	5	5	3	3
2	3	350	7	1	2	0	3	1	0.6	100	41	5	5	3	3	3	3	3
3	8	10	6	4	1	0	1	4	15.0	-99	41	7	7	5	5	5	6	6
4	5	290	5	4	1	5	3	4	0.1	-99	-99	3	3	3	3	3	3	3

Upstream Longitudinal Gradient

Method Used	Distance (m)	Elevation Rise (cm)
2	20	3

Upstream Flow Measure(s)

Record EITHER Hydraulic Head OR Volume OR Distance

Feature Number	Wetted Width (m)	Depth (mm) 1	Depth (mm) 2	Depth (mm) 3	Hydraulic Head (mm) 1	Hydraulic Head (mm) 2	Hydraulic Head (mm) 3	Volume (lt) 1	Volume (lt) 2	Volume (lt) 3	Distance (m) 1	Distance (m) 2	Distance (m) 3	Time (sec) 1	Time (sec) 2	Time (sec) 3
1	1.1	97	110	89	4	2	6									
3	15	5	3	7							1.0	1.0	1.0	30	35	31
4	0.3							0.5	0.5	0.5				10	12	13

Comments

POISON IVY ON LEFT BANK OF STREAM, DOG STRANGLING VINE PRESENT

If more than 1 downstream feature, complete a second Headwater Drainage Form.

Photo #	Photo Name	Photo #	Photo Name	***Downstream Site Length (m)***
439	RUO008DSTRM	440	RUO008DREDGE	20

Downstream Feature

Type	Flow	Sediment Transport Adja-cent	Sediment Transport Valley	Sediment Deposition	Width MT	Feature Width (m)	BF Depth (mm)	Entrenchment Width (m)	Perched Ht (mm)	Jumping Ht (mm)	Feature Roughness	Feat Veg	Riparian Vegetation 0-1.5 m Left	Riparian Vegetation 0-1.5 m Right	Riparian Vegetation 1.5-10 m Left	Riparian Vegetation 1.5-10 m Right	Riparian Vegetation 10-30 m Left	Riparian Vegetation 10-30 m Right
1	5	3	7	4	2	0.9	60	17	350	300	2	0	3	3	3	3	3	3

Downstream Longitudinal Gradient

Method Used	Distance (m)	Elevation Rise (cm)
2	20	5

Downstream Flow Measure

Record EITHER Hydraulic Head OR Volume OR Distance

Wetted Width (m)	Depth (mm) 1	Depth (mm) 2	Depth (mm) 3	Hydraulic Head (mm) 1	Hydraulic Head (mm) 2	Hydraulic Head (mm) 3	Volume (lt) 1	Volume (lt) 2	Volume (lt) 3	Distance (m) 1	Distance (m) 2	Distance (m) 3	Time (sec) 1	Time (sec) 2	Time (sec) 3
0.9							8.0	6.2	8.0				30	25	32

Upstream and Downstream Site Features	Category Value	Comments
Major Nutrient Sources Upstream	5	
Potential Contaminant Sources Upstream	1	SEWAGE TREATMENT PLANT UPSTREAM
Channel Hardening	1	RIP RAP AT THE ROAD NEAR THE CULVERT
Dredging or Straightening	1	DREDGED WITHIN THE LAST 2 YEARS (SEE PHOTO)
Barriers and/or Dams in proximity	1	FISHWAY DOWNSTREAM
Online Ponds Upstream	5	
Springs or Seeps at the Site	4	
Evidence of Channel Scouring/Erosion	1	RIGHT BANK ERODING
BMPs or Restoration Activities	4	

CHANNEL CONNECTIVITY (to downstream) :

☒ Connected ☐ Unconnected

Connected: A surface water flow connection is apparent from the donating feature, to the downstream watercourse with existing or potential overland flow.

Unconnected: A water flow feature that is not connected to the drainage network except by groundwater infiltration. These features drain to kettle wetlands or ponds, etc that have no outlet to the drainage network except via groundwater.

Site Feature Categories
1. Ongoing and active
2. Historical evidence
3. No evidence, but reported
4. No evidence
5. Unknown

Downstream Comments

LOTS OF ALGAE

Crew Leader (initial & last name)		Crew	Recorder
J	EVANS	EB, JR	AL

FEATURE TYPE

1 – DEFINED NATURAL CHANNEL

Channel banks and sorted substrates are visible; there is no evidence that the drainage feature has been historically dredged or straightened.

2 – CHANNELIZED OR CONSTRAINED

Channel banks and sorted substrates are visible and there is evidence that the stream has been historically dredged or straightened. In some instances the channel is constrained by filling, such that access to the flood-plain is no longer available

3 – MULTI-THREAD

Multiple channels for one flow source; multi thread channels are subdivided at low-water stages by multiple midstream bars of sand or gravel. At high water, many or all bars are submerged.

4 - NO DEFINED FEATURE

A topography with no identifiable depression to convey water and no facultative wetland species are present. Water is transported through overland or sheet flow.

5 – TILED

An outlet from a buried stream or tile drain is visible. There may be a defined channel downstream of the outlet caused by scouring.

6 – WETLAND

Feature with sustained water storage function. Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. Obligate wetland species will be dominant (e.g. cattails). Includes beaver ponds.

7 – SWALE

A shallow trough-like depression that carries water flow during rainstorms or snowmelt and has ill-defined banks. Water conveyance is the primary function for the purposes of this definition. Flow not sufficiently sustained to cause substrate sorting or prevent instream vegetation from establishing, and water storage not sustained to promote obligate wetland vegetation (e.g. cattails). Bed will contain facultative wetland plants (e.g. reed canary grass).

8 – ROADSIDE DITCH

A watercourse that conveys roadside and other impervious cover drainage that has been directed to run parallel with a roadway.

9 – POND OUTLET

Flow is from the outlet of an on or offline, irrigation, storm- water or other pond. Indicate the type of pond present in the comments field.

GRADIENT/SLOPE METHOD

1-Visual
2-Clinometer (Deg)
3-Laser Level
4-Survey Level
5-LIDAR
6- Other

FLOW CONDITIONS

(1) NO SURFACE WATER

The feature is dry.

(2) STANDING WATER

The feature has standing water, but there is no visible flow. Channel often alternating between standing water and dry.

(3) INTERSTITIAL FLOW

Flow is observed in the pavement layer of substrates only.

(4) SURFACE FLOW – MINIMAL

There is flow within the HDF that is estimated to be less than 0.5 litres per second

(5) SURFACE FLOW – SUBSTANTIAL*

There is flow within the HDF that is estimated to be more than 0.5 litres per second.

*If Class 5 is selected, record <u>Flow Measures</u>

SEDIMENT DEPOSITION

(1) NONE

No evidence of sediment deposition

(2) MINIMAL

An average of <5mm of new sediment deposits

(3) MODERATE

An average of 5 - 30mm of new sediment deposits

(4) SUBSTANTIAL

An average of 31 - 80mm of new sediment deposits

(5) EXTENSIVE

An average of >80mm of new sediment deposits

WIDTH MEASUREMENT METHOD

(1) CANNOT MEASURE

No definitive boundaries (e.g., defined banks, vegetation, soil)

(2) BANKFULL

Defined channel, measured at top of bank, ideally from one crossover

(3) MEAN WIDTH

Average Width of feature

(4) ESTIMATED

Defined feature but estimated visually

(5) GIS

(6) MEASURED & GIS

A combination of field measurement for bankfull and GIS for feature width

FEATURE ROUGHNESS

(1) MINIMAL

Less than 10% of the areal coverage of the channel substrates contains materials that diffuse flows

(2) MODERATE

10-40% of the areal coverage of the channel substrates contains materials that diffuse flows.

(3) HIGH

40-60% of the areal coverage of the channel substrates contains materials that diffuse flows.

(4) EXTREME

More than 60% of the areal coverage of the channel substrates contains materials that diffuse flows.

RIPARIAN VEGETATION

(1) NONE

Over 75% of the surface area within the 30 m wide buffers of each side of the HDF has no vegetation; includes hard surfaces such as roads and buildings

(2) LAWN

Grasses that are not allowed to reach a mature state due to mowing

(3) CROPPED LAND

Planted or tilled in preparation for planting of agricultural crops; plants typically arranged in rows (due to machine planting); may be subject to periodic tillage

(4) MEADOW

Less than 25% tree/shrub cover; characterized by grasses, forbs and sedges

(5) SCRUBLAND

More than 25% and less than 60% trees and shrubs interspersed with grasses and forbs (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height)

(6) WETLAND

Dominated by water tolerant wetland plants including rushes, and water tolerant trees or shrubs.

(7) FOREST

More than 60% of the canopy is covered by the crowns of trees

EQUIPMENT CHECKLIST:

-Field Sheets
- Safety Vests / Pylons
- Pencils
- One Wood Meter Stick
- One Metal Meter Stick
- Camera (Extra Battery)
- Clinometer
- Compass
- YSI Meter
- GPS Unit
- Measuring Tape

SEDIMENT TRANSPORT

<u>ADJACENT</u>: Soil transport/movement from adjacent lands into feature

<u>VALLEY</u>: All areas that are below the tablelands

1 – NONE

No evidence of sediment transport

2 – RILL

A narrow and shallow incision into soil resulting from erosion by overland flow or surface runoff that has been focused into a 'thin thread' by the soil surface texture of roughness. Generally, rills are less than 0.2 m deep.

3 – RILLS/GULLY

4 – GULLY

A landform created by running water eroding sharply

into soil, typically on a hillside. Gullies have steep sides and either U or V shaped valleys. They are greater than 0.2 m deep, but can be metres to tens of metres in depth and width. When the gully formation is in process, the water flow rate can be substantial, which causes the significant deep cutting action into soil and lack of vegetation growth.

5 – TILE OUTLET SCOUR

Tile outlet drains to a stream and erosive force is sufficiently concentrated to cause bank and/or bed erosion immediately downstream of or around a pipe outlet. Sediment deposits found within the HDF can be directly linked to this source of sediment

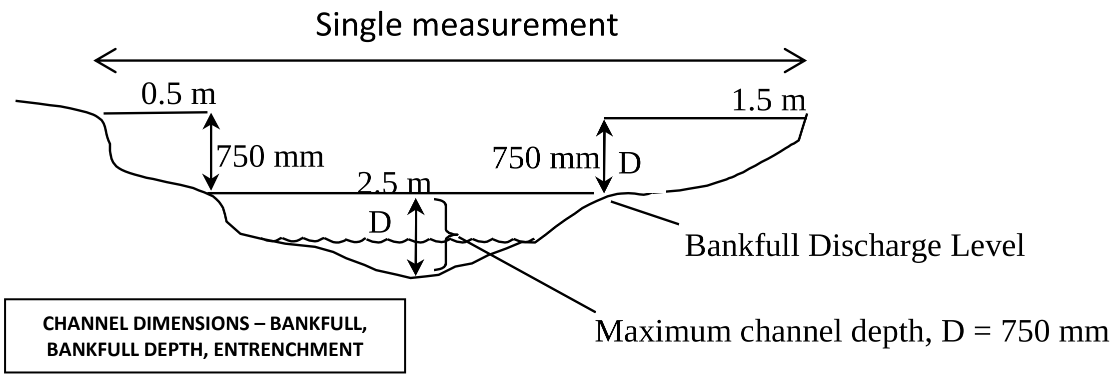
6 – SHEET EROSION

Soil particles are detached and transported as a result of raindrop impacts or by water flowing overland without the formation of rills and gullies. Often this is the precursor of the more obvious rill erosion. Typically associated with tillage on long gradual slopes and low rates of water infiltration

7 – INSTREAM BANK EROSION

Flows or livestock access have generated sediment from within the channel itself that is now available for transport downstream (e.g., bank slumping).

8 - OTHER



CHANNEL DIMENSIONS – BANKFULL, BANKFULL DEPTH, ENTRENCHMENT

Jumping Height – Distance from the <u>bottom of the culvert</u> to the <u>water surface</u>

Perched Height – Distance from the <u>bottom of the culvert</u> to the <u>stream bed</u>

CHANNEL CONNECTIVITY

1 – <u>CONNECTED</u>: A surface water flow connection is apparent from the donating feature to the downstream watercourse with existing or potential overland flow.

2 – <u>UNCONNECTED</u>: A water flow feature that is not connected to the drainage network except by groundwater infiltration. These features drain to kettle wetlands or ponds etc., that have no outlet to the drainage network except via groundwater.

SITE FEATURES – CATEGORY VALUE

(1) ONGOING & ACTIVE

there is evidence of the feature at the time of the site visit

(2) HISTORICAL EVIDENCE

there are signs that the activity has occurred in the past

(3) NO EVIDENCE BUT REPORTED

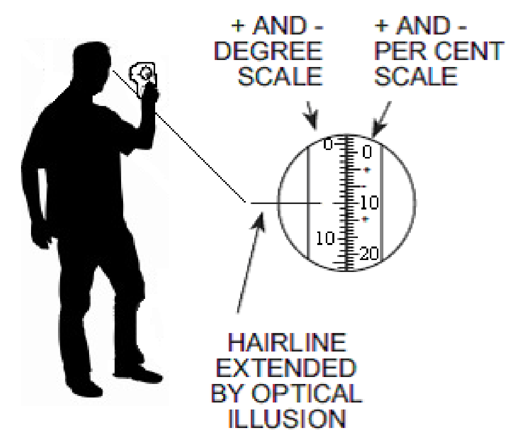
it has been historically reported, but no obvious physical signs exist

(4) NO EVIDENCE

there is no current or historical evidence of this activity

(5) UNKNOWN

the feature has not been sufficiently evaluated.



CLINOMETER UNITS

SITE FEATURES

1 – POTENTIAL CONTAMINANT SOURCE (POINT/NON-POINT)

Point or non-point sources: Look for outlets from storm sewers, tile drains, or industrial discharge pipes. Note any obvious signs of discharge at the site (odor, staining, sheen, etc.).

2 – MAJOR NUTRIENT SOURCES UPSTREAM

Algal blooms or dense growth of aquatic macrophytes are indicators of upstream nutrient sources. If present, look for potential sources such as sewage treatment plants, processing plants, intensive agricultural operations (e.g., chicken ranches, livestock, feed lots) upstream of the site.

3 – CHANNEL HARDENING

Hardening is indicated by rip-rap, armour stone, or gabion baskets.

4 - DREDGING OF CHANNEL

Straightened channels will often have dredged material piled adjacent to the stream, or will be atypically straight relative to the valley gradient.

5 – BARRIERS OR DAMS IN VICINITY OF SITE

Often visible from roads or air photos; historical evidence includes elevated floodplains with an atypically flat gradient throughout the reach. There may also be evidence along the banks (e.g., elevated culverts, fallen timbers or old bridges that have been buried).

6 – ONLINE PONDS UPSTREAM

Any pond with an outlet to a channel that does not have a bypass channel around the feature. This includes those in headwater areas that are groundwater fed with an outlet.

7 – SPRINGS/SEEPS AT SITE

Abundant watercress in the stream; differences in stream temperature between sections (record temperatures in comments); a rust-coloured deposit on sediments surrounding the groundwater discharge zones in areas with high mineral content.

8 – EVIDENCE OF CHANNEL SCOURING/EROSION

Presence of undercut banks, entrenched or incised channel, bare or slumped banks

9 – BMPS/RESTORATION APPLICATIONS

Activities such as fencing, tree planting, livestock watering outside valley etc,

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 11

Unconstrained Headwater Sampling[1]

TABLE OF CONTENTS

APPENDICES

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1.0 INTRODUCTION

The initial S4.M10 Assessing Headwater Drainage Features Module is generally applied as an inventory tool across a large spatial scale where access is limited. Site boundaries reflect these access limitations. This module describes a reach-based approach that explains how the methods can be applied to a study area that does not have access restrictions and can therefore inventory HDF features based on their longitudinal distribution. This module evolved as a result of efforts to apply the original headwater module (S4.M10) within the context of the CVC-TRCA (2014) technical guidelines but can support any study to inventory HDFs across a broad spatially unconstrained landscape

In January 2014, Credit River Valley Conservation (CVC) and Toronto and Region Conservation Authority (TRCA) finalized The Evaluation, Classification and Management of Headwater Drainage Features Guidelines document (hereafter referred to as the guidelines). The guidelines were developed to recognize the cumulative importance of headwater drainage features (HDFs) to the overall watershed, and provide direction to watershed planning activities, such as the development of natural heritage systems, stewardship initiatives and watershed planning. The survey methods outlined in the guidelines follow existing modules of the Ontario Stream Assessment Protocol (OSAP; Stanfield, 2010), including OSAP Section 4 Module 10 (OSAP S4.M10; Stanfield, et al., 2013), but are applied with differing sampling strategies and limitations. This module describes how to apply these methods to meet the needs of the guidelines. Since the sampling methods are described in other modules, this document focuses on study design and tips to help manage the volume of data generated from such surveys.

This procedure describes a rapid assessment approach for characterizing HDFs by providing a point-in-time measure of the feature type, hydrologic conditions, riparian vegetation and sediment transport conditions associated with classified lengths of HDFs. It does not directly outline methods to determine groundwater recharge or discharge functions, fish habitat classifications (refer to OSAP S3.M1), or terrestrial habitat classifications, although data collected following this procedure does inform classifications of these characteristics used in the guidelines. Most importantly, this inventory does not dictate management requirements for HDFs, rather it works to help inform these when they are applied within the guidelines.

Assessmernt of HDFs in karst or other complex geology areas that generate subsurface flows may not be able to be assessed by this protocol. These areas require a more detailed assessment to capture the complexity of water and sediment movements on the landscape.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people (a surveyor and a recorder). Note that with increasing availability of surveying equipment such as range finders and high resolution GPS units, it is becoming feasible for one person crews to be able to measure widths and depths effectively. That being stated, for safety concerns, we would still recommend a two person crew. The following section outlines activities to be completed in preparation for field application of the module.

2.1 Pre-Consultation

If this approach is being applied for the guidelines, a pre-consultation meeting with relevant agency staff represents a critical path for the integration of OSAP S4.M10. The guidelines state that:

> "*Pre-consultation should occur with the Conservation Authority to determine scope and to identify data gaps. Be advised that if the scoping exercise with the CA does not occur prior to the initiation of the assessment and aspects are scoped out of the field program that are not agreeable to the CA, which may result in delays to the project and the possible requirement for additional data collection during the appropriate seasons*."

At a minimum, discussions during the pre-consultation meeting should address the following:

- Review of the study area;
- Data requests;
- Submission requirements;
- Data sharing requirements;
- Timing of the field assessments (specifically Sample event 1); and
- Scoping of data collection specified through OSAP S4.M10, such as:
  - Limit field assessment to those features outside of Special Policy Area Boundaries;
  - Desktop calculation of HDF gradient referencing LiDAR derived contours; and
  - Scoping of specific criteria (e.g. evidence of sediment deposition).

An agreement should also be reached regarding the presentation of Sample event 1 findings to the CA, such that site meetings can be coordinated, as required, and a consensus can be reached on those features that do not require a second site assessment.

2.2 Acquisition of Background Data to Assist with Application of the Guidelines

If the assessment is in support of the application of the guidelines, then additional data acquisition should be initiated as soon as possible. Much of this information also enables integration of sampling across areas of expertise.

- Drainage lines generated by the Conservation Authority (CA) using Arc Hydro, or the watercourse layer as available through the CA or Ministry of Natural Resources and Forestry (MNRF);
- Recent aerial imagery;
- Topographic contour layer;
- Stream code (refers to the downstream mapped watercourse - provided by MNRF);
- Historic aerial imagery (optional);
- Tile drain records (optional);
- Ecological Land Classification layer (optional);
- Natural Heritage Information Centre data (optional);
- MNRF response to Species at Risk Information Request (to determine presence of aquatic Species at Risk); and
- Landowner contact where appropriate.

Species at Risk records and Natural Heritage Information are not required for the OSAP Headwater Module but will factor into the determination of management recommendations for HDFs through the guidelines.

2.3 Mapping

It is recommended that large-scale maps be prepared in advance of the field investigation. Maps should include the following information:

- Property boundaries and (where appropriate) landowner contact information;
- Recent aerial imagery;
- Watercourse layer labelled with stream code identifiers (see below);
- Arc Hydro drainage layer or headwater feature drainage layer referencing the available watercourse layer, topographic contours, and aerial imagery; and

- Bar scale

Unit of Study

A sample site is comparable to the term reach that is found within the headwater guidelines. A sample site in this module is different than those defined in Section 1 since length does not have a minimum criteria. Rather, it is defined by a change in ‘Feature type’, ‘Riparian or Feature Vegetation’.

2.3.1 Segment and Site Delineation

An integral part of this survey is the mapping of the spatial extent of HDFs. The extent of each HDF within a study area will be either the study area boundary (i.e. where the feature extends beyond a property boundary) or where it is no longer discernable on the landscape. This is determined by finding the location where the feature/HDF disappears or becomes so small as to indistinguishable from temporary rivulets. Typically HDFs lose the designation once they merge with a perennial stream, but agreement on the extent of surveys is something that is defined by individual study designs.

Each surveyed HDF site (unit of study) must be assigned a unique identifier that consists of a stream code, segment code and site code delineated into sites. HDFs refer to a length of drainage line from its confluence (or intersection with another HDF) to its origin. A site is comparable to an OSAP site except that the boundaries are not defined by crossovers, but by consistent governing controls on HDF form and function (i.e. classification criteria). Along each HDF, a new site begins when one of the following classification criteria changes:

- Feature type;
- Feature modifier;
- Flow conditions;
- Feature vegetation; or
- Riparian vegetation (either bank in any of the riparian bands described by the guidelines).

To help organize this data, a systematic naming convention is recommended, as described below. However, if the goal is to assign meaning to the coding, it must be done in the field as mapped segments will invariably be in error. Mark the codes on a base map and bring this with you on all subsequent field assessments. An OSAP sample event identifies field surveys using key numeric fields that relate to calendar years. In most situations they will be comparable. Follow the OSAP sample event enumeration guidelines for consistency of data management (S1.M1: Defining Site Boundaries and Key Identifiers).

2.4 Field Equipment

Required field equipment:

1. Headwater sampling field sheet (refer to **Appendix 1**)
2. Pencils
3. Clipboard
4. Large scale field map(s)
5. One wooden and one metal metre stick
6. Camera
7. 30 m tape measure
8. Hand-held GPS Unit
9. Thermometer

10. Stop watch;

Optional Equipment:

11. Bucket
12. White board
13. Float or wiffle ball (neutral buoyancy)
14. Hip or chest waders
15. Turbidity meter and/or YSI meter
16. Calibrated Buckets, funnel, etc., for volume by time discharge

2.5 Timing of field Sampling

As outlined in the guidelines, the timing of initial field sampling for HDFs is driven by hydrology classification assessment periods using flow condition and feature types. Subsequent sampling is directed by specific questions and study designs to ascertain temporal variability of features. The following direction is designed to meet the CVC-TRCA headwater guidelines. If applying the module for other purposes, (for example sediment transport assessment, research, impact assessment, etc.,) sampling should be undertaken at a time that best reflects the study design,

2.5.1 Initial field Surveys:

Initial field surveys should be conducted in the short period of time following a major freshet event, which in Ontario generally occurs during late winter and spring, and before new vegetative growth covers and disrupts any newly deposited sediment. Specific timing of when the sampling should be initiated is quite variable across regions and between years. In some areas, there may be several windows of opportunity before spring growth is sufficient to hinder sampling. Project Managers should develop a sampling strategy that recognizes these complexities and ensure that there is agreement among all agencies etc. that will interpret the findings[2]. Be prepared to blitz a study area when the conditions are appropriate. Factors to consider when choosing a sample period are:

- Following an extended warm period that enables frost to leave the ground;
- Surface flows from recent rain or melt conditions have provided sufficient flows to generate at least close to bankfull flows in some HDFs.
- And the main freshet is subsiding to enable safe sampling and the measurement of sediment deposition, erosion levels etc.

