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Standardized data collection methods in support of a classification protocol for the designation of watercourses as municipal drains

Nicholas E. Mandrak and Lynn D. Bouvier

Fisheries and Oceans Canada
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Rd.
Burlington ON L7R 4A6 Canada

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

Agricultural watercourses in Ontario have been designated as municipal drains. To streamline regulatory processes for maintenance works, these watercourses are classified based on temperature, permanency of flow, and fish species present. Currently, maintenance works on three drain types require a site-specific review by Fisheries and Oceans Canada (DFO) including Types D and E drains that contain sensitive fish species and those watercourses that have species at risk present and/or mapped critical habitat (includes fishes and/or mussels that are Threatened or Endangered). These three drain types are more sensitive to municipal drain maintenance works, which typically involve dredging the bottom of the drain and removing excess sediment. Drain types D and E are classified based on temperature and fish data that have been collected in the field. Species at risk presence is determined by using the Species at Risk Maps, or by detecting species at risk during fish sampling. If either source indicates the presence of species at risk (SAR), then an SAR class will be applied.

The presence of top predators in a watercourse initially determined whether a site-specific review and Fisheries Act Authorization was required. It was deemed that this approach may not be appropriate and rather a list of sensitive species be created, which would better align with DFO's Risk Management Framework. The Risk Management Framework uses species sensitivity to determine risk level and whether an Authorization is the appropriate regulatory tool. DFO Science has been asked to provide methods used to create the sensitive fish species list to ensure that the approach is scientifically sound, and to review the resulting list of sensitive species to ensure that no sensitive species have been omitted and non-sensitive species are not included. In addition, a draft sampling protocol has been created for collecting temperature, flow, and fish data required for municipal drain classification. DFO Science has also been asked to review this sampling protocol to ensure it is scientifically sound.

Méthodes de collecte de données normalisées à l'appui d'un protocole de classification pour la désignation des cours d'eau comme des drains municipaux

RÉSUMÉ

En Ontario, certains cours d'eau agricoles ont été désignés en tant que drains municipaux. Ces cours d'eau ont été classés en fonction de la température, de la permanence du débit et des espèces de poissons présentes afin de simplifier les processus réglementaires régissant les travaux d'entretien. Actuellement, Pêches et Océans Canada (MPO) doit réaliser un examen propre aux sites pour les travaux d'entretien de trois types de drains, notamment pour les drains des types D et E, lesquels contiennent des espèces de poissons sensibles, et les cours d'eau où l'on trouve des espèces en péril et/ou un habitat essentiel cartographié (ce qui comprend les poissons et les moules menacés ou en voie de disparition). Ces trois types de drains sont plus sensibles aux travaux d'entretien, qui nécessitent généralement de draguer le fond du drain et d'enlever l'excédent de sédiments. Le classement des drains de types D et E est établi en fonction des données sur la température et les poissons recueillies sur le terrain. La présence d'espèces en péril est déterminée à l'aide des cartes des espèces en péril ou si la présence d'espèces en péril est décelée pendant un échantillonnage de poissons. Si l'une ou l'autre de ces sources indique la présence d'espèces en péril (EP), il faut appliquer une catégorie EP.

Auparavant, la présence de prédateurs de niveau trophique supérieur déterminait la nécessité de procéder à un examen propre au site et d'obtenir une autorisation en vertu de la *Loi sur les pêches*. On a par la suite jugé que cette méthode n'était pas appropriée et créé une liste des espèces sensibles qui serait plus conforme au Cadre de gestion des risques du MPO. Ce Cadre s'appuie sur la sensibilité d'une espèce pour déterminer à la fois le niveau de risque et si une autorisation constitue le bon outil réglementaire. On a demandé au Secteur des sciences du MPO d'indiquer les méthodes utilisées pour dresser la liste des espèces de poissons sensibles, afin de vérifier si l'approche est rigoureuse sur le plan scientifique. On lui a également demandé de passer en revue la liste obtenue pour s'assurer qu'aucune espèce sensible n'a été omise et que des espèces non sensibles n'y figurent pas. On a aussi mis au point un protocole d'échantillonnage provisoire pour collecter les données sur la température, le débit et les poissons dont on a besoin pour la classification des drains municipaux. On a demandé au Secteur des sciences du MPO d'examiner ce protocole d'échantillonnage pour vérifier qu'il repose sur des bases scientifiques solides.

INTRODUCTION

Rural watercourses in Ontario have been designated as municipal drains under the *Drainage Act, 1990*. These rural watercourses are classified into a number of categories to facilitate the review and approval of drain maintenance activities with respect to fishes and fish habitat. This is done under a Class Authorization Process developed by Fisheries and Oceans Canada (DFO) pursuant to the federal *Fisheries Act, 1985*. Full details on the process are outlined in the document: Agricultural Drain Maintenance in Southern Ontario – Guidance to Meeting Requirements of the *Fisheries Act* (DFO 2002).

Details are also summarized in: Fact Sheet L-2 – "What You Should Know About Fish Habitat and A Class Authorization System for the Maintenance of Agricultural Municipal Drains in Ontario".