It is equally important to know when sampling should be stopped because the characteristics being assessed become unmeasurable or obscured. Such conditions occur when:

- Frost returns to the ground preventing sediment deposition from being measured
- New vegetative growth exceeds approximately 5 cm, and is sufficient to alter the roughness of a channel, obscure sediment deposition and hide HDF feature boundaries.
- Soils become dry enough that surface groundwater (interstitial flow) ceases.

Generally, this means that sampling should occur between in Ontario. Ideally, sampling will occur after the spring freshet, when shallow groundwater is the major contributing source of water, (generally between late March and the middle of April) however given the variability in conditions present in early spring, crews will begin surveying as soon as possible, recording the nature of flow sources observed.

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[2] It is recommended that surveyors obtain approval of sampling designs from Conservation Authroities prior to the field season to ensure they meet local needs.

1.1.1 Sampling Event 2 and 3

The second field assessment (sample event 2) is typically conducted in late April through mid-May, after the melt/thaw related interflow has ceased. This survey should be completed prior to leaf out so that vegetation growth does not impact findings, preferably, after at least three days with no precipitation. Sample Event 3 is conducted in July to mid-September, following at least three days without a significant (i.e. flow generating) precipitation event.

Systematic Naming Convention Example:

HDFs are numbered sequentially from downstream to upstream within a study area.

Figure 1. Sequential number of HDFs draining to watercourse BR2.

HDFs may be comprised of a single segment or multiple segments. If a mapped HDF branches into several segments, the primary segment is numbered “1” from it confluence to its origin; intersecting HDF segments are assigned alpha-numeric codes (1A, 1B, etc. – refer to **Figure 2**). Once the watercourse stream code, segment code and site code are combined, a unique identifier code is produced for each HDF site:

BRC-H2A-S2

Where:	**BRC**	refers to the watercourse stream code (Bruce Creek, for example)
	H2	refers to the headwater drainage feature (HDF) that confluences with BRC
	H2A	refers to an individual segment of an HDF that drains to Bruce Creek
	S2	refers to Site 2 of HDF segment **BRC-H1**

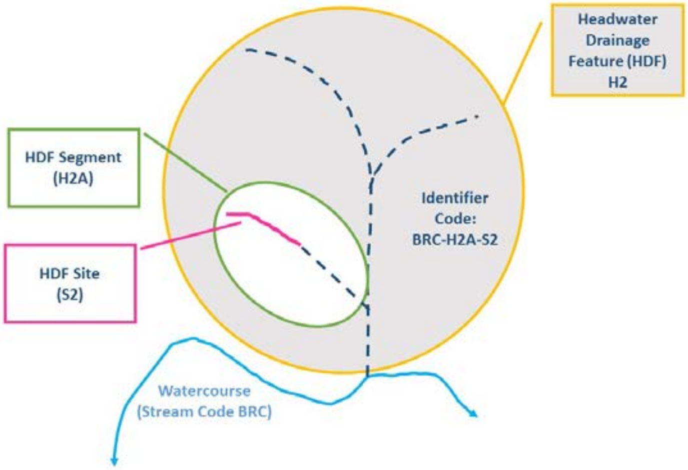

Figure 2. HDF naming convention.

3.0 FIELD PROCEDURES

The sampling methods are comparable to those in module S4.M10 except that they are applied to different site boundaries and that not all are applied in each sample event. Procedures are replicated below highlighting differences where necessary, following the overview of the procedures.

3.1 Overview of Sampling Procedures

One 'Unconstrained HDF assessment form' must be completed for each HDF site per sample visit (see an example in Appendix 1).

3.1.1 Sample 1

Step 1: Beginning at the downstream end of each HDF segment record the 'Geocoordinates' for the downstream end of the sample site and the state of the 'Flow influence' for the day. Then classify the 'Feature Type'; 'Flow conditions', 'Riparian Vegetation', 'Feature Vegetation' types; and the presence of a 'Boundary Modifier' such as a barrier. A change in any of the features or presence of a 'Boundary Modifier' creates the 'Upstream Site Boundary'.

Step 2: While walking upstream observe and record the state of 'Sediment Transport to Feature from Adjacent Lands'; 'Sediment Transport to Feature Within the Valley'; Evidence of Sediment Deposition'; 'Bankfull and feature width'; 'Feature Roughness; and Dominant and Sub-Dominant Particle Sizes';

Step 3: Watch for and record both the type and location 'Geocoordinates' of any important 'Site Features' that are located in or adjacent to the HDFs'.

3.1.2 Sampling Visit 2 and 3

The second and third sample events are intended to ascertain the importance of the HDF for seasonal use by biota, particularly fish[3]. The guidelines use the presence of flow (either minimal or substantial) during this survey to determine the hydrologic classification of each HDF site.

3.2 Flow Conditions

The observed flow conditions in HDF can be highly variable depending on timing relative to the spring freshet, recent rainfall, soil moisture etc., (see Williams 2006, Stanfield and Jackson 2011). Future use of the data will require a classification based on the degree to which flows reflect "spring baseflow" conditions. This can be challenging to ascertain, but with experience crews can classify the degree to which flows reflect either, spring baseflow, a low level freshet or a spate. Indicate on the field sheet which of the categories in Table best reflects the flow influence on the observation date.

Table 1: Definitions of Flow influence

Flow influence Code	Description	Observation
1	Baseflow	The feature is dry or flowing at a rate and condition consistent with only subsurface contributions of flow.
2	Freshet	Flows are elevated but within the bankfull channel
3	Spate	Flows are at or above the bankfull channel

Classify the amount of water flowing within each upstream HDF according to the criteria provided in Table 3:

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[3] These surveys are often associated with additional biological sampling, some that utilize OSAP methods (e.g. Section 3: fish sampling), but may also include benthic or herpetological studies that utilize other sampling protocols in all available habitats that contain water.

3.3 Site Boundary Determiners

Changes in any of the following HDF features will generate either an up or downstream boundary between HDF sites.

3.3.1 Downstream Boundary

The downstream boundary of an HDF is ideally determined by its confluence with another HDF or mainstem of a river (see Figure 2). Alternatively, the downstream boundary of a site could be demarcated by a property/accessibility boundary. If this criteria is used to demarcate a site boundary record this in the comments field for the site and in the metadata as part of the study design (see Section 0).

3.3.2 Feature type

The form of the HDF is a key factor in assessing its function. Categorize the feature type according to the Table 2 definitions and record the appropriate feature type code under 'Type'. Flow is only used in determining feature type when separating defined natural channels from wetlands. Natural (infilling) and unnatural processes (dredging, damming) act on HDF channel conditions. If there is a defined channel, even if the banks are poorly defined or absent because the of dense wetland vegetation, the feature is considered a defined natural channel. Where more than one feature type is present within the site boundaries, record the 'dominant' form by aerial coverage within the site boundaries (i.e. 20 m) on the field sheet.

Table 2: Definitions of types of headwater drainage features

Feature code	Feature Type	Feature Definition
1	Defined natural channel	Channel banks and sorted substrates are visible; there is no evidence that the drainage feature has been historically dredged or straightened.
2	Channelized or Constrained	Channel banks and sorted substrates are visible and there is evidence that the stream has been historically dredged, or straightened. In some instances the channel is constrained by filling, such that access to the flood-plain is no longer available.
3	Multi-thread	Multiple channels for one flow source; multi-thread channels are subdivided at low-water stages by multiple midstream bars of sand or gravel. At high water, many or all bars are submerged.
4	No defined feature	A topography with no identifiable depression to convey water and no facultative wetland species are present. Water is transported through overland or sheet flow.
5	Tiled	An outlet from a buried stream or tile drain is visible. There may be a defined channel downstream of the outlet caused by scouring.
6	Wetland	Feature with sustained water storage function. Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. Obligate wetland species will be dominant (e.g. cattails).
7	Swale	A shallow trough-like depression that carries water flow during rainstorms or snowmelt and has ill-defined banks. Water conveyance is the primary function for the purposes of this definition. Flow not sufficiently sustained to cause substrate sorting or prevent instream vegetation from establishing, and water storage not sustained to promote obligate wetland vegetation (e.g. cattails). Bed may contain facultative wetland plants (e.g. reed canary grass).

Feature code	Feature Type	Feature Definition
8	Roadside ditch	A watercourse that only conveys road runoff. It does not extend upslope of the road that could generate a catchment
9	Pond outlet	Flow is from the outlet of an on or offline, irrigation, storm- water or other pond. Indicate the type of pond present in the comments field.

3.3.3 Flow conditions

Classify the amount of water flowing within each upstream HDF according to the criteria provided in Table 3. If surface flows are classified as substantial (category 5), then, wherever the most convenient and accurate measure of flows can be obtained, follow the procedures and hierarchy of methods below to obtain an estimate of flow. The hierarchy is as follows:

Volume by time: If all of the flow passes over or through a structure such as a perched culvert so as concentrate flows to a central location, place a container so as to capture all the flow and measure the time to fill it takes to fill the container to a known volume. Repeat this measurement three times, recording the volume collected and time to fill to the nearest second.

Hydraulic Head: For streams with relatively uniform; low roughness beds; well confined channels, and velocities that exceed approximately 0.1 m/s in the thalweg, measure the depth and hydraulic head at three equally spaced locations across the stream, (Figure 3). Ideally these measurements would be made at or close to a cross-over, or within a culvert, but choice of the appropriate location will vary. Also record the wetted width of the stream to the nearest 0.01 m. **Record the depth measures to the nearest 5 mm and hydraulic head measures to the nearest mm for those less than 10 mm and nearest 5 mm for any heights greater than 10 mm.**

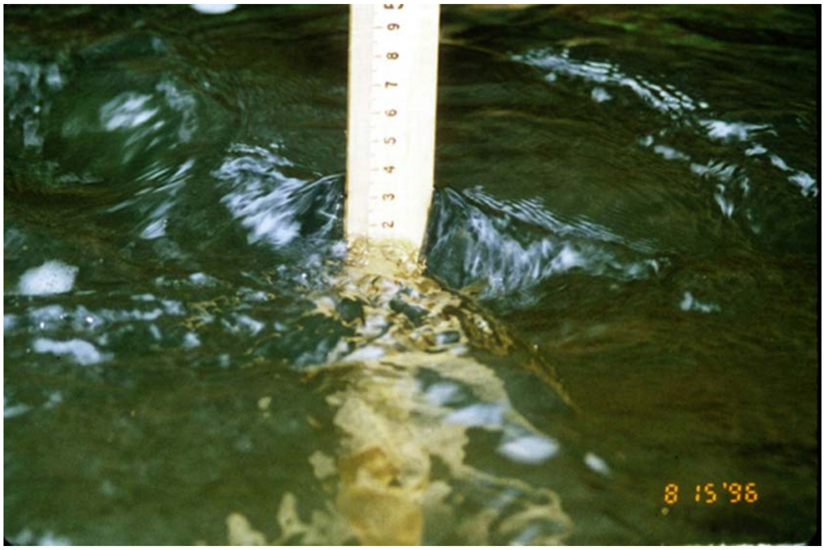


Figure 3: Measuring a 20 mm Hydraulic Head

Hydraulic Head

Hydraulic head is measured by placing a wooden ruler on the stream bed so that it is vertical and the **wide side with the markings is on the downstream side of flows**). The ruler will create a barrier to flow. Measure the maximum height difference observed over a 3-5 second period between the front and back of the ruler (Figure). 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.

Distance by time: Where velocities are insufficient to generate at least a 1 mm hydraulic head, measure the amount of time for a floating object to travel a set distance of stream. Conduct these measurements at any location where flow is relatively uniform and free of debris. In many instances local conditions will dictate where the measurement can be made. Repeat the measure three times.

Estimated Discharge: For streams where none of the above procedures can be applied, or for which access cannot be attained estimate the discharge to the nearest 0.1 l/s. Note that the ability to estimate discharge changes as volume increases. As discharge exceeds about 2 l/s accuracy will decrease to ± .5 l/s". This is recorded on page 2 of the field sheet.

If there is more than one HDF upstream then measure flow conditions from each feature individually and the accumulated flow from **all** the features on the downstream side. If there is only one feature identified upstream then the flow can be taken either up or downstream of the constriction point wherever the most accurate location to record flow may be. In some cases you may need to improvise in order to collect flow measurements (e.g. at multi-thread channels, channels that are too narrow or highly covered). If you feel that this is not possible without compromising the integrity of the results, take the measurement in the culvert. Record any variations from the protocol in the comments section.

Table 3: Definitions of Flow Conditions

Flow Conditions Code	Description	Observation
1	No surface water	The feature is dry.
2	Standing water	The feature has standing water, but there is no visible flow. Channel often alternating between standing water and dry.
3	Interstitial flow	Flow is observed in the pavement layer of substrates only.
4	Surface flow minimal	There is flow within the HDF that is estimated to be less than 0.5 litres per second.
5	Surface flow substantial	There is flow within the HDF that is estimated to be more than 0.5 litres per second.

3.3.4 Feature and Riparian Vegetation

For some types of HDFs the vegetation within the feature plays a significant role in flow and sediment movement and provides wildlife habitat. The vegetation can be quite different than what is found in the riparian corridor. For example, without the confined channel, a feature type that is a wetland could have substantial vegetation. For these and pond features the riparian zone classification is carried out at the edge of the wetland.

Record the type of vegetation found within the feature, i.e. within the area that is below the “bankfull channel” in the Feature Vegetation box. Note that the classification is hierarchical, ensuring that all riparian zones meet one criterion, only. Use the categories defined in Table 4 for both attributes. A feature with wetland as the type of riparian vegetation generally only occurs where the feature is defined as a natural (1) or a channelized/constrained channel (2) (see Figure 10 for an example). With these features, under low flow conditions, there will be distinct banks that enable flows to be concentrated in the channel.

Characterize the dominant vegetation type of the riparian zone on the right and left banks, using the following assessment zones, measured from the stream bank: 0-1.5 m, 1.5-10 m, and 10-30 m and definitions provided in Table 4 and illustrated in Figure 4. Remember, the right and left banks are always assigned looking upstream. Measurements begin at the edge of the feature (e.g. top of bank or at the edge of a wetland or swale). Dominant is the most commonly observed type by areal coverage of the canopy over the entire feature length. If it is not obvious which type is dominant, measure the area (total length and width) of each type, to sort out conflicts (illustrated in Figure 4). Remember, the right and left banks are always assigned looking upstream. Measurements begin at the edge of the feature (e.g. top of bank or at the edge of a wetland or swale). *Dominant* is the most commonly observed type by areal coverage of the canopy over the entire feature length. If it is not obvious which type is dominant, measure the area (total length and width) of each type, to sort out conflicts.

Figure 4: Vegetative zones for determining riparian vegetation.

In this example types are meadow, lawn and lawn for zones 0-1.5; 1.5-10 and 10-30 m respectively and there is no vegetation within the feature.

Figure 5: Example of wetland riparian vegetation on a naturally defined channel.

Table 4: Definitions of Riparian Vegetation Categories

Riparian Vegetation Code	Description	Observation
1	None	Over 75% of the surface area within the 30 m wide buffers of each side of the HDF has no vegetation; includes hard surfaces such as roads and buildings
2	Lawn	Grasses that are not allowed to reach a mature state due to mowing
3	Cropped Land	Planted or tilled in preparation for planting of agricultural crops; plants typically arranged in rows (due to machine-planting); may be subject to periodic tillage
4	Meadow	Less than 25% tree/shrub cover; characterized by grasses, forbs and sedges.
5	Scrubland	More than 25% and less than 60% trees and shrubs interspersed with grasses and forbs (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height)
6	Wetland	Dominated by water tolerant wetland plants including rushes, and water tolerant trees or shrubs
7	Forest	More than 60% of the canopy is covered by the crowns of trees

3.3.5 Boundary Modifier

Some point features can significantly alter the hydrology or sediment transport capabilities of an HDF and are therefore used to create site boundaries when they occur. The site conditions will remain until there is a change in point feature condition or one of the other factors changes (e.g. dredging is no longer evident). The boundary modifiers are:

- The presence of a barrier of sufficient height to cause sediment deposition behind it or scouring below it
- Channel dredging or straightening
- A culvert and road crossing
- A two stage change in flow condition as defined in Table 3 in the HDF (e.g. category 1 – 3 or category 2-4).

Record the reason for the boundary break under 'Site Break Trigger' on the field sheet, explaining the rationale in the comments/other field.

3.4 Site Attributes

3.4.1 Geocoordinates

The downstream and upstream boundaries of each site must be documented using a GPS waypoint for translation to digital maps. Record either the GPS Waypoint number (WP # on the field sheet), or the coordinates (safer) for both locations on the field sheet (see Appendix 1). It is recommended that reach boundaries be denoted on the field map as a backup for data recording errors.

3.4.2 Longitudinal Gradient

Measure the longitudinal gradient of the site using one of the approaches shown in Table 5 and as agreed upon by all members of the study team. Note, if available, LiDAR is a preferred and most efficient method of obtaining this information.

If being measured in the field, establish the measurement locations so that both the top and bottom of the site can be observed. If there is significant curving across the length of the site that will not be measured accurately using GIS, measure and record the site length through the thalweg of the HDF, to the nearest metre, the change in elevation to the closest 10 millimetres (or degrees if using a clinometer) and indicate the method used to measure the slope as defined in Table 5 in the box provided under “Upstream Longitudinal Gradient”.

For more details on measuring slope using a laser or survey level see module S4.M7 – Measuring Stream Slope.

Table 5: Longitudinal Gradient: Method Codes

Method Code	Method Used
1	Visual
2	Clinometer
3	Laser Level
4	Survey Leve l
5	LiDAR (Digital Mapping**)**
6	Other

3.4.3 Point Feature Data

This section represents an expansion of the Site Featrues section of S4.M10 to accommodate the more rigorous requirements of an Environmental Impact Study and to map the location of all observed features. Any evidence of point features as described in Table 6 should be recorded, including their absence (a blank box suggests that surveyors have failed to look for the feature. A list of point data codes and their associated descriptor is provided in Table 7. For each point feature, a waypoint is recorded and a photograph taken. Additional notes to inform or characterize the feature are highly recommended.

Table 6: Categories of evidence of a point data feature presence near a site.

Code	Category	Description
1	'Ongoing and Active'	There is evidence of the feature at the time of the sample event
2	'Historical Evidence'	There are signs that the activity has occurred in the past
3	'No Evidence but Reported'	It has been historically reported, but no obvious physical signs exist
4	'No Evidence'	There is no current or historical evidence of this activity
5	'Unknown'	The feature has not been sufficiently evaluated.

Record the point feature data code, category and a description of the feature on the field sheet (see example below). It is recommended that photo numbers and the name that the electronic file will be changed to be recorded on the field sheet include the site code and the data point code (e.g. RC-H1-R1-F2-25).

Example: Record of a Point Feature Observation.

POINT FEATURE DATA

WP#	Photo #	Code	Category	Description
1	25	F	2	Historic evidence of beaver dam (e.g., RC-H1-R1-F2-25)

3.4.4 Sediment Transport from Adjacent Lands

Examine the areas in the vicinity of the HDF site and note whether there is evidence of sediment transport moving into the feature laterally from the adjacent lands. Adjacent lands are considered all lands upslope of the feature limits.This information will assist in determining whether there is evidence that soil is being eroded from adjacent lands and being conveyed by the HDF. Match the type of sediment transport present to the definitions provided in Table 8, and record these observations in the "Sediment Transport-Adjacent" field. Note: some categories such as tile outlets and instream bank erosion are unlikely to be found outside of the feature, but one table is used for convenience.

Table 7: **Point Feature Data Codes**

Code	Point Feature	Description and information to be added in comments
A	Spring/ upwelling	Estimate <0.5 l/sec or >0.5 l/sec; measure temp
B	Seepage area -	Estimate length of bank where seepage occurs
C	Watercress	Estimate total surface area occupied
D	Outlet (tile or other)	Record flow status as per feature flow. Estimate volume <0.5 l/sec or >0.5 l/sec. Measure temperature.
E	Inlet (tile or other)	Record flow status as per feature flow. Estimate volume to be <0.5 l/sec or >0.5 l/sec.
F	Beaver dam	Measure perched height and jumping height
G	Manmade dam	Measure perched height and jumping height
H	Other barrier	Any other barrier to fish movement
I	Potential contamination source	Storm sewer outlet or industrial discharge pipe
J	Channel hardening	Indicated by rip-rap, armour stone, or gabion baskets etc.,
K	Culvert	Note type, size and whether or not perched. If perched, record perched height and jumping height.
L	Flow transition point –D/S	Flow condition changes from dry to standing water category to another that is not related to convergence with another waterbody
M	Flow transition point – M/S	Flow condition changes from minimal to substantial surface flow, independent of convergence with another waterbody
N	Flow transition point D-S/IF	Flow condition changes from dry/standing water to interstitial flow, independent of convergence with another waterbody
O	Fish	Fish observed during non-fish sampling activities
P	Potential nutrient source	From point or non-point sources such as sewage treatment plants, processing plants, intensive agricultural operations (e.g. chicken ranches, livestock, feed lots, manure spreading)
Q	Dredging	Dredged material piled adjacent to the stream, or will be atypically straight relative to the valley gradient.
R	Pond	Off or online ponds. Record which in the comments
S	Other	Any other features not already covered

Table 8: Sediment transport codes and descriptions.

Sediment Transport Code	Description	Observation
1	**None**	No evidence of sediment transport
2	**Rill**	A narrow and shallow incision into soil resulting from erosion by overland flow or surface runoff that has been focused into a 'thin thread' by the soil surface texture of roughness. Generally, rills are less than 0.2 m deep.
3	**Rills and Gully**	Both rills and gullies present on the tablelands
4	**Gully**	A landform created by running water eroding sharply into soil, typically on a hillside. Gullies have steep sides and either U or V shaped valleys. They are greater than 0.2 m deep, but can be metres to tens of metres in depth and width. When the gully formation is in process, the water flow rate can be substantial, which causes the significant deep cutting action into soil and lack of vegetation growth.
5	**Outlet Scour**	Tile outlet drains and other entombed HDFs outlet to a stream through a pipe with sufficient erosive force to cause bank and/or bed erosion immediately downstream of or around the outlet. Sediment deposits found within the HDF can be directly linked to this source of sediment (Figure 6a).
6	**Sheet Erosion**	Soil particles are detached and transported as a result of raindrop impacts or by water flowing overland without the formation of rills and gullies. Often this is the precursor of the more obvious rill erosion. Typically associated with tillage on long gradual slopes and low rates of water infiltration (Figure 6b).
7	**Instream Bank Erosion**	Flows or livestock access have generated sediment from within the channel itself that is now available for transport downstream (e.g. bank slumping).
8	**Other**	Describe in comments

Figure 6(a): Outlet erosion and (b) sheet erosion.

3.4.5 Sediment Transport to Feature from within the Feature

Sediment generated within the feature can also be transported downstream. Use the codes in Table 8 to record whether there is any evidence of erosion that originates within the high flow channel or areas where hydric soils extend beyond the the bankfull channel in which the HDF flows. Record the most appropriate code in the “Sediment Transport-Feature” field.

3.4.6 Evidence of Sediment Deposition

Assessing the amount of recent sediment deposited in a channel provides an index of the degree to which the feature could be transporting sediment to downstream reaches. The volume of new sediment deposits is an indicator of the amount of sediment transported by the HDF. Examine the hydrologically active area (i.e. valley that transports higher flows) of the HDF and note if a fresh (i.e. this year) layer of sediment has been deposited over the substrate or previous year’s vegetation (see Figure 7 examples). If sediment deposits are evident, lightly push a metal ruler or metre stick into the ground until resistance is met by either old vegetative material or compacted soils. Measure this depth in at least three different locations and record the category that represents the average depth of new sediment according to (see Examples Figure 7). Evidence of excessive sediment deposition might indicate the need for more detailed follow-up surveys.

Figure 7: Examples of HDF’s with varying amounts of sediment deposits.

Table 9: Definitions of sediment deposition categories.

All measurements are made at deposition areas (e.g. point bars) within the active channel.

Sediment Deposition Code	Description	Observation
1	None	No evidence of sediment deposition
2	Minimal	An average of less than 5 mm of new sediment deposits

3	Moderate	An average of 5 to 30 mm of new sediment deposits
4	Substantial	An average of 31 to 80 mm of new sediment deposits
5	Extensive	An average of greater than 80 mm of new sediment deposits

3.4.7 Feature Width

The width of a HDF provides a measure of its ability to convey or store water. Where a channel exists, water conveyance is positively associated with the width of the bankfull channel, while water storage capacity is positively associated with the overall width of the feature, as defined by the extent of hydric soils.

Wherer channels are less well defined, the hydric soils associated with the feature extend beyond the top of bank into the riparian zone. Table 10 provides guidance to assist with defining the feature width boundaries in various HDF types. Where access or safety concerns prevent an accurate measurement, estimations can be made (see Figure 8 below for one example). For larger features width can be measured using ortho-images and GIS. The FWIS also has these capabilities. Record the ‘feature width’ to the nearest tenth of a metre, although the accuracy of the measurement is considered to be one metre.

Table 10: Guidance for how to define Feature Width boundaries of various HDFs

Feature Type	Feature Width
Defined Channel	The inflection point that denotes the bankfull channel (see below)
Wetland	The wetland boundary will be where vegetation is 50% wetland species (e.g. cattails, willows, etc.) and 50% terrestrial species. Transitions to upland vegetation will usually be evident.
Swale	The swale boundary will be the top of the depression or conveyance channel. It is often demarcated by a change in vegetation (e.g. reed canary grass to upland vegetation species.
No Defined Channel	Not possible to measure. Record 0.
On-line Pond	Measure the width of the pond at its widest point.

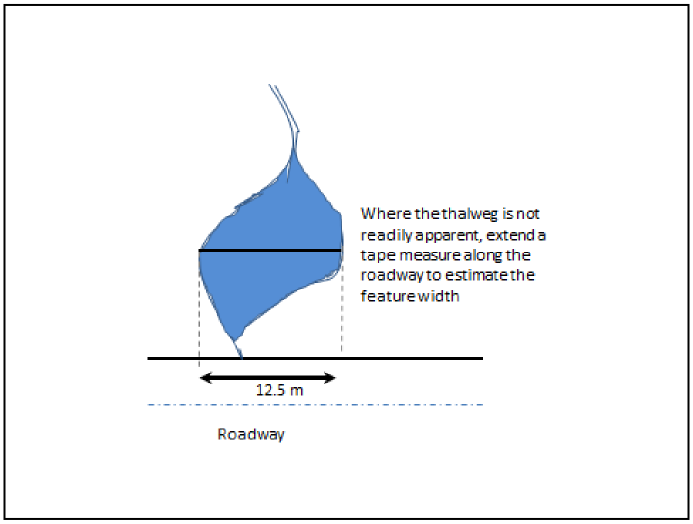


Figure 8: Estimating feature width where access is restricted or thalweg is indeterminate.

Measurement Method:

With so many options to determine feature widths a “Width Method (MT)” field is provided to offer a means of documenting the method used to make these measurements. Record the category that represents how the measurements were taken (Table 11). When possible physically measure a feature at a crossover or if necessary at a mean of three locations (for oddly shaped features e.g. multi-thread channels).

Table 11: Width Method Codes

Width Method Code	Description	Observation
1	Cannot Measure	No definitive boundaries (e.g. defined banks, vegetation, soil)
2	Bankfull	Defined channel, measured at top of bank or bankfull level from one crossover
3	Average Width	Average width of feature, measured at a representative location or if highly variable the mean of 3 locations
4	Estimated	Defined feature boundaries but width is estimated visually
5	GIS	Measured using ortho-image from a GIS for wetlands or ponds
6	Measured and GIS	A combination of field measurement for bankfull and GIS for feature width

3.4.9 Bankfull Width (Defined Channels Only)

Bankfull width is measured from the top of the bank on one side to the top of bank on the other side of the stream (Figure 9). More detail on how to consistently identify the bankfull level is available in S4.M3 (3.1.2 identifying the Bankfull Level). The specific location to place the tape measure is where the stream channel begins to spill onto the adjacent floodplain 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. Take the measurements at a location that represents the “average” bankfull width at the site; avoid unusually wide or narrow spots. This is best applied at the location where the thalweg (main concentration of flow) is in the middle of the channel at bankfull flows. If the bankfull width is highly variable within the site, take and record a true average bankfull width. Record the individual measurements in the comments field. Record the ‘bankfull width’ to the nearest tenth of a metre in the ‘Feature Width’ box and ensure the bankfull (2) method box is marked. This width measure is used in the ‘Bankfull Depth’ and ‘Entrenchment’measures below.

3.4.9 Bankfull Depth (Defined Channels Only)

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) (Figure 9). Record the bankfull depth to the nearest 5 millimetre in the field marked ‘Bankfull depth’.

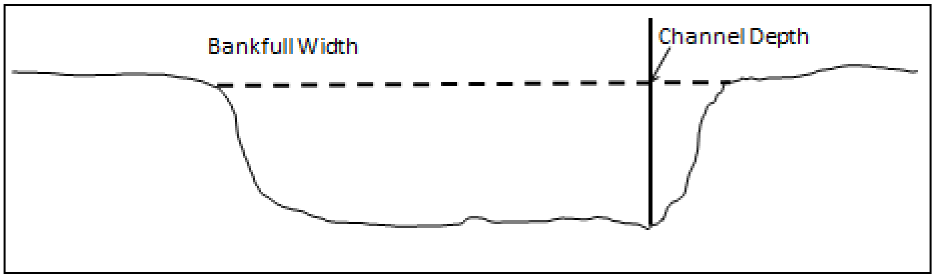


Figure 9: Measuring bankfull width and depth.

3.4.10 Channel Entrenchment (Defined Channels Only)

The degree to which flows are contained within its floodplain during high flow events is a measure of entrenchment. Channel entrenchment is defined as a ratio of the width of the floodplain relative to the bankfull width. For consistency the measurement is standardized to a vertical depth of two times the depth of the maximum depth of the channel at bankfull flows (Rosgen 1996). Channel entrenchment is typically measured on the primary channel at the same time that bankfull width and maximum channel depth are measured. To obtain the measurement, double the maximum channel depth and stretch a tape at right angles to the primary feature until it intersects with a bank. This distance represents the entrenchment width. This can also be calculated incrementally (see Figure 10).

Entrenchment width is used with bankfull width to assess channel confinement. If the entrenchment width is > 2 times the bankfull width the stream is considered unentrenched. For efficiencies, entrenchment need not be measured on streams for which the ratio is > 3. By definition surveyors record a width of 41 to indicate that the entrenchment ratio is > 3.

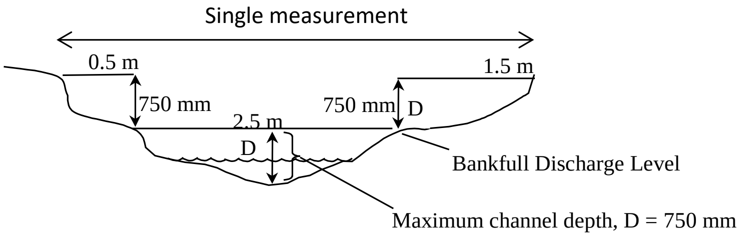


Figure 10: Measuring Channel Entrenchment.

This channel has an entrenchment width of 4.5 m for a confinement ratio of 1.8m (i.e. a confined channel).

3.4.11 Feature Roughness

Feature roughness will provide a measure of the amount of materials within the bankfull channel that could slow down the velocity of water flowing within the HDF "channel". Examine the extent of areal coverage of materials that could obstruct or diffuse flow within the site. Materials that provide roughness include: vegetation and sticks >20 cm long, boulders, rocks and logs (> 10 cm median diameter axis). Record the roughness of the channel for both the up and downstream sections of the site according to the following categories (Table 12):

Table 12: Definitions of Feature Roughness Categories

Feature Roughness Code	Description	Observation

1	Minimal	Less than 10% of the areal coverage of the channel substrates contains materials that diffuse flows.
2	Moderate	10-40% of the areal coverage of the channel substrates contains materials that diffuse flows.
3	High	40-60% of the areal coverage of the channel substrates contains materials that diffuse flows.
4	Extreme	More than 60% of the areal coverage of the channel substrates contains materials that diffuse flows.

3.4.12 Dominant and Subdominant Substrate

For the entire site, estimate and record the dominant and second dominant substrate types in the 'Substrate' section. Dominant substrate types are determined by visual estimation, and represent the most coverage of the HDF bed by space. If in doubt, estimate aerial coverage within several plots and average. Substrate categories can be viewed in Table 13.

Table 13 - Substrate Class Categories

Class	Description
1	Clay
2	Silt (floury, <0.06 mm)
3	Sand (grainy, 0.06 – 2 mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 – 250 mm)
6	Boulder (>250mm)
7	Bedrock

3.4.13 Presence of a Barrier to Fish Migration

A barrier to fish migration occurs when some object, such as a culvert or dam creates a perched stream. That is there is a drop from the top of the barrier (i.e. culvert) to the stream bed and results either from improper installation or stream erosion. Perched conditions may prevent fish from accessing upstream waters.

For sites where perched conditions exist, measure the distance from the bottom of the perched feature (i.e. culvert) to the stream bed and record as the 'Perched Height' (mm) on the field sheet. Also measure the distance from the lowest part of the feature (its center) to the water surface and record this as the 'Jumping Height' (mm) (Figure).

If the feature is dry, only record the perched height in the jumping height box. Record these measurements to the nearest 5 mm.

Figure 11: Measuring depth to bed and jumping height for fish at a perched culvert.

3.4.14 Channel Connectivity

Determine whether the HDF is connected or unconnected to downstream reaches of surface water flow using the definitions in Table 14 and the example in Figure 12. With this module connected is the default feature. Place an 'X' in the 'Unconfined HDF' box for all assessessed features found to be unconnected. Such an assessment would include HDFs that disappear or go underground.

Table 14: Definitions for channel connectivity

Connectivity Code	Categories	Definitions
1	**connected**	A surface water flow connection is apparent from the donating feature to the downstream watercourse with existing or potential overland flow.
2	**Unconnected**	A water flow feature that is not connected to the drainage network except by groundwater infiltration. These features drain to kettle wetlands or ponds etc., that have no outlet to the drainage network except via groundwater.

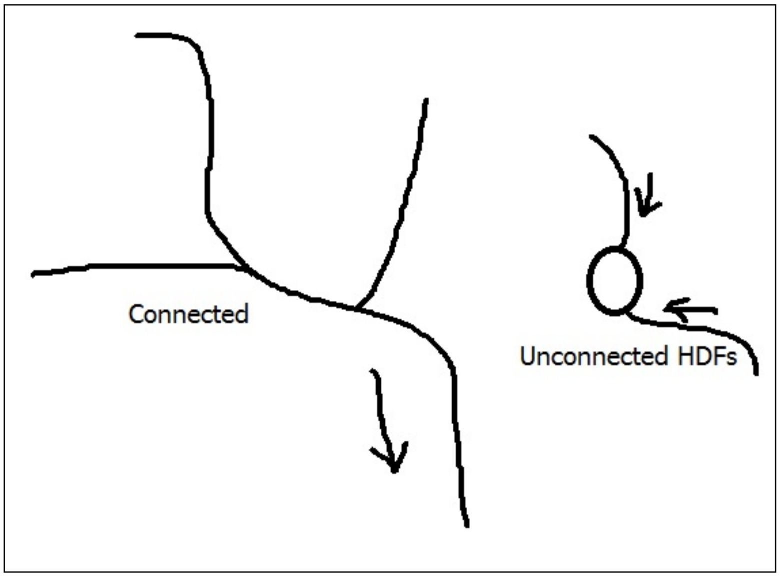
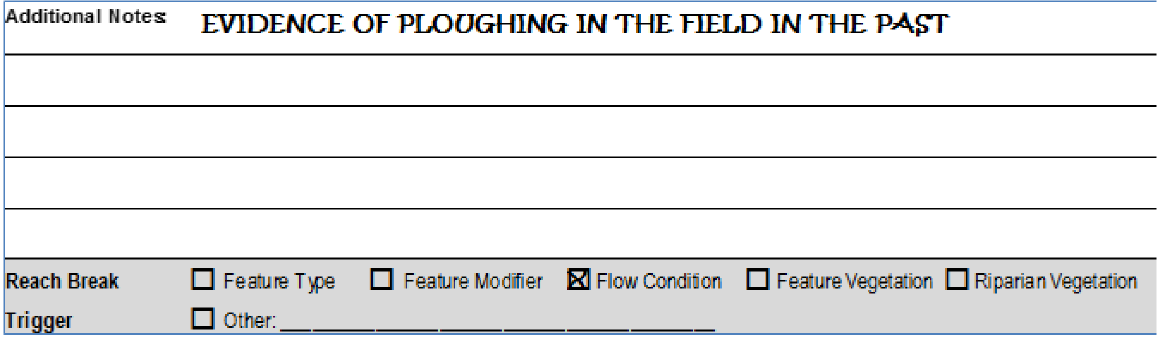


Figure 12: Differentiating connected and unconnected features.

3.4.15 Additional Notes

Any additional information that is relevant to the assessment of an HDF must be documented in the 'Additional Notes' section of the field form. For example, documentation of HDF modifiers, such as land use practices or suspected tile drainage should be recorded. The field form also allows the recorder to document such modifiers on HDF form and function as a site break trigger:

Example of Addiotional notes



Additional Notes: EVIDENCE OF PLOUGHING IN THE FIELD IN THE PAST

Reach Break Trigger ☐ Feature Type ☐ Feature Modifier ☒ Flow Condition ☐ Feature Vegetation ☐ Riparian Vegetation
☐ Other: ______________________

4.0 DATA MANAGEMENT

Particularly for large study areas, proper data management practices are critical to quality control and quality assurance. The following tips can be offered:

- Prepare field mapping in advance with the appropriate stream and HDF codes;
- In order to provide a spatial reference to the site identifier code, it is suggested that sites are numbered from downstream to upstream;
- Laminated field maps will ensure resilience in the face of variable weather conditions;
- GPS waypoints are critical to providing spatial references to field observations;
- In addition to documenting data on field forms, markup field maps to ensure data redundancy;
- Feature type and site limits are determined during Sample event 1; and
- To ensure consistent data collection during Sample events 2 and 3, pre-populate field forms with segment coding and bring a photo record from Sample event 1 (if possible) to allow for common photo vantage points.

The Flowing Waters Information System (FWIS) supports the management and summarizing of this data, including photos. Users can either enter the data on-line or obtain a data template for use in bulk uploads. Data custodians are encouraged to use this system and thereby receive the benefits of shared data and research. For more information on FWIS and how to use the system see OSAP S6.M1. To register for a FWIS account go to http://comap.ca/fwis.

5.0 ACKNOWLEDGEMENTS

This document was developed thanks to the contributions of the Headwater Steering Committee, with special thanks to Les Stanfield for the iterative review process. Thanks also to Cam Portt, Even Bearrs, and Justin Robert and George Coker for their efforts, along with many peer reviewers, including Paul Villard and John Parish, for their helpful comments in bringing this to completion.

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APPENDIX 1

Example Unconstrained Headwater Sampling Field Sheet

Unconstrained Headwater Drainage Feature Assessment

Date: yyyy/mm/dd: 2016/03/12 Project #: BEA656-2016 Recorder/Crew: KIRA/JUSTIN
Stream Name: BLACK CK Stream Code: BRC Site Code: H2A-S2
Site Limits: Upstream WP# 32
Downstream WP# 36
Direction of Assessment: ☐ Upstream ☐ Downstream
Field Assessment: ☒ Sample 1 ☐ Sample 2 ☐ Sample 3
Unconnected HDF: ☐ Not connected to downstream network

Flow Influence ☐ Freshet (1) ☐ Spate (2) ☒ Baseflow (3)

Flow Condition ☐ Dry (1) ☐ Standing Water (2) ☐ Interstitial Flow (3) ☐ Minimal Flow (4) ☒ Substantial Flow (5)

Feature Type ☒ Defined Natural Channel (1) ☐ Channelized or Constrained (2) ☐ Multi-thread (3) ☐ No Defined Feature (4) ☐ Tiled Feature (5) ☐ Wetland (6) ☐ Swale (7) ☐ Roadside Ditch (8) ☐ Pond (9)

Feature Vegetation ☐ None (1) ☐ Lawn (2) ☐ Cropped (3) ☒ Meadow (4) ☐ Scrubland (5) ☐ Wetland(6) ☐ Forest (7)

Riparian Vegetation

0 - 1.5 m	Left Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☒ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
	Right Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☒ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
1.5 - 10 m	Left Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☒ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
	Right Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☒ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
10 - 30 m	Left Bank	☐ None (1)	☐ Lawn (2)	☒ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
	Right Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☒ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)

Channel Gradient (S4.M7) ☐ Visual (1) ☒ Clinometer (2) ☐ Laser Level (3) ☐ Survey Level (4) ☐ Other (5) ☐ LiDAR (6)
Distance (m): ____ ____ ____ Elevation (cm) : ____ ____ ____ Gradient (%): ____

	Clay (Hard Pan)	Silt	Sand (0.06-2 mm)	Gravel (22-66 mm)	Boulder (250 mm)	Bedrock
Dominant Substrate (S2.M3)	☐	☐	☒	☐	☐	☐
Sub-Dominant Substrate (S2.M3)	☐	☐	☐	☒	☐	☐

Feature Roughness ☒ < 10% Minimal (1) ☐ 10 - 40% Moderate (2) ☐ 40 - 60% High (3) ☐ > 60% Extreme (4)

Width Measurement ☐ Can't Measure (1) ☒ Bankfull (2) ☐ Mean Width (3) ☐ Estimated (4) ☐ GIS (5) ☐ Measure/GIS (6)

Channel Dimensions Feature Width (m): 2.5 Bankfull Depth (mm) 350

Entrenchment Total: ☐ > 40 m ☐ < 40 m Left Bank 3.5 m Right Bank 4.7 m Total width ____ m

Surface Flow Method ☐ Perched Culvert (1) ☒ Hydraulic Head (2) ☐ Distance by Time (3) ☐ Estimated (4)

Wetted Width (m)	Wetted Depth (mm)			Hydraulic head (mm)			Volume (L)			Distance (m)			Time (s)		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1.1	15	20	20	3	5	2									

Sediment Transport
Adjacent ☐ None (1) ☒ Rill (2) ☐ Rill and Gully (3) ☐ Gully (4) ☐ Outlet Scour (5) ☒ Sheet Erosion (6) ☐ Instream Bank Erosion (7) ☐ Other (8)
Valley ☐ None (1) ☐ Rill (2) ☐ Rill and Gully (3) ☐ Gully (4) ☐ Outlet Scour (5) ☐ Sheet Erosion (6) ☒ Instream Bank Erosion (7) ☐ Other (8)

Sediment Deposition Measures (mm): ____ ____ ____ ____ ____
☐ None (1) ☐ Minimal: < 5 mm (2) ☒ Moderate: 5-30 mm (3) ☐ Substantial: 31-80 mm (4) ☐ Extensive: > 80 mm (5)

Unconstrained Headwater Drainage Feature Assessment

Date: 2016/03/12 Project #: 20BEA656-2016 Field Assessment: ☒ Sample # 1 ☐ Sample # 2 ☐ Sample # 3

POINT FEATURE DATA

Fish Barrier Measurements: WP# 4 Perched Height (mm): 125 Jumping Height (mm): 110

WP# ____ Perched Height (mm): ____ Jumping Height (mm): ____

WP#	Photo #	Code	Category	Description
1	33	A	1	Small spring with iron staining silt "bubbling"
2	34	P	1	Rivulet draining age from cattle feedlot
3	35	Q	2	Mounds of earth on west side, also straightening present
4	37	G	2	Stone check dam present with sediment deposition behind it

Additional Notes: Saw two fish (likely creek chub) near the stone check dam, heard American toad call

Site Break Trigger ☐ Feature Type ☒ Feature Modifier ☐ Flow Conditions ☐ Feature Vegetation ☐ Riparian Vegetation

☐ Other: Comments ____________________

Point Data Category	Ongoing and Active (1)	Historic Evidence (2)	Reported but No Evidence (3)
	No Evidence (4)	Unknown (5)	

POINT DATA KEY:

A	Spring/upwelling - estimate <0.5 l/sec or >0.5 l/sec; measure temp
B	Seepage area - measure or estimate length of bank where seepage occurs
C	Watercress - estimate total surface area occupied
D	Outlet (tile or other) - record flow status as per feature flow. Estimate volume <0.5 l/sec or >0.5 l/sec. Measure temperature.
E	Inlet (tile or other) - record flow status as per feature flow. Estimate volume to be <0.5 l/sec or >0.5 l/sec.
F	Beaver dam - measure perched height and jumping height
G	Manmade dam - measure perched height and jumping height
H	Other barrier to fish movement
I	Potential contamination source (storm sewer outlet or industrial discharge pipe).
J	Channel hardening - indicated by rip-rap, armour stone, or gabion baskets.
K	Culvert - note type, size and whether or not perched. If perched record perched height and jumping height.
L	Flow transition point D/S - flow condition changes from dry to standing water, independent of segment break
M	Flow transition point M/S- flow condition changes from minimal to substantial surface flow, independent of segment break
N	Flow transition point D-S/IF- flow condition changes from dry/standing water to interstitial flow, independent of segment break
O	Fish observed during non-fish sampling activities
P	Potential nutrient source
Q	Dredging of channel
R	Offline pond
S	Other

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 5

Water Temperature Assessment

TABLE OF CONTENTS

INTRODUCTION

This section describes techniques for assessing water temperature and estimating summer maximum water temperatures. Water temperature strongly influences the composition of aquatic communities. Knowledge of aquatic thermal regimes is important for predicting species composition, activity level, behaviours and life cycle events.

The modules in this section are suitable for use on wadeable streams with flowing water.

Although this section provides very restrictive advice on how to collect temperature data, it should be noted that temperature measurements taken at any time of the year are of value. Field technicians are encouraged to record stream temperatures, regardless of weather and time constraints.

S5.M1: Estimating Summer Maximum Temperatures Under Baseflow Conditions

This module describes a technique for determining the summer maximum water temperature of a site. Results can be used to assess the suitability of a stream for fish communities and for classifying thermal regimes (Barton *et al.* 1985, Stoneman and Jones 1996, Wehrly *et al.* 1999, Chu *et al.* 2009). This technique can be used for determining standardized summer maximum temperature. The methods for calculating the standardized summer maximum temperature are described in Stanfield and Kilgour (in press). This module must be applied within the weather and time constraints described.