The purpose of this sampling protocol is to provide preliminary guidance on standardized methods that should be used to collect field data in order to classify municipal drains in Ontario. Knowledge gaps are identified throughout the document and this guidance document should be updated as these gaps are addressed in the future.

STUDY DESIGN

DATA REQUIREMENTS

The following types of data are required to support the drain classification process (Figure 1; Table 1):

- drain location/extent;
- sensitive fish species present;
- flow characteristics (permanent or intermittent); and,
- water and air temperature (summer).

EXISTING DATA

In some cases, information may already be available to allow classification of a municipal drain. Prior to conducting field surveys, it is important to determine if fish, flow, and temperature data exist for the drain in question.

The Ontario Ministry of Natural Resources (OMNR), Fisheries and Oceans Canada (DFO), municipalities, and the local Conservation Authority should determine if they have the required data. Sources of data would include the OMNR Aquatic Resource Area layers, which may identify known spawning areas in drains and adjacent flooded riparian areas for species such as Northern Pike (*Esox lucius*). In addition, the DFO Species-at-Risk (SAR) maps should be used to identify systems that may contain species at risk. Records inputted in the creation of the SAR maps have been verified for accuracy and have been determined to be valid records. If the SAR maps indicate that a species at risk is present in the drain, a site-specific visit may be required to verify that the current habitat is suitable for the species at risk.

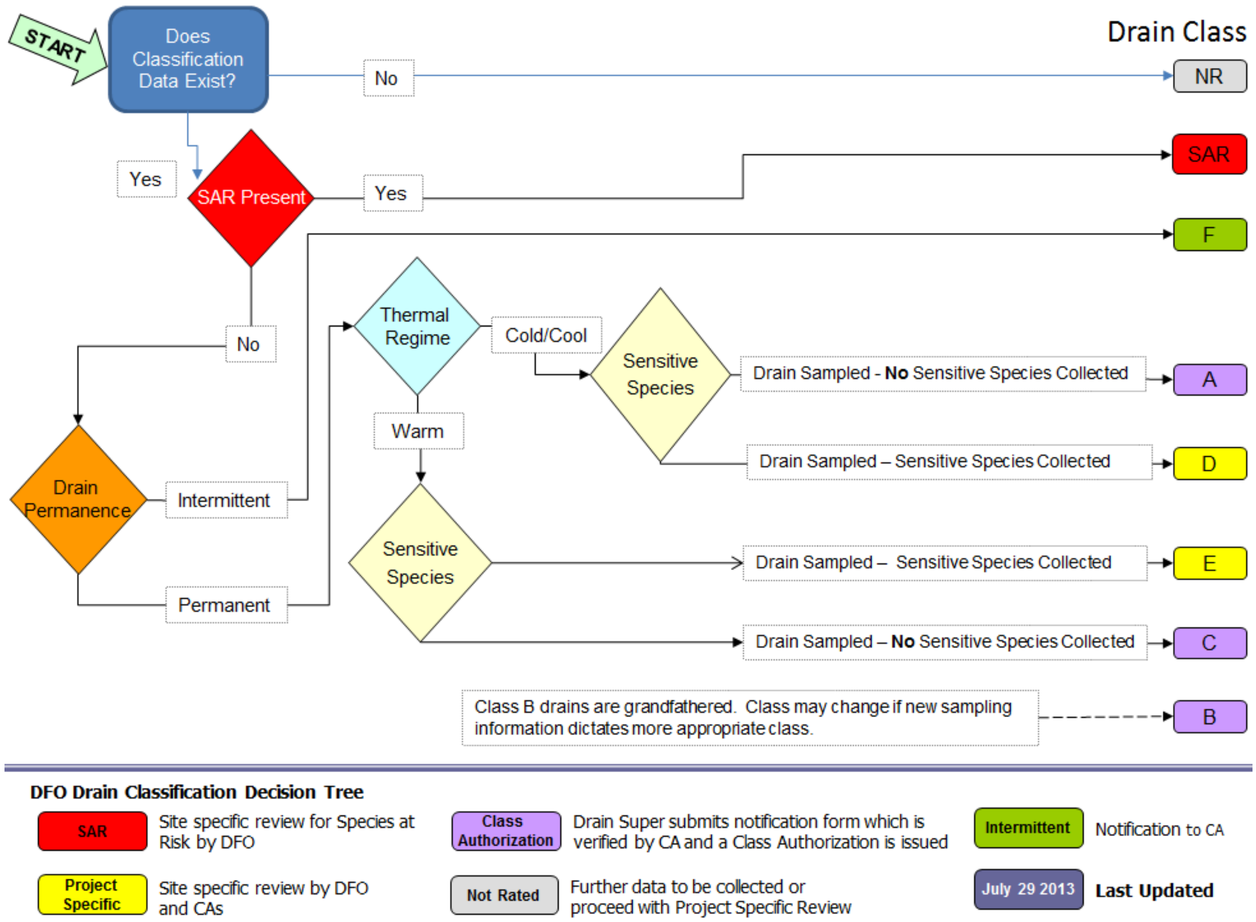

Figure 1. The agricultural drain classification process. The decision tree may result in a drain classification of SAR (endangered or threatened species at risk present), NR (not rated), or Class A to F.