S5.M2: Characterizing Stream Temperature Variability Using Digital Recorders

This module describes a method for characterizing stream temperature variability at a site using a digital recording thermometer. The data can be used for determining daily and seasonal fluctuations in water temperature (e.g. daily temperature pattern, diurnal fluctuations, maximum and minimum temperatures, growing degree days) and comparing thermal properties among sites.

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ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 5: MODULE 1

Estimating Summer Maximum Temperatures Under Baseflow Conditions[1]

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APPENDICES

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes a method for estimating the maximum summer water temperature of a site based upon a one-day measurement of air and water temperatures. This module has been developed through research conducted by the Great Lakes Salmonid Unit, Ontario Ministry of Natural Resources (Stoneman and Jones 1996) that demonstrated a relationship between stream maximum temperatures and weather conditions. Results can be used to assess the suitability of a stream for fish communities and for classifying thermal regimes (Barton *et al.* 1985, Stoneman and Jones 1996, Wehrly *et al.* 1999). This technique can be used for determining standardized summer maximum temperature. The methods for calculating the standardized summer maximum temperature are described in Stanfield and Kilgour (2006) and are repeated here in Appendix 1.

This module must be applied within the weather and time constraints described.

The methods described in this module may not provide the actual summer maximum temperature, as summer maximum may occur in conjunction with point discharges of storm runoff or industrial runoff. Those interested in this measure should use a digital recording device (see S5.M2 - Characterizing Stream Temperature Variability Using Digital Recorders).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people. Maximum air temperature data can be obtained from the Environment Canada website (http://www.weatheroffice.ec.gc.ca/canada_e.html) or The Weather Network (http://www.farmzone.com).

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment list is required:

1. Site Features Form (preferably on waterproof paper)
2. Pencils

3. Thermometer (calibrated and accurate to ± 0.5°C)[2] or
4. Digital recording thermometer (calibrated and accurate to ± 0.5°C)[2], with chain, lock and porous anchor (cement block, clay pipe etc).

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g. first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

3.0 FIELD PROCEDURES

This module should be done in conjunction with S1.M1 - Defining Site Boundaries and Key Identifiers and S1.M2 - Screening Level Site Documentation or S1.M3 - Assessment Procedures for Site Feature Documentation.

Data must be collected under the following conditions:

- from any well-mixed section of the stream,
- between July 1st and September 10th,
- between 4:00 pm and 4:30 pm[3],
- on days when the maximum air temperatures exceed 24.5°C, and
- **during a heat wave** (i.e. the sampling day must be preceded by at least two days with maximum air temperatures exceeding 24.5°C) during which there has been no rainfall that affected baseflow.

Water temperature can be determined using either a thermometer or a digital recording thermometer. Digital recording thermometers can be used to monitor temperature over a longer period of time and the data retrieved from the day/time using the above criteria.

If several sites will be sampled within a short period of time, temperatures may be measured at accessible locations (e.g. a road crossing near the site). If this approach is used, the water temperatures from within the site and at the accessible location must be compared prior to the actual sampling day. Temperatures should be the same indicating the absence of groundwater upwellings or other features that can affect stream temperature.

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[2] Equipment must be calibrated and this should be regularly verified. It should also be noted that maximum-minimum thermometers often produce inconsistent data.

[3] Although the predictability is best if temperatures are taken between 4:00 and 4:30 pm, it is recognized this may be logistically difficult, therefore it is acceptable to take temperatures between 3:45 and 4:45 pm.

3.1.1 Obtaining the Stream Temperature

Place a thermometer in the main flow of the stream (e.g. a run or scour pool), avoiding deep pools as they may be sources of groundwater upwellings. After 30 seconds have elapsed, record the water temperature to the nearest degree (‘Water Temperature (°C)’). Also record the time (‘Time:’) that the water temperature was taken.

3.1.2 Obtaining the Air Temperature

Measure and record the air temperature at the time of sampling (‘Air Temperature at Same Time (°C)’). The air temperature should be measured in the shade using a dry thermometer.

Record the ‘Maximum Air Temperature (°C)’ using data from Environment Canada or The Weather Network for the closest monitoring station to the stream. Record the ‘Source of Maximum Air Temp’.

3.1.3 Obtaining Daily Maximum Air Temperature Data

Daily maximum air temperatures are required from July 1st to September 10th. These data can be obtained using either of the following methods:

- placing a digital recording thermometer in a shaded area away from the cooling influence of the stream, or
- obtaining the data from Environment Canada or The Weather Network for the closest monitoring station to the stream.

3.2 Measuring Temperature Using a Digital Recording Thermometer

Secure the digital recording thermometer to an anchor. To protect the digital recording thermometer it can be placed inside a cement block or section of pipe. The device and anchor should be placed in a well-mixed but protected area in the stream. Record the location and the identification number on the digital recording thermometer (if more than one is deployed) in the ‘Comments:’ area on the Site Features Form. Record the ‘Time:’ and ‘Date:’ of deployment.

After at least one weather event that meets the criteria described above, retrieve the digital recording thermometer. Download the data, and sort and extract the stream temperature on the date/time that meets the requirements as stated above. Record this as the ‘Maximum Water Temperature (°C)’ on the Site Features Form. Record the ‘Maximum Air Temperature (°C)’ for that date and how it was determined.

3.3 Tips for Applying this Module

If multiple sites are being assessed using a thermometer, a customized spreadsheet field sheet can be created for recording data. Data should be transferred to the Site Features Form after they are collected.

Do not delay getting the water temperature data on days that satisfy the criteria.

Ensure that the temperature data are transferred to the Site Features Form described in Section 1 shortly after they are collected, since these data often get misplaced.

Summer maximum water temperatures should not be used from periods where there has been heavy rainfall that changes baseflow.

If digital recorders are used, ensure that all water temperature data are archived as they can be used to characterize stream temperature variability (see S5.M2 - Characterizing Stream Temperature Variability Using Digital Recorders).

Digital recording thermometers should not be placed in the open where they will be prone to theft.

Digital recording thermometers are prone to battery failure; therefore batteries should be checked prior to deployment.

Ensure that anchors are heavy enough to prevent digital recording thermometers from being washed downstream during storm events.

4.0 DATA MANAGEMENT

Upon returning from the field;

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 an appropriate digital storage system (e.g. FWIS), and save backup copies that are stored in a separate location from the master copy. See Section 6 for details on information management.

As technology develops the use of electronic devices or tablets are becoming more popular with organizations as a means of recording field data. With this technology it becomes easier to link databases provided the key fields and data structures are compatible with the data structure in FWIS. If you plan to use such devices, please contact the database administrator (available at: http://Comap.ca\fwis) for advice on structuring your data fields and advice for linking applications.

Regardless of the applications used to manage the information, users are encouraged to share provide the data in the appropriate format to provincial repositories to facilitate sharing, increase efficiencies, and lead to a better understanding of how to manage streams province-wide.

5.0 ACKNOWLEDGEMENTS

This module is the direct result of the efforts of Christine Stoneman and Mike Jones. The efforts of Cindy Chu who took up the challenge to determine that this methodology is valid across the Ontario side of the Great Lakes Basin are greatly appreciated.

6.0 LITERATURE CITED

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Chu, C., Jones, N.E., Piggott, A.R., Buttle, J.M. 2009. Evaluation of a Simple Method to Classify the Thermal Charatersistics of Streams Using a Nomogram of Daily Maximum Air and Water Temperatures. North American Journal of Fisheries Management. 29:1605-1619.

Stanfield, L. W., and B. W. Kilgour. 2006. Effects of percent impervious cover on fish and benthos assemblages and in-stream habitats in Lake Ontario Tributaries. Pages 577-599 i*n* R. M. Hughes, L. Wang, and P.Seelbach. Landscape influences on stream habitats and biological assemblages. American Fisheries Society, Symposium 48, Bethesda Maryland.

Stoneman, C.L. and M.L. Jones. 1996. A simple methodology to evaluate the thermal stability of trout streams. North American Journal of Fisheries Management. 16:728-737.

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Appendix 1

Classification of streams based on summer maximum temperature and standardizing temperatures between observations

Thermal Regime Classification

A number of methods exist for classifying the thermal regime of a stream using the data collected in either S5.M1 or S5.M2. Stoneman and Jones (1996) developed a nomogram (Figure A1) to determine thermal regime (cold, cool or warm water) based on results from a small number of tributaries to Lake Ontario. They suggested the algorithm was valid between July 1st and September 7th) and called for others to test the results in other areas.

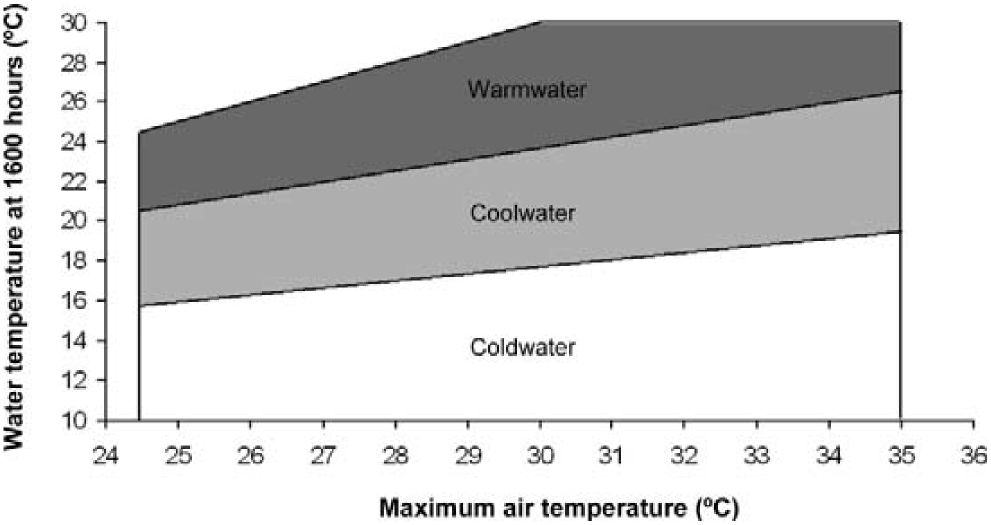


Figure A1. Stoneman and Jones (1996) Thermal Regime nomogram

Chu *et al.* (2009) took up the challenge and tested the relationship on 122 sites that were widely dispersed around the Great Lakes tributaries of Ontario. Their revised nomogram (Figure A2), includes 5 thermal regimes (cold, cold-cool, cool, cool-warm and warm). They also revised the sampling period to July 1st - August 31st and the sampling time was extended to between 1600 and 1800 hours. This suggests that the patterns are robust across the province.

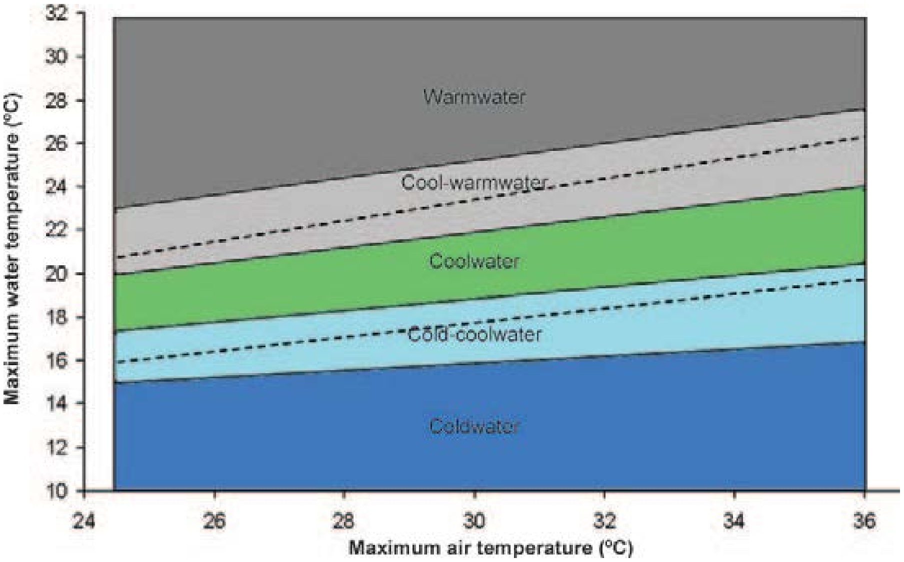


Figure A2. Chu *et al*. (2009) thermal regime nomogram (dotted lines represent the boundaries of the Stoneman and Jones (1996) classification.

Classifying streams into distinct thermal categories is used as a rapid assessment approach for identifying the potential fish assemblages that might be present in a segment. It is best applied in concert with biological data, as summer maximum temperature, at a point in space, is only one of the factors that influence the fish assemblage in a stream segment.

Estimating Summer Maximum Temperature (standardized to air temperature)

There is often a desire to quantify differences in stream temperatures between sites or years of sampling to either look for trends or for inclusion in modeling. However, as shown above the observed stream temperature is dependent on the air temperature. To correct for this effect, requires standardization of stream temperatures to a given air temperature (e.g. 30 C). This is achieved by:

1. Assign each site to an appropriate reference class (Table a.1) based on the lowest deviation from the observed and the predicted water temperature for the air temperature on the day of collection;
2. Predict the stream temperature of each site for an air temperature that you wish to standardize to.
3. Determine the difference between the observed and predicted temperature for each site. This measures whether each site is warmer or colder than a median stream of each reference class.
4. Add or subtract the difference between observed and predicted to the measured temperature to obtain the standardized stream temperature.

Table a.1: Regression Parameters used to predict water temperatures from air temperatures for Stoneman and Jones Nomogram.

Reference Class	Slope	Constant
Cold	0.251	7.513
Cool	0.583	3.497
Warm	0.555	8.838

Table a.2: Regression Parameters used to predict water temperatures from air temperatures for Chu *et al.* Nomogram.

Reference Class	Slope	Constant
Cold	0.1565	11.165
Cold-cool	0.2870	10.170
Cool	0.3304	11.904
Cool-warm	0.4087	12.787
Warm	0.6968	8.0147

For example if a stream temperature of 25°C was determined at an air temperature of 27°C, it would be classified as warm (using Stoneman and Jones Table a.1). This site is 1.2°C warmer than predicted from the algorithm for a warm water stream and therefore the standardized stream temperature would be 26.7°C:

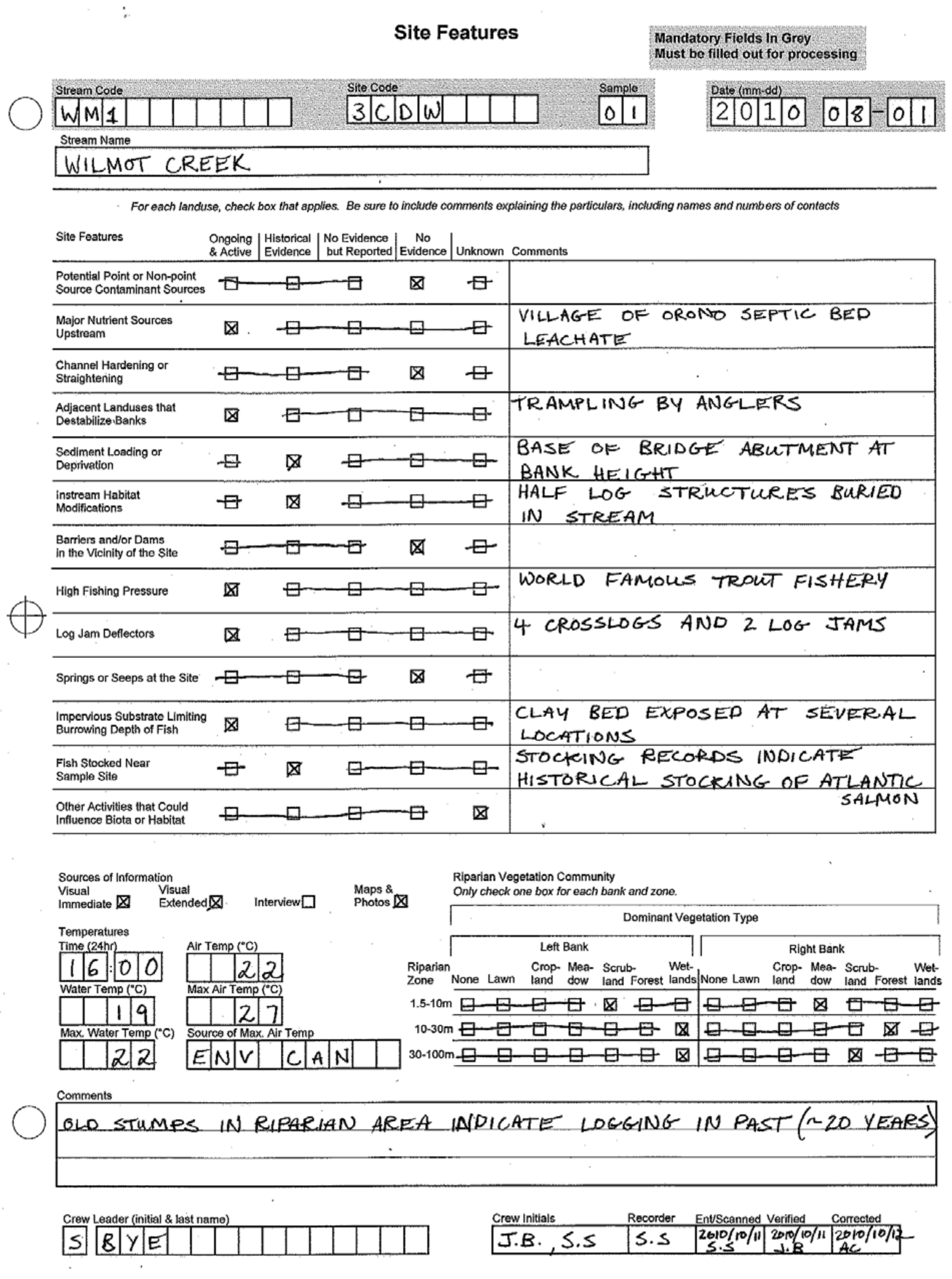
standardized temperature= (30*.555 +8.838)+ (25-23.8). [1]

Either the Stoneman and Jones (1996) or the Chu *et al*. (2009) algorithms can be used for this purpose.

APPENDIX 2

Example Site Features Form

Note that this example also shows data that was collected in conjunction with S1.M3, Assessment Procedures for Site Feature Documentation.



Site Features

Mandatory Fields In Grey
Must be filled out for processing

Stream Code: WM1
Site Code: 3CDW
Sample: 01
Date (mm-dd): 2010 08-01

Stream Name: WILMOT CREEK

For each landuse, check box that applies. Be sure to include comments explaining the particulars, including names and numbers of contacts

Site Features	Ongoing & Active	Historical Evidence	No Evidence but Reported	No Evidence	Unknown	Comments
Potential Point or Non-point Source Contaminant Sources	☐	☐	☐	☒	☐	
Major Nutrient Sources Upstream	☒	☐	☐	☐	☐	VILLAGE OF ORONO SEPTIC BED LEACHATE
Channel Hardening or Straightening	☐	☐	☐	☒	☐	
Adjacent Landuses that Destabilize Banks	☒	☐	☐	☐	☐	TRAMPLING BY ANGLERS
Sediment Loading or Deprivation	☐	☒	☐	☐	☐	BASE OF BRIDGE ABUTMENT AT BANK HEIGHT
Instream Habitat Modifications	☐	☒	☐	☐	☐	HALF LOG STRUCTURES BURIED IN STREAM
Barriers and/or Dams in the Vicinity of the Site	☐	☐	☐	☒	☐	
High Fishing Pressure	☒	☐	☐	☐	☐	WORLD FAMOUS TROUT FISHERY
Log Jam Deflectors	☒	☐	☐	☐	☐	4 CROSSLOGS AND 2 LOG JAMS
Springs or Seeps at the Site	☐	☐	☐	☒	☐	
Impervious Substrate Limiting Burrowing Depth of Fish	☒	☐	☐	☐	☐	CLAY BED EXPOSED AT SEVERAL LOCATIONS
Fish Stocked Near Sample Site	☐	☒	☐	☐	☐	STOCKING RECORDS INDICATE HISTORICAL STOCKING OF ATLANTIC SALMON
Other Activities that Could Influence Biota or Habitat	☐	☐	☐	☐	☒	

Sources of Information
Visual Immediate ☒ Visual Extended ☒ Interview ☐ Maps & Photos ☒

Temperatures
Time (24hr): 16:00
Air Temp (°C): 22
Water Temp (°C): 19
Max Air Temp (°C): 27
Max. Water Temp (°C): 22
Source of Max. Air Temp: ENV CAN

Riparian Vegetation Community
Only check one box for each bank and zone.

	Dominant Vegetation Type													
	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands
1.5-10m	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐
30-100m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☒	☐	☐

Comments
OLD STUMPS IN RIPARIAN AREA INDICATE LOGGING IN PAST (~20 YEARS)

Crew Leader (initial & last name): S BYE

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected
J.B. , S.S	S.S	2610/10/11 S.S	2010/10/11 J.B	2010/10/12 AC

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 5: MODULE 2

Characterizing Stream Temperature Variability Using Digital Recorders[1]

TABLE OF CONTENTS

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes a method for characterizing stream temperature variability using a digital recording thermometer. The data can be used for determining daily and seasonal fluctuations in stream temperature at a site (e.g., daily temperature pattern, diurnal fluctuations, maximum and minimum temperatures, growing degree days), or to document changes due to spike events such as point source discharges of unusually warm or cold water. Data can be extracted and summarized to enable comparisons between sites.

More details and background on the use of, calibration and interpretation of digital temperature loggers is available in Jones and Allin (2010).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment list is recommended:

1. Pencils
2. Digital recording thermometer (calibrated and accurate to ± 0.5°C) [2],
3. Porous anchor (e.g., cement block, clay pipe, 8-10’’ L joint, etc.)
4. chain and lock for securing object

Each digital recorder requires initiation at the office prior to deployment. Follow the operational instructions of the unit prior and ensure it has been calibrated prior to leaving for initial placement. An important consideration in this step is the periodicity of sampling. Make sure to set the device to capture data at a time spacing that meets the project needs and will ensure the unit is operational for the duration of the sampling period.

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.).

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[2] Equipment must be calibrated and this should be regularly verified.

3.0 FIELD PROCEDURES

This module should be done in conjunction with S1.M2 - Screening Level Site Documentation or S1.M3 - Assessment Procedures for Site Feature Documentation.

3.1 Measuring Temperature

Secure the digital recording thermometer to an anchor. Zip ties have been found to be highly reliable for this task. There are many options for securing the thermometer, such as:

- tying it inside a cement block or section of clay pipe;
- attaching it to an existing root wad, or other structure that is unique and can be readily described;
- tying it to 8-10" L brackets that can be driven into the substrate

If the stream is deep or turbid, surveyors should tether the logger and the anchor to shore using wire cable and a padlock. Regardless of the approach used, balance the need for the surveyor to relocate the equipment with the reality that if found, it is likely to be tampered with and your data will at minimum be compromised. Therefore, in most situations surveyors should provide both accurate GPS coordinates and a detailed sketch and description of where the unit is deployed. Record this information on the Site Identification field sheet (Section 1).

The device and anchor should be placed in a well-mixed and and protected area in the stream. The data logger should be shaded from direct sunlight by using a protective boot for this purpose, by installing it in a cinder block (or pipe), or by installing it in a location that is shaded by vegetation or other structures. Record the location and the identification number of the digital recording thermometer (if more than one is deployed) and the 'Time:' and 'Date:' of deployment in the 'Comments' area on the Site Identification Form.

The study design will determine the duration that the digital recording thermometer will be in the stream. If the study design requires comparisons between the water and air temperatures, the latter can be obtained from the Environment Canada website (http://www.weatheroffice.ec.gc.ca/canada_e.html) or The Weather Network (http://www.farmzone.com) or can be measured by placing a digital recording thermometer in a shaded area away from the cooling influence of the stream.

3.2 Analyzing digital temperature data

Digital loggers can be used to determine the summer maximum temperature as defined in S5.M1. Download weather data and determine the hottest and driest period of the summer and find the stream temperature that corresponds with 16:30 for the date. Surveyors are encouraged to transfer this observation to the Site Feature field sheet (S1.M3) and to record this observation in the Flowing Waters Information System (FWIS), to facilitate a better understanding of this metric and fish assemblages across the province.

A number of methods exist for reading and analyzing temperature logger data. Temperature logger manufacturers provide proprietary software that enables initial download and some analysis features. One locally developed tool, ThermoSTAT[3] provides a means to both manage and clean the data as well assist with analysis. ThermoSTAT helps identify and remove out-of-water days and calculates summary statistics and optimal/critical temperature ranges for fish species, among other things. Other products and websites are also available (e.g., CUASI-HSI[4] to facilitate information sharing and analysis.

If a third party program is to be used to analyze the data, consult the user manual for the program to determine the appropriate date:time format that the temperature loggers should be set at before they are deployed.

3.3 Tips for Applying this Module

Digital recording thermometers should not be placed in the open where they will be prone to theft.

Digital recording thermometers are prone to battery failure; therefore batteries should be checked prior to deployment.

Ensure that anchors are heavy enough or are secured to permanent structures in order to prevent digital recording thermometers from being washed downstream during storm events.

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3. http://people.trentu.ca/nicholasjones/thermoStat_home.htm

4.http://his.cuahsi.org/system.html

4.0 DATA MANAGEMENT

Upon returning from the field;

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

2. Download data from temperature loggers and backup data to a secure location. While convenient, it is recommended that spreadsheets not be used to store the raw data, as these systems can readily be corrupted and the sheer volume of information will rapidly overwhelm the practitioners. A number of initiatives are underway that will hopefully address the long standing issue of management of this data. Updates on the progress of these initiatives will be provided on the FWIS website.

5.0 ACKNOWLEDGEMENTS

The field crews of the Salmonid Ecology Unit provided much of the advice for how to best deploy digital temperature recorders so they could be relocated with viable data.

6.0 LITERATURE CITED

Jones, N.E. and Allin, L. 2010. Measuring Stream Temperature using Data Loggers: Laboratory and Field Techniques. Ontario Ministry of Natural Resources, Aquatic Research and Development Section, OMNR Trent University, Peterborough, Ontario. 28 pp.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 6: MODULE 1

OSAP Data Management[1]

TABLE OF CONTENTS

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[1] Authors:, L. W. Stanfield, J. Blondin and D. Mulholland

1.0 INTRODUCTION

This module is designed to provide guidance in how to incorporate the information collected using the various OSAP modules into a “master” dataset that helps manage the uniqueness and quality of the data[2]. Some of the features that users can benefit from are also described, although since this tool is evolving, users will need to visit the Flowing Waters Information System (FWIS) to keep updated (http://comap.ca/fwis). This new tool replaces the HabProgs database that has served to manage the information since 1996.

FWIS has been developed to help Ontario’s flowing water practitioners to access and manage information on flowing waters. This tool offers a one window approach for identifying where and what data has been collected, by whom and using which techniques/protocols. Data are organized by projects, and descriptions are provided to assist users in understanding why data were collected, how site locations were selected and any specific biases that might be associated with the data. Administrators have retroactively applied as much of the Study Design Metadata module (S0.M1) as feasible to historic datasets and practitioners are being encouraged to document this data for all recent and future surveys. One of the greatest benefits of FWIS is that it provides a means of managing site location information in the province. At present, there is no other province-wide repository of site information and no way to resolve duplicate records that exist in multiple databases across the province. By using FWIS, practitioners will not only be able to improve the accuracy of site locations, but will also be able to identify duplicate records in long term data records that have been shared by agencies. Discovering and managing this information will offer tremendous opportunities to better understand the current state, trends and spatial patterns in Ontario’s streams.

FWIS is intended to provide the same functionality and summary capabilities as was available in HabProgs with the added benefits of having immediate mapping capabilities. The FWIS is also being designed to provide linkages to partner databases so that in the future users will be able to synchronize local databases with FWIS so that users will have immediate access to the most up to date information on flowing waters data in the province and partners who wish to can maintain control of their datasets in-house. In the interim, data managed in alternate applications is being manually uploaded through a system of matching fields (see Section 2).

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[2] FWIS has been designed to support both a centralized and distributed data model. It offers secure central data storage as well as connectivity to other databases to create a “virtual master dataset” - one that can utilize web services and other communications linkages to access and synchronize data to or from multiple disparate databases, depending on each partner’s preferences. Implementation of this phase of FWIS requires coordination with the partners and in the mean-time manual and semi-automatic synchronization processes are offered.

Information management for flowing waters is entering a new and exciting new phase based on technological advances that enable storage and sharing of data across systems and that facilitate more efficient capturing and management of data. As important, is a new interest in the networking of agencies and individuals to work collaboratively on monitoring studies. In Ontario a number of "SMART" networks (Stream Monitoring and Research Teams) have emerged that at their core have a desire to share monitoring information to better assess stream condition and understand the factors that influence their condition[3]. FWIS has been developed to support these goals and to provide assurances that data can be permanently archived and be available to others.

FWIS is evolving in a modular way, without core funding, and as such its progress is incremental. Progress would not be possible if not for the ongoing support of the Centre for Community Mapping (COMAP) and the Computer Systems Group at the University of Waterloo and the various funding supporters (see the FWIS main page). Further, various modules and tools have been created through the generous support of partner organizations such as, the Ontario Ministry of Natural Resources and Forestry, Natural Heritage Section, Toronto and Region Conservation Authority, and the Rideau Valley Conservation Authority. As such, this module will be by definition incomplete. To accommodate this, a living "User Guide" is available on the FWIS website that is periodically updated. In the mean-time the following sections will provide users with guidance towards using the database, with the full knowledge that these guiding principles will apply to future versions of FWIS.

FWIS enables users several options for reviewing and verifying data. Contributors can either review their data on-line, making "live" corrections, or download data in various formats that facilitate desktop editing that when f returned is resynchronized with the master. Finally, other FWIS users can suggest corrections to data that are discovered as the data is used. These suggestions must be approved by the data owners/custodians (see data editing below).

With the appropriate permissions, FWIS enables any authorized user to download subsets of the FWIS database in a format that facilitates use of the data, that is, as either raw or summarized data and in a variety of formats. As more queries and linkages to analytical software emerge, more capabilities will be available. That FWIS can be accessed from any web browser provides a means for crews to confirm site locations from the field that should reduce the frustration of trying to relocate previously sampled sites.

There is agreement among the OSAP collaborators that data should only be entered and housed in one location. Implementation of this strategy requires considerable cooperation and

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[3] See either: http://www.trca.on.ca/sosmart/ or http://www.rvca.ca/watershed/SMARTER/index.html

innovation among partners. An immediate challenge is the provincial management of benthic data that is collected and housed within the MOECC portal[4] as part of the Ontario Benthos Biomonitoring Network (OBBN). As an interim strategy, MNRF and MOECC have established a quasi-manual process to link datasets for surveyors that collect more than one type of data at a site (see Section 2.4) FWIS will continue to be the main location to help manage and document site location information. Other agreements are under negotiation to make even more datasets available in FWIS.

1.1 Background on FWIS

FWIS is a database and data access system that enables data that are collected at more than one scale (e.g. site, transect, point etc.), to be stored and related, and reduces the possibility of duplicate records. It also ensures that users store data in similar formats and measurement units, thereby facilitating study comparisons. FWIS is:

- a secure, web-based portal for discovering and accessing OSAP data on flowing waters;
- a means to help manage and correct site location information and to discover and manage duplicate records;
- an information management system for storing and sharing data collected using all of the OSAP protocols;
- a system for transferring results from scientific collection permit reports; tracked species reports and invasive species to other provincial databases;
- a means of virtually linking internal databases of an organization to the system;
- a tool for generating summary reports for site information;
- a tool for sharing datasets collected using other protocols (i.e. non OSAP) that are not available/accessible to researchers[5]
- intended to provide a means to help manage data from other protocols in addition to OSAP in the future.

FWIS tracks all changes to the database so that for example, historical site codes are maintained so that collaborators can maintain linkages to the contributing organization’s original field sheets and database records.

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[4] http://www.moegisportal.ca/welcome/front.html

[5] FWIS has evolved into a repository for any flowing waters information but is focusing on datasets that are of special interest to the research community, are at risk of being lost to the community and are not available. Contact the database administrator is you know of such a dataset and wish to facilitate its capture and use within FWIS.

1.1.1 Access to FWIS data

Access to data contained within FWIS is governed by a data sharing strategy (see http://www.comap.ca/fwis/adminEdit.php?ListType=adminDataSharingAgreement) that gives preference to those that freely share information in a collaborative way. The sharing agreement is replicated in Appendix I for your convenience. Access to information within FWIS is password controlled, with different levels of access based on criteria defined within the sharing strategy. The general public has access to the generic information on where and what types of data have been collected at individual sites. Varying levels of access permissions are proposed depending on the contribution of the agencies/researchers and the sensitivity of the data. Data custodians are notified when users request downloads of their data to provide additional opportunities for engagement and collaboration.

To be in compliance with the Province's guidelines on the management of sensitive information of rare species, communities and special features, only FWIS users that have successfully taken the sensitivity training provided by the NHIC[6] are permitted to view the location of sensitive taxa that they are not the custodian of.

1.1.2 Freedom of Information Personal Privacy Act Implications

Managing OSAP data must conform to the conditions as defined in the Freedom of Information Personal Privacy Act (FIPPA). Crew names and biota identifiers of agency personnel are not considered private and can therefore be shared. However, land owner names and contact information, names and email addresses, phone numbers etc., are considered private and cannot be stored in FWIS. Names of volunteers that collect OSAP data are also considered private. As such the revised FWIS application will have a screen that users will be asked to toggle to indicate if they are a volunteer and if they are a volunteer they will be asked whether they wish their contact information to be made available to users of their data. A response of "no" will stop the system from recording crew names and biota identifiers for this survey data. Operationally, names will be only visible to an organization that is the custodian of a dataset. Should practitioners require this information; a request will be submitted to the database custodian, which will be forwarded to a project custodian to provide the information.

While crew leader and identifiers are not a required field for any field sample, surveyors are encouraged to volunteer this information, with the full knowledge that it will not be shared with another organization/user without the written consent of the organization that is the custodian of a dataset.

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[6] https://www.ontario.ca/page/natural-heritage-information-centre

Surveyors should be aware that any other personal information found with the database may be deleted by the database manager.

1.1.3 Proprietary Rights and Acknowledgments of Contributions

The intention of the government of Ontario and something that has been endorsed by the FWIS development committee[7] is to move towards freer access to information while still protecting sensitive data; the rights of researchers to first publication and the importance of providing acknowledgements to partners that contribute data to a project. A permissions function is available in FWIS that prevents data from being shared to partners without the consent of a representative of the custodian[8]. In lieu of consent, proprietary rights are applied to data for a period of five years from when the data were collected. Data belonging to projects where no proprietary rights are identified are considered to be public domain and are available for use by partners.

A notification facility within FWIS is available that can send a message to custodians when a project dataset is used by a FWIS member. This is intended to keep partners connected with each other; to ensure data is used appropriately; and to ensure appropriate acknowledgements are provided. Data custodians must ensure that their contact information (e-mail address) is up to date if they wish to be notified when others seek access to their data.

2.0 DATA ENTRY/UPLOADING OPTIONS

Several options exist or are being developed for getting the data into FWIS. These include:

- Direct entry over the internet to the COMAP Portal, including; bulk uploads from another database using a prescribed CSV file format
- Manual data entry on a desktop, tablet or other portable device.

All techniques depend on the continuity and completeness of the key identifiers (see section 1) being available and consistent between nested tables for each sample event.

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[7] The FWIS development committee includes representatives of conservation authorities, several branches of MNR, DFO, OFAH, Trout Unlimited and MOE. A charter and data sharing strategy are available from the FWIS website that guides the development of the application.

[8] Data Custodian: Is the person responsible for the collection of data associated with a project and who has the authority to authorize use of data for analysis or provide the appropriate acknowledgement guidelines.

2.1 Overview of Data Entry Procedures

Regardless of the method used to enter data the following steps must be performed. Details for use of the online version of FWIS are available at the FWIS website.

1. Enter metadata associated with your project to at minimum ensure that the organization that is responsible for the data is recorded. Organization and project are key fields that must be identified, then ideally, the remainder of Module S0.M1 - Study Design Metadata, will be populated so that future users of the database will understand the biases associated with each dataset.
2. Document the sharing criteria for the dataset associated with a project. The default is open access.
3. Use the stepped process below to select a sample site that field data will be assigned to:

    a. Identify the stream that has or is to be sampled and if it has already been sampled use the existing stream name and stream code. If no codes exist for the watershed assign a new unique code. Assigning new codes to tributaries should be done cautiously as future tabular queries will miss sites if watersheds are split too much.
    b. If a site code exists on the same branch of stream within 40m of the sampled location, use this code. Otherwise, users of the FWIS data will erroneously assume that data associated with the newer code is unique spatially. The alternate site code will be maintained in FWIS for querying purposes.
    c. If the site is new, create a new site using the drop down menus.

4. Document the location of the site by ensuring data from S1.M2 to S1.M3 are entered into the system. If site location documentation data exists in FWIS, simply review the existing record to ensure its accuracy.
5. Establish a sample event[9] for the site for which data is available by entering the date (key field) and following up with the field observations for each sample event.
6. Review and correct the data and once completed mark the sample as validated in the data discovery window.
7. Use the data to answer your specific questions, taking advantage of existing summary and reporting procedures and export capabilities.

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[9] A sample event is the application of any part of an OSAP module on a given day. In some instances it may take more than one day to complete a module. In these instances use the start date to identify the sample event date and record in the comments the finishing date.

2.2 Data Entry into the FWIS Portal

Data for any site or sample event can be entered directly into the FWIS portal, either before or after sampling is conducted. Because the portal incorporates high resolution imagery and GIS-style mapping facilities, site location information can be reviewed and corrected immediately. Users enter data by following these steps:

1. Enter or assign (for existing sites) the data that is mandatory following S1.M2 (Screening Level Site Documentation). That is: site code; stream code; stream name and the co-ordinates. If no site code exists within 40m of the sampled location, a new site code and related site data is entered. Similarly, a new stream code can be entered if the stream has not previously been assigned a stream code. Then, if available, enter the access route and site description text and any other optional datasets associated with section 1. This data can also be added after a survey is completed. The new site information will not become active in the system until a sample event date is assigned to the site.
2. A site becomes active when a sample event date is recorded that includes data that has been collected using any of the OSAP modules. Enter the data associated with the module(s) that are collected at each site.
3. Review the data accuracy and completeness and when completed mark the validation box to indicate that the custodian is comfortable that the data accurately reflects the field observations.

Up to date information and help menus are available at the FWIS portal.

2.3 Using a Desktop, Tablet or Other Portable Device

Several initiatives are underway to develop one or more versions of FWIS that will enable users to enter the data on a desktop or tablet device. These applications will have as their core the SQL database structure or equivalent so that uploading to the master database will be seamless. The intent is to use drop down menus to populate the various key fields (e.g. organization, project, stream code etc.) and also take advantage of the drop down menus for as many attributes as possible to increase efficiencies of data entry and to improve quality assurance. As of the spring of 2012 beta versions of both a tablet and a personal computer were piloted successfully. The development team continues to build on these beta versions and will post updates and download links on the FWIS web site[10].

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[10] If you have an interest in developing a data input application for one of the OSAP modules visit http://www.comap.ca/fwis or contact Les.Stanfield@ontario.ca

3.0 DATA VERIFICATION

Regardless of the approach used to make data available in FWIS, the project manager must facilitate the review and verification of all records in the system. The most effective strategy for verifying data is to print a copy of the entered data and to compare this to the field records. Any errors should be marked on the verification copy (using a red pen) and then the corrections should be made in the database. A complete audit of the data should be performed - it is not acceptable to simply check a sample of data points to gauge the probability of errors. If possible, someone other than the data entry technician should conduct the verification process. When the data have been completely 'Verified' and 'Corrected', fill out working boxes in the lower right corner of each field sheet to keep track of the data entry/verification process.

During the verification process, it is also important to make sure that the type of data entered is valid, e.g. that codes are correct, data is recorded in the correct units (e.g. 100 mm not 10 cm), all unique fields are filled in on every field sheet, etc. Therefore, ensure that whoever is verifying the data is also familiar with the protocols used to collect the information so that in the event that errors exist on the field sheet (e.g. a numerical scale issue), these can also be corrected.

If data are missing from any forms, the form should be marked as being incomplete and the information should be obtained and entered prior to the form being marked off as being verified. In some instances the data cannot be obtained and in these instances a comment should be made in the appropriate box to indicate this. Such a note will prevent future users of the data from trying to track down field sheets only to find that the data is truly missing.

If the verification is done within FWIS, make the corrections and when completed, toggle the verification button for the sample event to indicate it is complete. This important step makes draft data accessible as a completed package.

3.1 Bulk Data Export Review and Upload from FWIS

For those users who wish to verify records on their desktops, FWIS incorporates facilities to export data in a simplified structure consisting of at present, six tables (CSV files), as follows:

- Stream Names and Codes
- Site Codes
- Site Feature Sample Events
- Fish Sample Events
- Bulk Fish Sample Events
- Individual Fish Sample Events

The remaining OSAP tables for other modules are under development. These tables can be readily viewed and edited with common desktop office tools such as Microsoft Excel, or Microsoft Access[11]. Users download the tables and review each individually or in their favourite software, making sure to maintain the key field values that will enable the later synchronization back to the FWIS. In particular, DO NOT alter the contents of any column with the term “ID” in it (e.g. VisitID or SEventID) as these include Global Unique Identifiers (GUI_IDs for short) that enable uploads of updates to existing records in the system. Also ensure that the overall column structure of the CSV file is preserved during any manipulations and editing. For example, DO NOT change numeric to text fields etc. Once the data has been verified resubmit it to the database custodian (currently: Les.Stanfield@ontario.ca). In the event that new records are added, users should leave the various GUI_IDs blank to indicate to us that these values need to be populated within FWIS.

4.0 ENTERING/MANAGING OBBN DATA

The fact that data collected using OSAP meets the needs of the partners that participate in the OBBN demonstrates a strong commitment by both MNR and MOE to standardization. However, information management has yet to be fully integrated within these ministries. This is only of concern where datasets overlap at sampling locations as there is potential for duplication of effort amongst practitioners in establishing sampling locations and describing the metadata associated with projects. With duplication of effort comes the real possibility of issues when users attempt to integrate datasets stored within the two applications (FWIS and the MOEportal). This will result when locations or site codes differ in the two databases. To alleviate this concern the FWIS and OBBN development teams have developed the following process to be followed by practitioners:

FWIS should be used as the tool for managing metadata and site location key identifiers (stream codes, site codes). Since OBBN does not at present have a field for stream codes it is recommended that practitioners incorporate both the stream code and the site code in the site code designation (e.g. BN1_SITE2). There are two options for managing the benthic site description data:

1. Users that are collecting data using multiple OSAP modules and wish to contribute benthic data to the OBBN can enter all data except the benthic tally information into FWIS. On returning from the field collection portion of a survey, enter the data into FWIS and use the export functions to obtain electronic copies of the data that can then be emailed to f.chris.jones@ontario.ca for uploading to the MOECCportal. Then when the tally data is available, surveyors can access their uploaded sample and site data and

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[11] The format is readily usable in many formats including: OpenOffice Spreadsheet, Oracle, Sybase SQL Anywhere, MS SQL Server or MySQL.

record the catches. This option will serve practitioners that are not in an immediate rush to enter the tally data

2. Users that do not wish to wait for the upload of data can enter the site description information into the MOECCPortal, in addition to the FWIS database. The database custodians will work to harmonize the data after the fact, so it is essential that site codes and coordinates are comparable between the two databases.

5.0 SUMMARY REPORTS AND QUERIES

FWIS employs a new strategy for providing summary and query capabilities for the data stored within FWIS. The development team is taking advantage of the web, open source coding, and other applications to provide even more capabilities than were available in Habprogs. Basic summary procedures are still available (see below), but in addition users have the capability to either create new summary metrics or to export the data in a format that enables easy analysis in standard applications such as R or CUAHSI-HIS. In this way, users have ready access to a myriad of analytical procedures and can share these with others.

Summary queries are being developed modularly and over time will improve upon those that were available in HabProgs[12]. The summary queries are accessed through the ‘Data Summary and queries tab’ and include:

- Fish distribution map and export table for individual species[13]
- Fish sample event report that generates catch summaries, including corrected catches (Stanfield *et al*. 2013) and estimated biomass of salmonids for species for which correction data is available for individual surveys following Jones and Stockwell 1995.
- Fish summary multiple events export query extracts summary catches of fish surveys for all samples within a designed time period or area of interest and exports them to a database for further analysis.
- Channel Structure individual first conducts a QA/QC on site data from Module 4.2 and then provides summary data on aspects of channel morphology, cover, bank stability, channel homogeneity, substrate characteristics and riparian vegetation; creating a summary report for printing and sharing of results.

Channel Structure Multiple Events compiles summary data from all channel morphology samples from within a specified spatial area or temporal period and exports them to facilitate further analysis.A synopsis of these summary functions is described in the compendium manual

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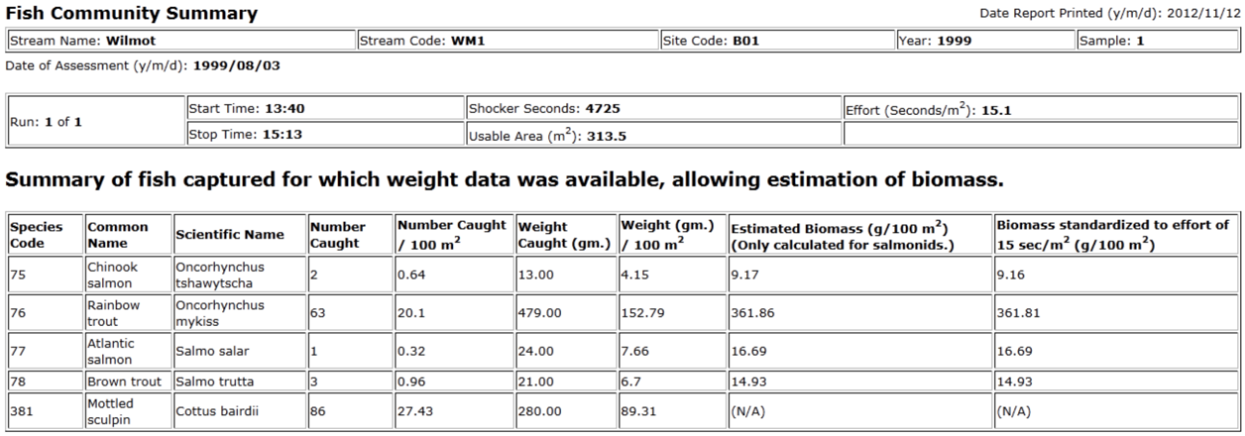
[12] The original MS Access database that supported OSAP data and provided a number of pre-developed queries and analysis options.

[13] In the near future this query will access both FWIS records and the 44,000 records that are available from the fish distributional database.

for OSAP (Stanfield, 2003). This document is available at http://www.trca.on.ca/the-living-city/monitoring/ontario-stream-assessment-protocol.dot.

Future priority summary queries to be generated include those for headwater sampling (S4.M10) and to generate site and then multiple event reports for the various discharge modules (S4.M4-M6). Efforts continue to expand the use of “R” analysis packages. Ultimately, the goal is to have FWIS data directly support various decision support systems and canned State of the Resource reporting tools.



Fish Community Summary

Date Report Printed (y/m/d): 2012/11/12

Stream Name: **Wilmot**	Stream Code: **WM1**	Site Code: **B01**	Year: **1999**	Sample: **1**

Date of Assessment (y/m/d): **1999/08/03**

Run: **1** of **1**	Start Time: **13:40**	Shocker Seconds: **4725**	Effort (Seconds/m^2): **15.1**
	Stop Time: **15:13**	Usable Area (m^2): **313.5**	

Summary of fish captured for which weight data was available, allowing estimation of biomass.

Species Code	Common Name	Scientific Name	Number Caught	Number Caught / 100 m^2	Weight Caught (gm.)	Weight (gm.) / 100 m^2	Estimated Biomass (g/100 m^2) (Only calculated for salmonids.)	Biomass standardized to effort of 15 sec/m^2 (g/100 m^2)
75	Chinook salmon	Oncorhynchus tshawytscha	2	0.64	13.00	4.15	9.17	9.16
76	Rainbow trout	Oncorhynchus mykiss	63	20.1	479.00	152.79	361.86	361.81
77	Atlantic salmon	Salmo salar	1	0.32	24.00	7.66	16.69	16.69
78	Brown trout	Salmo trutta	3	0.96	21.00	6.7	14.93	14.93
381	Mottled sculpin	Cottus bairdii	86	27.43	280.00	89.31	(N/A)	(N/A)

Figure 1: Example fish summary report that includes a comprehensive species list, single to multiple pass population estimates for salmonids and standardizes catches to account for differences in electrofishing effort.

6.0 DATA EXPORT FUNCTIONS

An important function of FWIS is to provide access to the data contained within the system so that project managers or their designates can export larger datasets or subsets of these. This is useful for sharing partial datasets and for assisting with analysis. Export tabs are located at multiple levels within the system to enable full or partial datasets to be exported, subject to user access criteria (see above). Data exported as a comma delimited file is useful for facilitating importing into analysis software such as Excel or R.

Regardless of the data being requested, a query identifies any samples for which permission must be sought based on proprietary rights or there being sensitive data (e.g. location of SAR organisms) in the request. The data custodian may request the user to obtain such permission prior to continuing. Regardless the query will generate a subset of the master for distribution to all members of the OGDE and other members that meet the data sharing guidelines for FWIS data.

7.0 DATA SHARING STRATEGY

FWIS is being developed on the premise that scientific data should be accessible to the community of practice as:

> *The value of data lies in their use. Full and open access to scientific data should be adopted as the international norm for the exchange of scientific data derived from publicly funded research*[14].

There are of course caveats around open access to ensure: openness; flexibility; transparency; legal conformity; protection of intellectual property; formal responsibility; professionalism; interoperability; quality control/assurance; security; efficiency; accountability and sustainability. To meet these needs a data sharing team has been working to develop the guidelines under which FWIS will operate. While in their infancy some criteria are already being implemented.

FWIS metadata on sample events (e.g. sample location mapping, data collection protocols, collection years and contributing/collection agencies) will be accessible to everyone through a publically accessible web-page. Data sharing the philosophy of reciprocity to ensure FWIS maintains a wide range of data availability and currency and that sharing is considered to be fair among practitioners. The intent of this strategy is to encourage sharing and demonstrate fairness to all contributors. Under the proposed model, reciprocal data upload is proposed to occur within one year, this proposal needs to be flexible and recognize potential unforeseen delays (e.g. staffing constraints, ongoing data use (academic or development/OMB)) prior to penalizing users. Data will not be the only currency for reciprocity. Practitioners are able to reciprocate in many ways – with the intention of a “demonstration of intent” to the rest of the practitioners (e.g. analysis of datasets that meet user needs; development of summary queries or reports for use by partners). Practitioners are encouraged to be creative and discuss their ideas with members of the SMART networks or the database custodians.

8.0 TIPS FOR IMPROVING DATA QUALITY

In addition to the quality assurance queries that identify data entry errors there are a number of summary reports and export tables available within FWIS. Take frequent breaks while entering and verifying data in order to reduce eyestrain and fatigue.

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[14] The Organisation for Economic Co-operation and Development (OECD) (a 34 nation consortium to which Canada is a member), ref. http://www.oecd.org/scti/sci-tech/38500813.pdf retrieved April 8, 2013.

Have someone other than the person who entered the data perform the data verification, or wait at least three days after entering the data before verifying it.

Check that all codes, values in fields, etc., are appropriate when doing data verification.

Make sure that all data fields have been completely filled in before marking the field form as being verified. If data are missing (such as information about the site location) it will likely be a long time before someone notices and it will not only jeopardize the value of the data but will reflect poorly on the technicians who entered and verified the data.

Be careful not to mix up data forms from different samples.

Original data sheets should never be sent out of their permanent repository; only photocopies should be shared!

If validating data on-screen, a person other than the data entry technician should review the data using the printed version to ensure that all errors are corrected.

9.0 ACKNOWLEDGEMENTS

This section is dedicated to the developer of the initial database and the field sheets that supported OSAP for its first 17 years, Mike Stoneman. Without the willingness of people such as Ken Minns, Peter Hulsman and Donna Wales, to find resources where none existed, HabProgs and by inference OSAP would have collapsed during the turbulent years of the late 90s. Erin Rees, Brent Harlow and Robert Arends acted as database managers from 2002 until 2010. Since 2010, field sheets and information management has been moving to a new phase that involves multiple applications and various options for transferring the information to its digital format. Over this period the following people have contributed to this process, including: Robert Arends, Laura Jackson and Sarah Chartrand. Silvia Strobl, Helen Ball and Jean Blondin, as well as a steering committee of around 20 individuals have provided strong support and guidance throughout the process of developing this new approach to managing flowing waters information. Harold Doran has developed the new data model, database and developed/managed the new process for obtaining digital records. Don Cowan, Fred McGarry and Doug Mulholland among others at COMAP have contributed significant resources to make FWIS their flagship application and the Salamander foundation has contributed significant resources towards this new vision for information management and sharing in the province. Doug Mulholland and Harold Doran have worked diligently to merge the historic datasets into the new structure. To all of you, stream practitioners owe a debt of gratitude.

10.0 LITERATURE CITED

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Appendix I

FWIS Data Sharing Agreement

Introduction:

The Flowing Waters Information System (FWIS) — comap.ca/fwis — was developed by the Centre for Community Mapping (COMAP) and the University of Waterloo Computer Systems Group (UWCSG) with the cooperation of the Ontario Ministry of Natural Resources and Forestry, Ontario's Conservation Authorities, not-for-profit stewardship organizations and a number of Ontario municipalities. FWIS provides a software platform to allow individuals gathering ecological data using the Ontario Stream Assessment Protocol (OSAP) to contribute, edit, analyze, share and report on information that can be useful in understanding the condition of water courses and also support a broad spectrum of legislative and policy needs. Future plans for FWIS include incorporating data collected using other standardized protocols.

COMAP does not own FWIS data and has not contributed data to FWIS. FWIS holds data for the expressed goal of facilitating the sharing of Ontario stream information. Members of Ontario's stream monitoring and research community who contribute data to FWIS have the right to contribute, desist from contributing or withdraw contributions at any time.

FWIS operates on a premise of reciprocity and there is an expectation that users of the data will also contribute data to the overall monitoring community. Failure to share data or results of research based on analysis of FWIS data could result in denied access to FWIS data in the future.

Internet Guidelines

Please read these "Terms of Use" carefully before using this website.

The term "User" as used herein refers to you and/or the company, partnership, joint venture, association, or other entity of any nature you are representing. By clicking on the "I agree" button, you are representing that you have the authority to bind the company, partnership, joint venture, association or such other entity you are representing to the Terms and Conditions.

Terms of Use:

i. FWIS data are being loaned to the User by the Centre for Community Mapping (COMAP) and the FWIS data contributor(s) for the express use of the project specified under 'Intended use of data and intended publications' in question. Further use beyond said project, or resale or redistribution of any of these data components in whole or in part is prohibited.
ii. FWIS data contributors must be acknowledged in any publication that involves these data, and any data analysis based upon this data, by displaying the following text:
iii. "In appreciation of the benefit of the Ontario Stream Assessment Protocol, of the Flowing Waters Information System infrastructure, the Centre for Community Mapping and of the

effort of southern Ontario’s stream monitoring community, we gratefully acknowledge the (insert name(s) of organization(s)) for the use of their data”

iv. Data will be used at the User's own risk. COMAP and the data contributors assume no responsibility for errors or omissions in any of the information contained on this web site. In no event shall the Centre for Community Mapping or any of the data contributors to FWIS be held liable for any costs, claims or damages resulting from the User's use of the data.

v. The User may not transfer, sublicense, sell (commercially or privately), loan, or distribute the data or otherwise transfer the data in whole or in part to any third party, without prior written consent of the data contributor. This license cannot be assigned.

vi. The User will identify obvious data entry errors within the FWIS application and COMAP will communicate the error reports to the data contributor for review.

vii. COMAP and the FWIS data contributors assume no obligation or liability to provide updates or corrections to the data to users. Quality assurance and quality control of the data is ongoing. FWIS data contributors are continually adding to FWIS datasets.

viii. Failure to comply with the terms of this agreement will result in the termination of this agreement. This agreement will automatically terminate upon completion of the User’s Project. Upon termination, the User shall cease all use of the data and destroy any and all copies of the raw data obtained.

ix. Title to the datasets and any copies thereof and all rights in copyright and other intellectual properties in such shall remain with the FWIS data contributors.

x. COMAP and the data contributors may make any changes to their information on this web site, including the addition, deletion or modification of data and information, at any time without prior notice.

xi. The terms and conditions upon which users may access and use this web site are governed by the laws of Ontario and the laws of Canada applicable in Ontario.

xii. The following condition can be checked by a data contributor; if checked, it will also apply:

xiii. The User shall submit to the FWIS data contributor hardcopy and/or digital copies of data, reports and information products produced using the data, within a reasonable timeframe.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 7

Glossary and List of Acronyms

active channel	the area between the two outermost banks, which includes all active flow (i.e., moving water) at the time of the survey
aquatic macrophytes	includes many different species of aquatic plants; all are rooted in the stream bottom and have obvious stems or leaves or filaments (e.g., *Veronica* spp., pondweed, tape grass, arrowhead, bulrush and cattail)
armouring	rip rap, gabion, concrete, etc., placed on the banks
backwater pools	wet areas adjacent to the active channel that are fed by intergravel flow
bank angle	a measure of the slope of the bank which can be used in determining stream bank stability
bankfull stage	in alluvial streams, defined as the point at which the channel is completely full just prior to flows overtopping the banks and occupying the floodplain; the flows at bankfull stage are typically considered the channel forming flows
bank grid	used to record the amount of living bank vegetation, measures 100 cm long by 5 cm wide, and is comprised of 20 (5 cm) blocks
benthic macroinvertebrates	animals without backbones that live on the bottom of lakes, rivers, and streams and are visible with the naked eye
assessment surveys	these methods require more effort than screening surveys; they are recommended for monitoring or impact assessment studies
baseflow	the portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion or other human activities
beaver cones	A variably shaped cone of metal rods that extend upstream of a culvert that discourage beavers from blocking the structure while still allowing water and biota to pass through

benthos	benthic macroinvertebrates
bottom	when referring to the site, pertains to the downstream end
bulk weights	obtained by sorting a sample of fish by species or like groups, counting the individuals, and measuring the combined weight of each species or group to the nearest gram
cobble areas	exist where at least 10 particles with a median axis > 100 mm occur within the riffle
cover particle	any object that touches the water within the sample area, is at least 100 mm wide along the median axis and of sufficient density to block >75 % of sunlight from reaching the stream bottom; it can consist of a mat of materials such as twigs, macrophytes, or the bank
crossover point	the location where the thalweg (main concentration of flow, normally the deepest part of the channel) is in the centre of the channel during bankfull discharge
data custodian	The person responsible for the collection of data associated with a project and who has the authority to authorize use of data for analysis or provide the appropriate acknowledgement guidelines.
defined channel	A sloped depression in the land that conveys water that are confined within banks that have a distinct inflection point (change in bank angle) that differentiates flow velocities when the stream is flowing at levels above and below this depth.
diagnostic surveys	these methods provide detailed data and a higher degree of interpretative power than the screening or assessment surveys, but require more effort to conduct
DFO	Department of Fisheries and Oceans
dot tally	a convenient means of recording data when a number of categories are being counted simultaneously; one dot or line represents a single observation, four dots are used to form the outside of a box, then four lines are used to form the outside of the box and finally two lines are used to form a cross for a total of ten observations per filled box
drop structures	perched culvert, weir, flume etc.
embedded cover	provides only a velocity refuge and has less than a 4 cm overhang (e.g., the interstitial spaces around the cover object are filled with

	material)
entrenchment	the degree to which the stream is restricted from accessing the flood plain, or how incised the stream is within the valley (i.e., the valley width/bankfull width)
entrenchment width	the width of the flood-prone area of a channel at twice the height of its maximum bankfull depth from the channel bed
filamentous algae	have hair-like filaments, are slimy to the touch, and are often attached to rocks
flat rock	the longitudinal axis is at least twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis > 2
GIS	Geographic Information Systems
GPS	Global Positioning System
gravia feces	Dense mat of floating detritus that generally fills the entire water column. It is often so dense as to prevent wading a stream
grass	terrestrial grasses (as opposed to tape grass or eelgrass) which are growing in the stream; terrestrial grasses tend to be found at the margins of the stream
heat wave	three consecutive days where maximum air temperatures exceed 24.5°C and during which there has been no rainfall that affected baseflow of the stream
hydraulic head	a surrogate measurement of velocity measured as the difference in height of water between the front and back of a vertically held ruler that is placed at right angles to the flow of water
inflection points	a change in the slope along the bank, perpendicular to the stream flow
inlets	presence of tributaries that provide sufficient discharge to produce a plume or delta, or major outfalls emptying into the channel
inorganic deflectors	mid-channel islands, large rocks (erratics), etc., that are sufficiently large to cause erosion on either bank
jumping height	depth from water surface to the lip of a feature (i.e. the lowest part of a culvert)
knickpoint	a point along a river's length at which it suddenly begins to flow in a steeper course in the downstream waters. These represent high

	points in bed elevation
left	when referring to the site, refers to the left side while facing upstream
macroinvertebrates	aquatic invertebrates retained by a sieve of 500 μm
macrophytes	include many different species, all are rooted in the stream bottom and have obvious stems or leaves or filaments (examples: *Veronica* spp., pondweed, tape grass, arrowhead, bulrush and cattail)
Meandering Streams	A stream channel form characterized as having low to moderate slope (typically < 2%), unconfined in the valley enabling lateral movement of the channel through erodible material
median axis	there are three axes to every particle; the median axis represents the intermediate width of any particle
mid-channel island	any solid object with a median diameter greater than 30 cm (located within the active channel) which protrudes above the water
moss	small plants (2-20 cm) found in a matted colony on coarse substrate and wood; they are distinguished from plants by the absence of a distinctive stem or true leaves
non-filamentous algae	are slimy to the touch with no hair-like filaments
NRVIS	Natural Resource Value Information System
OBBN	Ontario Benthos Biomonitoring Network
OBM	Ontario Base Map
OMNR	Ontario Ministry of Natural Resources
OSAP	Ontario Stream Assessment Protocol
pavement boundary	the bottom of the active flowing channel and is identified as the point where substrate particles form a fairly uniform layer across the bottom
Perch Height	the distance from the bottom of a culvert or other lip of an elevated feature (spillway, rock shelf etc.) to the stream bed
‘press’ disturbance	permanent landuse changes that typically have long lasting (i.e. centuries rather than decades) effects on the biophysical features of a stream
‘pulse’ disturbance	catastrophic changes to stream processes, including weather events

	such as hurricanes, tornadoes, extreme floods, fire etc.
RAM	Rapid Assessment Methodology
riffles	areas of relatively fast, turbulent flow, where the water's surface is typically broken and has an obvious slope
right	when referring to the site, refers to the right side while facing upstream
ROM	Royal Ontario Museum
round rock	the longitudinal axis is less than twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis < 2
sand and gravel areas	have less than 10 particles with a median axis < 100 mm
sample	one completion of the protocol (i.e., a module) , regardless of how many days it takes to finish it; a second sample would be a repeat assessment or a sample carried out in a different year
sample event	A sample event is the application of any part of an OSAP module on a given day. In some instances it may take more than one day to complete a module. In these instances use the start date to identify the sample event date and record in the comments the finishing date.
sampling site	represents at least one riffle-pool sequence, is at least 40 m long, and begins and ends at a crossover point
screening surveys	these methods are used to perform rapid inventories tend to be visually based; they are useful for the collection of information for 'state of the resource' reports and for identifying future collection efforts
Segment	A stream segment is a relatively homogenous length of stream or waterbody that has similar hydrology, gradient, geology and flood plain characteristics. They are considered a good candidate as a sample unit for studies.
site length	the longitudinal length of the site (measured to the nearest metre) as measured down the centre of the stream
Step Pool Stream	A stream channel form characterized as having moderate to steep slope (typically > 2%), confined in the valley forcing vertical erosion to dominate erosion. Creation of steps and pools in close proximity

	of stream length (i.e. < 3 bankfull widths)
stratification	dividing the study design into equal or representative groupings of various factors
stream width	the wetted width of the stream (i.e., subtract the width of islands and include undercuts), to the nearest tenth of a metre
Swale	A shallow trough-like depression that carries water flow during rainstorms or snowmelt and has ill-defined banks. Water conveyance is the primary function for the purposes of this definition. Flow not sufficiently sustained to cause substrate sorting or prevent instream vegetation from establishing, and water storage not sustained to promote obligate wetland vegetation (e.g. cattails). Bed will contain facultative wetland plants (e.g. reed canary grass).
tablelands	Term used in the headwater module to denote relatively flat areas outside a concentrated flow feature. There is typically a knick point or change in elevation between the tablelands and the valleylands
terrestrial plants	firm stemmed plants that occasionally grow on the margins of streams, such as jewelweed, stinging nettles, poison ivy, willow, dogwood, etc.
thalweg	main concentration of flow, normally the deepest part of the channel
top	when referring to the site, pertains to the upstream end
trim line depth	an equivalent to the bankfull stage in streams flowing through channels that are affected by bedrock, roots and woody material, large glacial deposits etc., identified as the upper limit of a regularly scoured zone and a distinct change in vegetation
watercress	plants that have dark green, non-woody stems with flat, broad, opposite compound leaves with 3 to 9 leaflets per stem; often found in large clusters along margins of stream, they are indicators of groundwater inputs and are also nitrate fixers
wetted width	the average width of the stream at the edges of the wetted channel, taken at right angles to the stream flow. Islands are not included and undercuts are included
umbrication	refers to stream condition where larger substrate particles are stacked in ways that mimic fallen dominoes
unembedded cover	provides overhead and velocity protection for small fish and has at least a 4 cm overhang

UTM	Universal Transverse Mercator
wood deflectors	large logs or trees which impede the flow causing bank erosion on either side of the deflector
WRIP	Water Resources Information Project

Metadata Form

Project Name	Project Code
Lead	Organization
Partner(s)	Organization(s)

Project Description

Study Area

Location of Field Data Sheets

Study Design Factors

Category	Factor	Used?	Comments
Spatial	Geology	☐	
	Catchment size/stream order/position	☐	
	Ecoregion	☐	
	Climate	☐	
	Watershed	☐	
	Land cover	☐	
	Stream/valley segment	☐	
	Other	☐	
Administrative/Political	Administrative/political boundaries	☐	
Management	Land use	☐	
	Barriers to migration	☐	
	Stocking strategy	☐	
	Other	☐	
Biological/Physical/Chemical	Species distribution	☐	
	Productivity	☐	
	Thermal regime	☐	
	Structure	☐	
	Flow	☐	
	Conductivity/turbidity	☐	
	Other	☐	

Temporal	Season	☐	
	Flow conditions	☐	
	Date	☐	
	Temperature	☐	
	Other	☐	
Primary Site location Criteria	Random	☐	
	Targeted	☐	
	Targeted-random	☐	
Secondary Site Location Criteria	Control-Impact Design	☐	
	Boundary	☐	
	Previous Sampling	☐	
	Accessible	☐	
	Representative	☐	
	Hypothesis test - Gradient	☐	
	Other	☐	
Site boundary	Ontario Stream Assessment Protocol	☐	
	Point (no extent)	☐	
	Bankfull widths	☐	
	Wetted widths	☐	
	Riffle to riffle	☐	
	Riffle with set length	☐	
	Access point with set length	☐	
	Habitat boundaries	☐	
	Road right of way	☐	
	Sampleable area	☐	
	Knick points	☐	
	Entire strata	☐	
	Set length of representative habitat	☐	
	No specific rules	☐	
	Other	☐	
Additional Comments			
Associated References			
Proprietary Rights Requested? ☐			

Site Identification

Stream Code

Site Code

Sample

Date (yyyy-mm-dd)

Stream Name

Alternate Site Code

Site Length (m)

*** Record using NAD83 datum

	Zone	Easting	Northing
Uncorr. UTM	1	.	.
Corr. UTM	1	.	.

OR

	DD	MM	SS.sss
Lat.			.
Long.			.

Source of Uncorrected UTM Coordinates

GPS/DGPS ☐

GIS ☐

OBM ☐

Other

Source of Corrected UTM Coordinates

FWIS ☐

Ortho-photos ☐

GIS ☐

Other

Name of Layer Used for Correction

Access Route

Site Description

☐ Site Was Unsampleable - add reason(s) on reverse

Sketches

Site/Access Route Sketch

Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Comments

Crew Leader (init. & last name)

Crew	Recorder	Entered	Verified	Corrected

Site Marker Details

UPSTREAM SITE MARKER
(measure from stake to site)

Bearing (D) ☐☐☐

Distance (m) ☐☐☐.☐

Description

DOWNSTREAM SITE MARKER
(measure from stake to site)

Bearing (D) ☐☐☐

Distance (m) ☐☐☐.☐

Description

ADDITIONAL SITE MARKER
(measure from stake to site)

Bearing (D) ☐☐☐

Distance (m) ☐☐☐.☐

Description

Photos

		Photo No.	Photo Name	Photo Description
Upstream	Upstream			
	Downstream			
Downstream	Upstream			
	Downstream			
Other Features				

Site is Unsampleable Reason(s)

☐ Stream dry

☐ Insufficient water to sample effectively

☐ Stream is no longer present at location (tiled or relocated, etc)

☐ Naturally unwadeable (i.e. > 1.5 m deep)

☐ Unwadeable due to ponding from a permanent barrier

What is the permanent barrier?

☐ Unwadeable due to ponding from temporary barrier (eg. beaver dam)

What is the temporary barrier?

☐ Landowner could not be contacted

☐ Landowner refused access

☐ Inaccessible for safety reasons (add details in comments below)

☐ Stream is wadeable but not appropriate for the intended sampling

Modules to have been used (e.g. S2.M1, S3.M1):

Comments

Site Features

Mandatory Fields In Grey
Must be filled out for processing

Stream Code ☐☐☐☐☐☐☐☐☐☐

Site Code ☐☐☐☐☐☐☐☐

Sample ☐☐

Date (mm-dd) 201☐ ☐☐–☐☐

Stream Name

For each landuse, check box that applies. Be sure to include comments explaining the particulars, including names and numbers of contacts

Site Features	Ongoing & Active	Historical Evidence	No Evidence but Reported	No Evidence	Unknown	Comments
Potential Point or Non-point Source Contaminant Sources	☐	☐	☐	☐	☐	
Major Nutrient Sources Upstream	☐	☐	☐	☐	☐	
Channel Hardening or Straightening	☐	☐	☐	☐	☐	
Adjacent Landuses that Destabilize Banks	☐	☐	☐	☐	☐	
Sediment Loading or Deprivation	☐	☐	☐	☐	☐	
Instream Habitat Modifications	☐	☐	☐	☐	☐	
Barriers and/or Dams in the Vicinity of the Site	☐	☐	☐	☐	☐	
High Fishing Pressure	☐	☐	☐	☐	☐	
Log Jam Deflectors	☐	☐	☐	☐	☐	
Springs or Seeps at the Site	☐	☐	☐	☐	☐	
Impervious Substrate Limiting Burrowing Depth of Fish	☐	☐	☐	☐	☐	
Fish Stocked Near Sample Site	☐	☐	☐	☐	☐	
Other Activities that Could Influence Biota or Habitat	☐	☐	☐	☐	☐	
Intensive Logging Activitties within the Riparian Zone	☐	☐	☐	☐	☐	

Sources of Information
Visual Immediate ☐ Visual Extended ☐ Interview ☐ Maps & Photos ☐

Temperatures
Time (24hr) ☐☐:☐☐
Air Temp (°C) ☐☐☐☐
Water Temp (°C) ☐☐☐☐
Max Air Temp (°C) ☐☐☐☐
Max. Water Temp (°C) ☐☐☐☐
Source of Max. Air Temp ☐☐☐☐☐☐☐☐☐

Riparian Vegetation Community
Only check one box for each bank and zone.

	Dominant Vegetation Type													
	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands
1.5-10m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
30-100m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Comments

Crew Leader (initial & last name) ☐ ☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected

Restoration Project Tracking Form

Stream Name	Stream Code	Site Code	Date (yyyy-mm-dd)

Project Name if known:

Project Organization:

Site Ownership ☐ Corporate ☐ Private
☐ Federal ☐ Provincial ☐ Municipal
☐ NGO ☐ First Nations

Location of activity

Mark 'x' if Site Id data available ☐

Zone	Downstream/ Point location	Easting	Northing
	Upstream location		

UTM Source

Known Completion Date (yyyy-mm-dd)

Estimated Decade of Completion:
☐ 60's ☐ 70's ☐ 80's ☐ 90's ☐ 00's ☐ 10's

Restoration Length (m)

Restoration Width (m)

Photo No	Photo Name	Photo Description

Issue	Restoration Techniques
☐ Fish Barrier	☐ Rocky Ramp/Vortex Weir ☐ Bypass Channel ☐ Fishway ☐ Dam Removal ☐ Online Pond Removal ☐ Other: ________________________________
☐ Erosion	☐ Live Fascines ☐ Gabion Baskets ☐ Log jam ☐ Tree Revetment ☐ Rootwads ☐ Crib Wall ☐ Live Staking ☐ Riprap ☐ Bank Grading ☐ Concrete ☐ Other: _____________________
☐ Instream Habitat	☐Spawning Bed Creation ☐ Boulder Placement ☐ Half Log Cover ☐ Woody Material Placement ☐ Lunker structures ☐ Debris Removal ☐ Other: ________________________________
☐ Riparian Habitat	☐ Riparian Planting ☐ Cattle Fencing ☐ Tile Drain Removal ☐ Wetland Restoration ☐ Garbage Removal ☐ Invasive Species Removal ☐ Other: ________________________________
☐ Channel Morphology	☐ Meander Enhancement ☐ Riffle/Pool Creation ☐ Rock Weir Vortex ☐ Backwater Creation ☐ Flood Plain Enhancement ☐ Bed Stabilization ☐ Wetland Creation ☐ Other: ________________________________
☐ Storm Water & Online Ponds	☐ Bottom Draw ☐ Wetland ☐ Infiltration Trench ☐ Dredge ☐ Tree Planting ☐ Outlet Naturalization ☐ Sediment Trap ☐ Improve Access ☐ Other: ________________________________
☐ Other (Please Describe)	
☐ Other Documentation Available	☐ Eng. Drawings ☐ Report ☐ Pre-Post Monitoring Plan ☐ Environmental Impact Study ☐ Video ☐ Legal contracts ☐ other: ________________________________

Comments

Tracked Species

Mandatory Fields in Grey
Must be filled out for Processing

Stream Name ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Date (yyyy-mm-dd) ☐☐☐☐ — ☐☐ — ☐☐

Stream Code ☐☐☐☐☐☐☐☐☐☐

Site Code ☐☐☐☐☐☐☐☐☐☐

Algae

Observed	Common Name:	Scientific Name:
☐	Didymo	*Didymosphenia geminata*
☐		
☐		

Amphibians

Observed	Common Name:	Scientific Name:
* ☐	Jefferson Salamander	*Ambystoma jeffersonianum*
☐		
☐		

Birds

Observed	Common Name:	Scientific Name:
* ☐	Acadian Flycatcher	*Empidonax virescens*
* ☐	Louisiana Waterthrush	*Seiurus motacilla*
☐		
☐		

Fishes

Observed	Common Name:	Scientific Name:
☐	Bighead Carp	*Hypophthalmichthys nobilis*
☐	Black Carp	*Mylopharyngodon piceus*
☐	Chain Pickerel	*Esox niger*
☐	Eastern Mosquitofish	*Gambusia holbrooki*
☐	Fourspine Stickleback	*Apeltes quadracus*
☐	Goldfish	*Carassius auratus*
☐	Grass Carp	*Ctenopharyngodon idella*
☐	Rainbow Smelt	*Osmerus mordax*
☐	Round Goby	*Neogobius melanostomus*
☐	Rudd	*Scardinius erythrophthalmus*
☐	Ruffe	*Gymnocephalus cernuus*
☐	Silver Carp	*Hypophthalmichthys molitrix*
☐	Tench	*Tinca tinca*
☐	Threespine Stickleback	*Gasterosteus aculeatus*
☐	Tilapia	
☐	Tubenose Goby	*Proterorhinus marmoratus*
☐	White Perch	*Morone americana*
☐	Wiper	*Morone chrysops x saxatilis*
☐		
☐		

Invertebrates

Observed	Common Name:	Scientific Name:
☐	Asian Clam	*Corbicula fluminea*
☐	Banded Mysterysnail	*Viviparus georgianus*
☐	Bloody Red Shrimp	*Hemimysis anomala*
☐	Channeled Apple Snail	*Pomacea canaliculata*
☐	Chinese Mitten Crab	*Eriocheir sinensis*
☐	Chinese Mysterysnail	*Cipangopaludina chinensis*
☐	Fishhook Waterflea	*Cercopagis pengoi*
☐	Freshwater Jellyfish	*Craspedacusta sowerbii*
☐	Gammarid	*Echinogammarus ischnus*
* ☐	Laura's Clubtail	*Stylurus laurae*
* ☐	Mapleleaf Mussel	*Quadrula quadrula*
☐	New Zealand Mud Snail	*Potamopyrgus antipodarum*
☐	Quagga Mussel	*Dreissena rostriformis*
* ☐	Rainbow Mussel	*Villosa iris*
* ☐	Rapids Clubtail	*Gomphus quadricolor*
☐	Red Swamp Crayfish	*Procambarus clarkii*
☐	Rusty Crayfish	*Orconectes rusticus*
☐	Spiny Waterflea	*Bythotrephes longimanus*
☐	Zebra Mussel	*Dreissena polymorpha*
☐		
☐		

Aquatic Plants

Observed	Common Name:	Scientific Name:
☐	Brazillian Waterweed	*Egeria densa*
☐	Common Reed	*Phragmites australis ssp. australi*
☐	Curly Pondweed	*Potamogeton crispus*
☐	Eurasian Water-milfoil	*Myriophyllum spicatum*
☐	European Frog-bit	*Hydrocharis morsus-ranae*

Observed Key
(blank) - Not identifiable or unable to thoroughly sample
0 - None observed
1 - Few (1 or 2 observed)
2 - Common (some observed)
3 - Highly abundant (many observed)

*** indicates a listed species at risk (SAR)**

Tracked Species (Page 2)

	Common Name:	Scientific Name:
☐	European Lake Sedge	*Carex acutiformis*
☐	European Water Chestnut	*Trapa natans*
☐	Fanwort	*Cabomba caroliniana*
☐	Flowering-rush	*Butomus umbellatus*
* ☐	Heart-leaved Plantain	*Plantago cordata*
☐	Himalayan Balsam	*Impatiens glandulifera*
☐	Mosquito Fern	*Azolla pinnata*
☐	Parrotfeather	*Myriophyllum aquaticum*
☐	Purple Loosestrife	*Lythrum salicaria*
☐	Water Hyacinth	*Eichhornia crassipes*
☐	Water Lettuce	*Pistia stratiotes*
☐	Water Soldier	*Stratiotes aloides*
☐	Watermoss	*Salvinia spp.*
☐	Yellow Floating-heart	*Nymphoides peltata*
☐	Yellow Iris	*Iris pseudacorus*
☐		
☐		

Reptiles

Observed		
* ☐	Snapping Turtle	*Chelydra serpentina*
* ☐	Spotted Turtle	*Clemmys guttata*
* ☐	Gray Ratsnake	*Pantherophis spiloides*
☐		
☐		

Terrestrial Plants

Observed	Common Name:	Scientific Name:
☐	Amur Honeysuckle	*Lonicera maackii*
☐	Climbing Nightshade	*Solanum dulcamara*
☐	Common Buckthorn	*Rhamnus cathartica*
☐	Cow Vetch	*Vicia cracca*
☐	Creeping Jenny	*Lysimachia nummularia*
☐	Dame's Rocket	*Hesperis matronalis*
☐	Dog-Strangling Vine	*Cynanchum rossicum*
☐	European Barberry	*Barberis vulgaris*
☐	European Privet	*Ligustrum vulgare*

	Common Name:	Scientific Name:
☐	Garlic Mustard	*Alliaria petiolata*
☐	Giant Hogweed	*Heracleum mantegazzianum*
☐	Glossy Buckthorn	*Rhamnus frangula*
☐	Green Spurge	*Euphorbia esula*
☐	Guelder rose	*Viburnum opulus*
☐	Japanese Barberry	*Barberis thunbergii*
☐	Japanese Honeysuckle	*Lonicera japonica*
☐	Japanese Knotweed	*Polygonum cuspidatum*
☐	Kudzu	*Pueraria montana var. lobata*
☐	Lily of the Valley	*Convallaria majalis*
☐	Morrow's Honeysuckle	*Lonicera morrowii*
☐	Mossy Stonecrop	*Sedum acre*
☐	Multiflora Rose	*Rosa multiflora*
☐	Norway Maple	*Acer platanoides*
☐	Oriental Bittersweet	*Celastrus orbiculatus*
☐	Tartarian Honeysuckle	*Lonicera tatarica*
☐	White Sweet-clover	*Melilotus alba*
☐		
☐		

☐ Kept voucher specimens ☐ Took pictures

Comments

Identifying Crew Member

Observed Key
(blank) - Not identifiable or unable to thoroughly sample
0 - None observed
1 - Few (1 or 2 observed)
2 - Common (some observed)
3 - Highly abundant (many observed)

*** indicates a listed species at risk (SAR)**

Benthic Survey Sheet

Mandatory Fields in Grey
Must be filled out for processing

Stream Code

Site Code

Sample

Date (mm-dd) 201

Time (24hr) :

NOTE:
For all measurements, right and left banks defined facing upstream.

Stream Name

Water Quality

Water Temp (°C) .

Conductivity (uS/cm)

pH .

DO (mg/L) .

Alkalinity (mg/L as CaCO3) .

Substrate

Enter dominant substrate class and second dominant class for each sub-sample.

	Collect. Area 1	Collect. Area 2	Collect. Area 3
Dominant			
2nd Dominant			

Class	Description
1	Clay (hard pan)
2	Silt (floury, <0.06 mm particle diameter)
3	Sand (grainy, 0.06 - 2mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (>250 mm)
7	Bed Rock

Bankfull Width (m) .

Gear Type

☐ Poled Seine ☐ Ponar

☐ D-Net ☐ Ekman

☐ Surber ☐ Other :

MeshSize (microns)

☐ 250 ☐ 600

☐ 500 ☐ 1000

(Select the box that most closely represents the mesh size used.)

% Canopy Cover

☐ 0 - 24 ☐ 50 - 74

☐ 25 - 49 ☐ 75 - 100

If instrument used, record type:

River Characterization

☐ Perennial

☐ Intermittent

☐ Unknown

Candidate Reference Site?
(ie. minimally impacted)

☐ Yes

☐ No

Comments

Crew Leader (initial & last name)

Aquatic Macrophytes & Algae *Enter appropriate abundance class for each type and sub-sample.*

Macrophytes	Collect. Area 1	Collect. Area 2	Collect. Area 3
Emergent			
Rooted Floating			
Submergent			
Free Floating			

Algae	Collect. Area 1	Collect. Area 2	Collect. Area 3
Floating Algae			
Filamentous			
Attached Algae			

Class	Description
0	Absent
1	Present
2	Abundant

Riparian Vegetation Community

Only check one box for each bank and zone.

Dominant Vegetation Type

	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-lands
1.5-10m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
30-100m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Pool or Riffle (P/R)	Sampling Dist.(m)	Sampling Time (min : sec)	Max. Depth (mm)	Hydraulic Head (mm)	Wetted Width (m)	Grabs/ Area
Collection Area 1:		.	:			.	
Collection Area 2:		.	:			.	
Collection Area 3:		.	:			.	

Enter a P or an R to indicate whether the collection was a riffle or pool.

1, 2, or 3 grabs can be collected within each collection area.

Pebble sizes (mm) use sizes from table 1

Crew Names

Recorder Init. Entered	Verified	Corrected

Benthic Tally Sheet

Mandatory Fields In Grey
Must be filled out for processing

Date (yyyy-mm-dd)
201 - -

Stream Name

Stream Code

Site Code

Sample

Collection Area

Survey Type ☐ Rapid ☐ Stationary Kick ☐ Travelling Kick Habitat Sampled ☐ Riffle ☐ Pool

Stream Width (m)

Water Depth (mm)

Hydraulic Head (mm)

Sampling Time (sec)

Unknown Species

Comments

Net Type
☐ Square
☐ Surber
☐ D-net

Mesh Size (microns)
☐ 251-500
☐ 501-1000

Sample Preserved? ☐ Yes ☐ No

No. of Vials

Sorting Method
☐ Unsorted
☐ Marchant Box
☐ Splitter

Sample Size ☐ mL ☐ C

Total Vol/Wt

Vol/Wt not Picked

Identification
☐ In Field
☐ In Lab
☐ Microscope
☐ no Microscope

Median sizes of 10 substrate particles randomly chosen from collection area (mm).


2 - 25 mm
Hydrozoa
(Hydra)


5 - 20 mm
Platyhelminthes
(Flatworms)


1 - 10 mm
Nemata
(Roundworms/Threadworms)


1 - 30 mm
Oligochaeta
(Aquatic Earthworms)


5 - 300 mm
Hirudinea
(Leeches)


5 - 200 mm
Isopoda
(Aquatic Sowbugs)


2 - 250 mm
Bivalvia
(Clams)


5 - 20 mm
Amphipoda
(Scuds)


10 - 150 mm
Decapoda
(Crayfish)


1 - 7 mm
Acari
(Aquatic Mites)


3 - 30 mm
Ephemeroptera
(Mayflies)


15 - 45 mm
Anisoptera
(Dragonflies)


10 - 25 mm
Zygoptera
(Damselflies)


5 - 50 mm
Plecoptera
(Stoneflies)


15 - 40 mm
Hemiptera
(True Bugs)


25 - 90 mm
Megaloptera
(Fishflies)

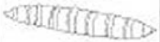

2 - 50 mm
Trichoptera
(Caddisflies)

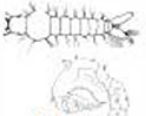

10 - 25 mm
Lepidoptera
(Aquatic Moths)


2 - 40 mm
Coleoptera
(Beetles)


2 - 70 mm
Gastropoda
(Snails)


2 - 20 mm
Chironomidae
(Midges)


15 - 40 mm
Tabanidae
(Horse & Deer Flies)


2 - 15 mm
Culicidae
(Mosquitos)


3 - 15 mm
Ceratopogonidae
(No-see-ums)


10 - 50 mm
Tipulidae
(Crane Flies)


3 - 15 mm
Simuliidae
(Black Flies)


Misc. Diptera
(Misc. True Flies)

Dot Tally (track total no. sampled)

Crew Leader (init. & last name)

Crew Init.

Recorder Init.

Entered

Verified

Corrected

Fish Sampling

Mandatory Fields In Grey
Must be filled out for processing

Stream Name

Date (yyyy-mm-dd) 2 0 1 _ – _ _ – _ _

Stream Code

Sample

Run No. of

Site Code

Science Collect. No.

Start Time (24hr) :

Stop Time (24hr) :

Elapsed Min.

Shocker Sec.

Model No.

Anod. Voltage

Frequency

Pulse

Channel Morphology Available?

☐ Yes ☐ No

If no, measure the stream length surveyed and 10 wetted widths.

Length (m) .

Widths (m)

1	.	6	.
2	.	7	.
3	.	8	.
4	.	9	.
5	.	10	.

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☐ Total Length

☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B O	P S	Sp Name/Remarks
1				☐ ☐	☐ ☐	
2				☐ ☐	☐ ☐	
3				☐ ☐	☐ ☐	
4				☐ ☐	☐ ☐	
5				☐ ☐	☐ ☐	
6				☐ ☐	☐ ☐	
7				☐ ☐	☐ ☐	
8				☐ ☐	☐ ☐	
9				☐ ☐	☐ ☐	
10				☐ ☐	☐ ☐	
11				☐ ☐	☐ ☐	
12				☐ ☐	☐ ☐	
13				☐ ☐	☐ ☐	
14				☐ ☐	☐ ☐	
15				☐ ☐	☐ ☐	
16				☐ ☐	☐ ☐	
17				☐ ☐	☐ ☐	
18				☐ ☐	☐ ☐	
19				☐ ☐	☐ ☐	
20				☐ ☐	☐ ☐	

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name)

Crew

Recorder

Field ID (init. & last name)

Cert. Level

Lab ID (init. & last name)

Cert. Level

Entered/ Scanned

Verified

Corrected

No Catch = 1

Fish Sampling: Additional Samples

Mandatory Fields In Grey
Must be filled out for processing

Stream Code

Site Code

Sample

Run No. Of

Date (yyyy-mm-dd) 201 - -

Comments

Individual Fish Data

ID	Species	Length (mm)	Weight (g)	B P O S	Sp Name/Remarks
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	
				☐ ☐ ☐ ☐	

Bulk Fish Data

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks

B = Bulk P = Preserved O = Otolith S = Scale

Grp #: 0 = unsorted or mixed sizes/ages 1 = YOY salmonines with total length < 100mm 2 = salmonines with total length > 100mm

** For individual and bulk records > 100, record ID and/or Batch numbers in the 'Remarks' field'.*

Fish Sampling with Seines

Mandatory Fields In Grey
Must be filled out for processing

Date (mm-dd) 201_-__-__

Stream Name

Stream Code | Sample | Coll. Area | Run

Site Code | Scientific Collectors Permit

Net Type

Net Type
1 = Straight
2 = Bag

Mesh Size: Wing | Bag

Mesh Sizes
0 = N/A
1 = 1/8 inch
2 = 1/4 inch

Collection Area Length (m)

Transect Width (m)

Depth and Hydraulic Head

	Depth 1	H Head 1	Depth 2	H Head 2	Depth 1	H Head 3
T1						
T2						
T3						

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☐ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B / O	P / S	Sp Name/Remarks
1				☐ ☐	☐ ☐	
2				☐ ☐	☐ ☐	
3				☐ ☐	☐ ☐	
4				☐ ☐	☐ ☐	
5				☐ ☐	☐ ☐	
6				☐ ☐	☐ ☐	
7				☐ ☐	☐ ☐	
8				☐ ☐	☐ ☐	
9				☐ ☐	☐ ☐	
10				☐ ☐	☐ ☐	
11				☐ ☐	☐ ☐	
12				☐ ☐	☐ ☐	
13				☐ ☐	☐ ☐	
14				☐ ☐	☐ ☐	
15				☐ ☐	☐ ☐	
16				☐ ☐	☐ ☐	
17				☐ ☐	☐ ☐	
18				☐ ☐	☐ ☐	
19				☐ ☐	☐ ☐	
20				☐ ☐	☐ ☐	

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (init. & last name)

Field ID (init. & last name) Cert. Level

Lab ID (init. & last name) Cert. Level

Crew | Recorder

Entered/ Scanned

Verified

Corrected

Rapid Assessment Methodology Field Form

Mandatory Fields In Grey
Must be filled out for processing

Stream Code

Site Code

Sample

Date YY — MM — DD

Site Type
☐ Calibration ☐ Survey

Stream Name

Crew Leader (initial & last name)

Crew

Recorder

Channel Structure

Depth (mm)	Pools (Hydraulic Head = 0-3 mm)		Glides (Hydraulic Head = 4-7 mm)		Slow Riffles (Hydraulic Head = 8-17 mm)		Fast Riffles (Hydraulic Head > 17 mm)	
	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present
0 - 100 mm								
101 - 600 mm								
601 - 1000 mm								
> 1000 mm								
Total # Points								

Note:
Grey hatched areas are for tally marks.

●—●
● ●

Instream Cover

Cover Types	Flat Rock	Round Rock	Wood	Macrophytes	Bank	Other
Number of Points						

Substrate Types

	Fines (<2 mm)	Gravel (2-100 mm)	Cobble (100-1000mm)	Bedrock (>1000mm)	gavia feces
Point Particle					
Maximum Particle					

Bank Stability

Mean Stream Width (m) ☐☐.☐ Mean Depth at Crossover (mm) Maximum Particle Size (mm)

Eroding Bank		Angle > 45°, erodible soil, undercut or bare soil
Vulnerable Bank		Angle > 45°, erodible soil, no sign of recent erosion
Protected Bank		Angle > 45°, non-erodible material/soil
Deposition Zone		Angle < 45°, (gradual slope from river), fine grained sediments

Comments

Ent/Scanned	Verified	Corrected

Channel Morphology

Mandatory Fields In Grey
Must be filled out for processing

Stream Name

Date (mm-dd) 201_ – __ – __

Stream Code

Site Code

Sample

Transcript No. of

Bearing (D)

Min. Width (m) .

Site Length (m) .

Active Channel Width (m) .

No. of Transects

Transect Spacing (m) .

Point Spacing (m) .

Points per Transect

Transect & Point Layout			Calculations:		
Use this table to determine the number of transects & points required, given the minimum stream width.			Transect Spacing	=	Site Length / (No. of Transects - 1)
Minimum Width (m)	No.Transects at Site	Points per Transect	Point Spacing	=	Active Channel Width / Points per Transect
> 3.0	10	6	1st Point	=	Point Spacing / 2 (from left bank)
1.5 - 3.0	12	5			
1.0 - 1.49	15	3			
< 1.0	20	2			

		Measure depth & hydraulic head to nearest 5 mm		Particle Sizes (mm)		Cover								Aquatic Vegetation Types Present						
Point No.	Location (m)	Depth (mm)	Hydraulic Head (mm)	Point	Max. in Ring	Unmeas-urable	Quality	Wood	Round Rock	Flat Rock	Macro-phyte	Bank	Other	FL	AL	SS	MC	WC	GR	TR
1	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Bank Angle & Particle Median Diameters
(Bank to tape height; if a height is >2m use check box, else enter values in proper observation points)

		> 2 m	0 mm	250 mm	750 mm	1500 mm	Amount of Undercut (mm)	No. of Veg. Squares on Bank
Left Bank	Height	☐						
	Substrate Diameters							
Right Bank	Height	☐						
	Substrate Diameters							

Dominant Vegetation Type
(Check box of the dominant type within the 1 x 2 m area)

	None	Lawn	Crop-land	Mea-dow	Scrub-land	Forest	Wet-land
Left Bank	☐	☐	☐	☐	☐	☐	☐
Right Bank	☐	☐	☐	☐	☐	☐	☐

Table Codes

Particle Sizes:
Measure all particles between 2.00mm and 1000mm

Material	Size
Unconsolidated Clay	0.01
Consolidated Clay	0.011
Silt	0.05
Sand	0.10
Large Boulders	1001
Bedrock	1111

Cover Quality:
0 = No Cover
1 = Embedded Cover
2 = Unembedded Cover

Aquatic Vegetation Types:
FL = Filamentous Algae
AL = Non-Filamentous
SS = Moss
MC = Macrophytes
WC = Watercress
GR = Grass
TR = Terrestrial Plants

Comments

Crew Leader (initial & last name)

Crew	Recorder	Ent/Scanned	Verified	Corrected

Bankfull Profile and Transect Discharge

Mandatory Fields In Grey
Must be filled out for processing

Transect No. ____ of ____

Page No. ____ of ____

Date (yyyy-mm-dd) 2 0 1 _ – _ _ – _ _

Stream Name

Discharge Approximates Baseflow yes ☐ no ☐

Stream Code

Site Code

Sample

Record only on the 1st transect.

Site Length (m) .

Transect Spacing (m) .

Discharge Approximates Baseflow?

☐ Yes ☐ No

Obstructions to Flow
(*Check all applicable types*)

☐ None Present ☐ Armouring
☐ Trampled Banks ☐ Inlets
☐ Wood Deflectors ☐ Other
☐ Inorganic Deflectors

Others

Indicators Used to Locate Bankfull Level

	Left Bank	Right Bank
Inflection Point	☐	☐
Bank Material	☐	☐
Top of Point Bar	☐	☐
Vegetation	☐	☐
Min. Width:Depth	☐	☐

Others

L

R

Entrenchment
Entrenchment Height = 2 x Max. Channel Depth

Entrenchment Width = horiz. distance from the location of the Max. Channel Depth to the bank at the Entrenchment Height

Record either the Left and Right width or the Total Width

Left Entrenchment Width (m) .

Right Entrenchment Width (m) .

Total Entrenchment Width (m) .

Transect & Point Layout
Use this table to determine the number of measured points per transect, given the minimum stream width.

Minimum Width (m)	Low Variance in Velocity or Depth	High Variance in Velocity or Depth
> 3.0	8+1 every 2 m	10+1 every 1m
1.5 - 3.0	5	8
1.0 - 1.49	3	6
< 1.0	2	4

Point Spacing = Active Channel Width / Points per Transect

1st Point = Point Spacing / 2 (from left bank)

Active Channel Width (m) .

Point Spacing (m) .

Channel Profile

Ht. Represents Bankfull? ☐ Yes ☐ No

	Horiz. Loc. (m)	Vert. Ht. (mm)
Left BFD	.	
Right BFD	.	
Max. Chann. Depth	.	

Velocity Measurements
(*Recommended depth ratio from stream bottom is 0.4 m)*

	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
Left Active Chann.	.					.
Right Active Chann.	.					.

Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.

Velocity Measurements

Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.

Comments

Crew Leader (init. & last name)

Crew	Recorder	Ent/Scanned	Verified	Corrected

Diagnostic Indicators of Channel Stability: Additional Observations

Mandatory Fields In Grey Must be filled out for processing

Stream Code

Site Code

Sample

Date (yyyy-mm-dd) 201_ - __ - __

Transcect No. __ of __

Page No.

Channel Profile			Velocity Measurements			
Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.
	.					.

Comments

			Velocity Measurements			
Observ.	Horiz. Loc. (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/ Min.	Velocity (m/s)
	.					.
	.					.
	.					.
	.					.
	.					.
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	.					.
	.					.
	.					.
	.					.
	.					.

Rapid Stream Discharge Survey

Stream Name

Discharge Approximates Baseflow yes ☐ no ☐

Stream Code

Watershed Code

Sample

Survey Zone

Date (yyyy-mm-dd) 20__ – __ – __

UTM Zone 1

Source of UTM Coordinates GPS ☐ GIS ☐ OBM ☐ Other

Crew Leader (init. & last name)

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow % LOST ☐		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)
			.		.		.	
			.		.		.	
			.		.		.	

Site Description

*Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface

---

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow % LOST ☐		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)
			.		.		.	
			.		.		.	
			.		.		.	

Site Description

*Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface

---

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow % LOST ☐		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)
			.		.		.	
			.		.		.	
			.		.		.	

Site Description

*Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface

---

Comments (please incl. names of crew members)

Recorder	
Entered/ Scanned	
Verified	
Corrected	

Rapid Stream Discharge Survey

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		% LOST	
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)		Time to Fill (sec)
1			.		.	1	.		
2			.		.	2	.		
3			.		.	3	.		

Site Description

**Perched Ht: distance from the bottom of the culvert to the stream bed.* **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		% LOST	
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)		Time to Fill (sec)
1			.		.	1	.		
2			.		.	2	.		
3			.		.	3	.		

Site Description

**Perched Ht: distance from the bottom of the culvert to the stream bed.* **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		% LOST	
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)		Time to Fill (sec)
1			.		.	1	.		
2			.		.	2	.		
3			.		.	3	.		

Site Description

**Perched Ht: distance from the bottom of the culvert to the stream bed.* **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Additional Comments

Water Level Record Field Sheet for CSG Installation

of

Stream Name	Stream Code	Date	Crew Page

Site Code	CSG length (mm)	Reference rebar height[1] (mm)	Distance from bottom of CSG to water level (mm)	Distance from reference pt. to tape[2] (optional)	Comments: (justify negative numbers)

Notes: 1 If CSG is lower than the rebar record as a negative number
2: If rebar is lower than the bankfull height (tape measure) record as a negative number.

Water Level Record Field sheet for CSG Event Data Sheet

Page
of

Stream Name	Stream Code	Date	Crew

Event Identification	Event Description	Rainfall Amount (mm)	Rainfall Source

Site Code	Sample	Replicate	Time: (2400)	Height bottom of tube to response height (mm)	Height rebar to top of tube (mm)	Reset height bottom of tube to water level (mm)	Reset height rebar to top of tube[1] (mm)	Comments (readability, reliability, cap on, etc.)

Note: 1. if rebar higher than tube record as negative number.

Site Slope Field Form

Page __1__ of __1___

Stream Name

Site Code

Site Code

Date (yyyy/mm/dd)

Crew Leader

Crew Members

Equipment Used

☐Survey Level ☐ Laser Level ☐ GPS ☐

Range Finder ☐ GIS

Description of Station Marker or Benchmark (if used):

Comments

Obs. Num.	Loc. Iden.	Instream Observation Points					Station Markers (if used)				Comments
		Distance from Previous Obs. (m)	Water Depth (mm)	Stadia Rod Reading (mm)	Corrected Difference (mm)	Bearing (Deg)	Distance to Station Marker (m)	Stadia Rod Reading (mm)	Corrected Difference (mm)	Bearing (Deg)	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											

Rapid Assessment Methodology for Instream Substrate Form

Stream Name	Stream Code	Site Code	Sample	Date (yyyy/mm/dd)

Wetted Width (m)	Mean Water Depth (mm)	Comments

Record standard substrate particles using a dot tally under the Standard Sizes section. Substrate particles ranging from 2mm – 100 mm must be measured along their median axis and recorded in the Measured Particles section.

Substrate Measurements

Standard Sizes

Material	**Description**	Count *(use box tally)*				
		Substrate Particles	Total	Maximum Particles	Total
Unconsolidated Clay	Very hard packed when dry and sticky when wet				
Consolidated Clay	Hard even when wet, slippery, gray in colour, often laminated				
Silt	Feels soft like a powder or flour				
Sand	Gritty, sizes >0.05 and less than <2mm				
Bedrock	Exposed Bedrock				
Large Boulders	> 1000 mm but not attached to bedrock				
Concrete/ashphalt	Human made				
Gavia feces	Dense floating detritus				

Measured Particles

Between 2mm and 1000 mm

Measure median axis and record under 'Measured Particles'

Substrate Particles						Maximum Particles					

Crew Leader	Crew	Recorder	Entered	Verified	Corrected

Stream Crossing and Barrier Attribution

Stream Code ☐

Site Code ☐

Zone ☐

Easting ☐

Northing ☐

Date 2 *y y y m m d d*

Time (24 hr) *Hr : min*

Stream Name

Alternate Site Code(s)

Access Route

Site Description

Optional Measurements

Water Temp *C*

Air Temp *C*

pH

Conductivity *(Ns)*

Turbidity *(NTV)*

Dissolved O_2 *(mg/l)C*

Number of Features

Photo #

Photo Name

	Respon-sible Agency	Pur-pose	Feat. Type	Mater-ials	Outlet Flow Type	Outlet Drop Type	Outlet # Drops	Subst-rate	Perch Ht. (mm)	Jump Ht. (mm)	Max Pool Depth (mm)	Water in Feature/Culvert Depth (mm)	Water in Feature/Culvert Width (m)	Water in Feature/Culvert HH (mm)	Feature/Culvert Width (m)	Feature/Culvert Depth (mm)	Feature Length (m)	Jump Dist. (m)	Rise MT	Rise (mm or ^{0})	Plug Depth (mm)	Feat. Cond.[1]	Culverts % Rust
1																							
2																							
3																							
4																							

Comments

Perch height: depth from stream bed to lip of feature;
Jumping height: depth from water surface to lip of feature

Note 1: Record the additive values of feature condition for categories 3, 4 and 5.

Erosion Amount ☐

Erosion Categories

1. *Minimal*
2. *Moderate*
3. *Extreme*
4. *Can't assess*

Grate/ Cone ☐

No =0
Human = 1
Beaver = 2

Storage Width *(m)*

Upstream ☐ Downstream ☐

Crew Leader (initial & last name)

Crew Initials

Recorder

Responsible Agent
1. Municipality - e.g., road allowances
2. Crown: located on provincially managed lands
3. Conservation Authority
4. Private landowner - non-commercial
5.Commercial- including farms, businesses
6. Federal government, e.g., Parks Canada
7. First Nations
8. Other, record in comments
9. Unknown

Main Purpose
1. Road Conveyance
2. Storage for wildlife
3. Industrial Storage
4. Water power
5. Irrigation Storage
6. Mill use
7. Fish barrier
8. Flow mitigation
9. Field drainage
10. Entombed outlet
11.Other
12. Unknown

Constriction Type
1. Culvert
2. Tile
3. Arch
4. Constructed Dam/weir
5. Rock shelf
6. Gorge/cascade
7. Bridge abutments
8. Ford - instream crossing
9. Other

Feature Material
1. Corrugated Steel
2. Mud and sticks
3. Natural rock
4. Sheet steel
5. Concrete
6. Gabion and rock boulders
7. Reinforced Concrete
8. Earthen Fill
9. Masonry/inlaid stones
10. Plastic or other flexible material
11. Other Describe in comments

Outlet Flow Type
1. Stream Grade – minimal difference in bed elevation
2. Concentrated pore point (e.g., culvert, spillway
3. Partial Diffuser –reduced width flat overflow
4. Diffuser- uniform depth across > half width of stream
5. Other

Outlet Drop Type
1. Stream grade
2. Rip-rap
3. Apron
4. Pool - water drops into pool
5. Chute - strong velocity gradient
6. Other

Dominant substrate in feature
1. None
2. Silt or clay (smooth)
3. Sand (> .06-2 mm)
4. Gravel (2-65 mm)
5. Cobble (65-250 mm)
6. Boulders (>250 mm)
7. Bedrock

Slope measurement method
1. Visual
2. Clinometer
3. Lazer level
4. Survey level
5. Other

Standard Width Conversions	
10”	25 cm
12”	30 cm
18”	46 cm
24”	60 cm
36”	91
48” – 4’	122
60” – 5’	152
72” – 6’	182
84” – 7’	213
96” – 8’	244

Feature Condition Categories
1. No Evidence of issues - no evidence of damage
2.Minor Evidence of issues - example surface rust
3. Plugged - part or all of the feature infilled
4. Crushed – some part is crumpled
5. Perforated – rusted holes and other escapes for water
6. Unknown

Erosion Codes
1. None or minimal
2. Moderate - feature integrity not immediately threatened
3. Extreme - feature integrity threatened
4. Unknown - can’t effectively assess

Headwater Drainage Features - Up- and Down- Stream

Stream Code ☐ *Site Code* ☐ *Zone* ☐ *Easting* ☐ *Northing* ☐ *Date (YYYY)* ☐☐☐☐ - *(MM)* ☐☐ - *(DD)* ☐☐ *Time (24hr)* ☐☐ : ☐☐

Stream Name ☐

Discharge Approximates Baseflow? ○ **Baseflow** ○ **Freshet** ○ **Spate**

Upstream Site Length (m) ☐

Access Route

Site Description

Optional Features

Water Temp (C) ☐ Air Temp (C) ☐ pH ☐ Conductivity (Ns) ☐ Turbidity (NTV) ☐ Dissolved O_2 (ppm) ☐

Number of upstream features ☐

Upstream Roughness ☐

Photo #	*Photo Name*

Upstream Feature(s)

Feature Number	Distance (m)	Bearing	Type	Flow	Sediment Transport Adjacent	Sediment Transport Feature	Sediment Deposition	Width MT	Feature Width (m)	BF Depth (mm)	Entrenchment Width (m)	Feat. Veg	*Riparian Vegetation* 0-1.5 m Left	0-1.5 m Right	1.5-10 m Left	1.5-10 m Right	10-30 m Left	10-30 m Right
1																		
2																		
3																		
4																		

Upstream Longitudinal Gradient

Method Used	Distance (m)	Elevation Rise (cm)

Upstream Flow Measure(s)

Record EITHER Hydraulic Head OR Volume OR Distance

Feature Number	Wetted Width (m)	Depth (mm) 1	2	3	Hydraulic Head (mm) 1	2	3	Volume (lt) 1	2	3	Distance (m) 1	2	3	Time (sec) 1	2	3

Comments

If more than 1 downstream feature, complete a second Headwater Drainage form.

Photo #	Photo Name	Photo #	Photo Name	***Downstream Site Length (m)***

Downstream Feature

Type	Flow	Sediment Transport Adja-cent	Sediment Transport Valley	Sediment Deposition	Width MT	Feature Width (m)	BF Depth (mm)	Entrenchment Width (m)	Perched Ht (mm)	Jumping Ht (mm)	Feature Roughness	Feat Veg	Riparian Vegetation 0-1.5 m Left	Riparian Vegetation 0-1.5 m Right	Riparian Vegetation 1.5-10 m Left	Riparian Vegetation 1.5-10 m Right	Riparian Vegetation 10-30 m Left	Riparian Vegetation 10-30 m Right	Downstream Longitudinal Gradient Method Used	Downstream Longitudinal Gradient Distance (m)	Downstream Longitudinal Gradient Elevation Rise (cm) 0
☐	☐	☐	☐	☐	☐							☐	☐	☐	☐	☐	☐	☐	☐		

Downstream Flow Measure

Record EITHER Hydraulic Head OR Volume OR Distance

Wetted Width (m)	Depth (mm)			Hydraulic Head (mm)			Volume (lt)			Distance (m)			Time (sec)		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3

Upstream and Downstream Site Features	Category Value	Comments
Major Nutrient Sources Upstream		
Potential Contaminant Sources Upstream		
Channel Hardening		
Dredging or Straightening		
Barriers and/or Dams in proximity		
Online Ponds Upstream		
Springs or Seeps at the Site		
Evidence of Channel Scouring/Erosion		
BMPs or Restoration Activities		

CHANNEL CONNECTIVITY (to downstream) :

☐ Connected ☐ Unconnected

Connected: A surface water flow connection is apparent from the donating feature, to the downstream watercourse with existing or potential overland flow.

Unconnected: A water flow feature that is not connected to the drainage network except by groundwater infiltration. These features drain to kettle wetlands or ponds, etc that have no outlet to the drainage network except via groundwater.

Site Feature Categories
1. Ongoing and active
2. Historical evidence
3. No evidence, but reported
4. No evidence
5. Unknown

Downstream Comments

Crew Leader (initial & last name)		Crew	Recorder

Unconstrained Headwater Drainage Feature Assessment

Date: __________ Project #: __________ Recorder/Crew: __________

Stream Name: __________ Stream Code: __________ Site Code: __________

Site Limits: Upstream WP# __________

Downstream WP# __________

Direction of Assessment: ☐ Upstream ☐ Downstream

Field Assessment: ☐ Sample 1 ☐ Sample 2 ☐ Sample 3

Unconnected HDF: ☐ Not connected to downstream network

Flow Influence ☐ Freshet (1) ☐ Spate (2) ☐ Baseflow (3)

Flow Condition ☐ Dry (1) ☐ Standing Water (2) ☐ Interstitial Flow (3) ☐ Minimal Flow (4) ☐ Substantial Flow (5)

Feature Type ☐ Defined Natural Channel (1) ☐ Channelized or Constrained (2) ☐ Multi-thread (3) ☐ No Defined Feature (4) ☐ Tiled Feature (5) ☐ Wetland (6) ☐ Swale (7) ☐ Roadside Ditch (8) ☐ Pond (9)

Feature Vegetation ☐ None (1) ☐ Lawn (2) ☐ Cropped (3) ☐ Meadow (4) ☐ Scrubland (5) ☐ Wetland(6) ☐ Forest (7)

Riparian Vegetation

0 - 1.5 m	Left Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
	Right Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
1.5 - 10 m	Left Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
	Right Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
10 - 30 m	Left Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)
	Right Bank	☐ None (1)	☐ Lawn (2)	☐ Cropped (3)	☐ Meadow (4)	☐ Scrubland (5)	☐ Wetland (6)	☐ Forest (7)

Channel Gradient (S4.M7) ☐ Visual (1) ☐ Clinometer (2) ☐ Laser Level (3) ☐ Survey Level (4) ☐ Other (5) ☐ LiDAR (6)

Distance (m): ____ ____ ____ Elevation (cm) : ____ ____ ____ Gradient (^{0}): ____

	Clay (Hard Pan)	Silt	Sand (0.06-2 mm)	Gravel (22-66 mm)	Cobble (67-249 mm)	Boulder (250 mm)	Bedrock
Dominant Substrate (S2.M3)	☐	☐	☐	☐	☐	☐	☐
Sub-Dominant Substrate (S2.M3)	☐	☐	☐	☐	☐	☐	☐

Feature Roughness ☐ < 10% Minimal (1) ☐ 10 - 40% Moderate (2) ☐ 40 - 60% High (3) ☐ > 60% Extreme (4)

Width Measurement ☐ Can't Measure (1) ☐ Bankfull (2) ☐ Mean Width (3) ☐ Estimated (4) ☐ GIS (5) ☐ Measure/GIS (6)

Channel Dimensions Feature Width (m): __________ Bankfull Depth (mm) __________

Entrenchment Total: ☐ > 40 m ☐ < 40 m Left Bank _____ m Right Bank _____ m Total width _____ m

Surface Flow Method ☐ Perched Culvert (1) ☐ Hydraulic Head (2) ☐ Distance by Time (3) ☐ Estimated (4)

Wetted Width (m)	Wetted Depth (mm)	Hydraulic head (mm)	Volume (L)	Distance (m)	Time (s)
	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
______	______	______	______	______	______

Sediment Transport

Adjacent ☐ None (1) ☐ Rill (2) ☐ Rill and Gully (3) ☐ Gully (4) ☐ Outlet Scour (5) ☐ Sheet Erosion (6) ☐ Instream Bank Erosion (7) ☐ Other (8)

Feature ☐ None (1) ☐ Rill (2) ☐ Rill and Gully (3) ☐ Gully (4) ☐ Outlet Scour (5) ☐ Sheet Erosion (6) ☐ Instream Bank Erosion (7) ☐ Other (8)

Sediment Deposition Measures (mm): ____ ____ ____ ____ ____

☐ None (1) ☐ Minimal: < 5 mm (2) ☐ Moderate: 5-30 mm (3) ☐ Substantial: 31-80 mm (4) ☐ Extensive: > 80 mm (5)

Unconstrained Headwater Drainage Feature Assessment

Pg. 2 of 2

Date: ________________ Project #: ________________________ Field Assessment: ☐ Sample # 1 ☐ Sample # 2 ☐ Sample # 3

POINT FEATURE DATA

Fish Barrier Measurements: WP# Perched Height (mm): Jumping Height (mm):
WP# Perched Height (mm): Jumping Height (mm):

Groundwater Indicators ☐ None ☐ Watercress ☐ Seepage ☐ Bubbling ☐ Stained ☐ Other: ____________________
Fish Collection ☐ Absent ☐ Present Comment:

WP#	**Photo #**	**Code**	**Category**	**Description**

Additional Notes:

Site Break Trigger ☐ Feature Type ☐ Feature Modifier ☐ Flow Conditions ☐ Feature Vegetation ☐ Riparian Vegetation
☐ Other: Comments ______________________________

Point Data Category: Ongoing and Active (1) Historic Evidence (2) Reported but No Evidence (3)
No Evidence (4) Unknown (5)

POINT DATA KEY:

A	Spring/upwelling - estimate <0.5 l/sec or >0.5 l/sec; measure temp
B	Seepage area - measure or estimate length of bank where seepage occurs
C	Watercress - estimate total surface area occupied
D	Outlet (tile or other) - record flow status as per feature flow. Estimate volume <0.5 l/sec or >0.5 l/sec. Measure temperature.
E	Inlet (tile or other) - record flow status as per feature flow. Estimate volume to be <0.5 l/sec or >0.5 l/sec.
F	Beaver dam - measure perched height and jumping height
G	Manmade dam - measure perched height and jumping height
H	Other barrier to fish movement
I	Potential contamination source (storm sewer outlet or industrial discharge pipe).
J	Channel hardening - indicated by rip-rap, armour stone, or gabion baskets.
K	Culvert - note type, size and whether or not perched. If perched record perched height and jumping height.
L	Flow transition point D/S - flow condition changes from dry to standing water, independent of segment break
M	Flow transition point M/S- flow condition changes from minimal to substantial surface flow, independent of segment break
N	Flow transition point D-S/IF- flow condition changes from dry/standing water to interstitial flow, independent of segment break
O	Fish observed during non-fish sampling activities
P	Potential nutrient source
Q	Dredging of channel
R	Offline pond
S	Other