Table 1. Summary of key characteristics of each drain classification.

TYPE	Flow	Temperature	Species	Time Since Last Clean-out	Authorization
A	Permanent	Cold/Cool	No sensitive fish species present	N/A	Class A
B*	Permanent	Warm	Sensitive species present	Less than 10 years	Class B
C	Permanent	Warm	No sensitive species present	N/A	Class C
D	Permanent	Cool/Cold	Sensitive species present	N/A	Project specific
E	Permanent	Warm	Sensitive species present	N/A	Project specific
F	Intermittent	N/A	N/A	N/A	None required (work done in dry or low flow)
Not Rated	Unknown	Unknown	Unknown	Unknown	Site specific or assess drain
SAR	N/A	N/A	Species at risk present	N/A	Site specific

* Note: No new Class B drains will be assigned, and any existing Class B drains will not change classification unless new data becomes available to support the reclassification to Class A, C, D, or SAR. Time since last clean out is no longer collected as part of the Drain Classification Project as per a decision made by the Drainage Action Working Group in 2010.

IDENTIFYING DRAINS TO BE SAMPLED

Areas that require drain classification will be prioritized by the local municipality or Conservation Authority based on current needs and concerns in the area. Priority areas might include:

- Areas with no existing data;
- Drains within which maintenance work is proposed in the near future, but at least a year away; and,
- Drains where the presence of sensitive fish species or habitat (e.g. spawning habitat, coldwater seeps) is suspected.

Knowledge Gap/Recommendation

- Need to incorporate and consider species that are listed (Special Concern, Threatened or Endangered) under the *Endangered Species Act*, *2007* (ESA) (e.g., Redside Dace, *Clinostomus elongatus*, Black Redhorse, *Moxostoma duquesnei*, Cutlip Minnow, *Exoglossum maxillingua*) but not listed under the federal Species at Risk Act (SARA) when completing the initial screening for fish SAR. The DFO Species-at-Risk maps do not currently include information for species listed under the ESA, but not under the SARA.

SAMPLING PROCEDURE

The extent of the drain should be determined on the OMAFRA/DFO/CA drains layer. Any given drain will be comprised of one or more segments, each of which may be classified independently. A drain segmentation layer does not currently exist; therefore, segmentation will be based on the sampling procedures outlined below. In the absence of a drain segmentation layer, it is recommended, for ease of access and delineation, that road crossings be the basis for potential segmentation. To assist in potential future segmentation projects, basic characteristics should be recorded upstream of the road crossing. These characteristics should include drain name, latitude, longitude, date, maximum stream width, maximum depth, water temperature, air temperature, riparian cover, adjacent land use, and intermittency.

It is necessary to sample away from the road crossing to avoid the hydrological influence of the road crossing. Where access to the drain is available, the first site should be placed where the channel morphology becomes uniform. The intent of the habitat sampling is to determine changes in hydrology along the drain for segmentation purposes. If sampling was only to occur at road crossings, these data may falsely lead one to believe that the channel is uniform throughout the entire drain segment (from downstream road crossing to upstream road crossing) when, in reality, the drain segment may differ between road crossings. If access to the drain upstream of the road crossing is not available, the measurements should be taken at the road crossing. **NOTE:** Changes in surficial geology may occur along a drain segment and may be used to alter the drain segmentation. For example, coldwater seeps, moraines, or isolated pools upstream from the road crossing should be noted, and may be used to create a break in the drain segmentation layer. In addition, impassable barriers within the drain should be used to create a break in the drain segmentation layer.

Knowledge Gap/Recommendation

- Drain segmentation layer for Ontario based on landscape and hydrology.

FLOW DETERMINATION

Each watercourse must be classified as either “permanent” or “intermittent”.

Permanent systems flow year round, or are consistently wet. If a watercourse continues to flow (in an average year), or is consistently wet, during the dry summer months, it should be considered permanent.

Intermittent systems flow continuously for only a portion of the year, or are consistently dry, during the summer months. If a watercourse flows during brief periods (usually during the spring and/or fall), or for brief periods following storm events during the summer months, or has a defined channel but is dry for at least three months of the year, it should be considered intermittent.

If the watercourse is categorized as an intermittent system, but habitats are present within the drain where there are known sensitive species, the drain cannot be considered intermittent.

The permanency of the watercourse can be determined in a number of ways, including a review of historical data and existing information (1), application of published methods (2), the use of water-level loggers (3), the use of temperature loggers (4), or regular site visits with georeferenced photographic evidence (5).

1. Documentation of existing information obtained from CA, OMNR, or DFO records (e.g. drainage reports, fisheries reports, watershed reports). This includes flow data/water depth of the drain collected at monthly intervals throughout the open-water period, supported by georeferenced photographs and dated field notes. Consideration must be given to the amount of precipitation received immediately prior to observation, or during the sampling year. Local weather statistics (e.g., from Environment Canada) should be reviewed if there are any concerns regarding abnormalities during observation periods. Such data will indicate if the drain, from that point upstream, is intermittent, but will not provide information on the segment(s) downstream.
2. Applying the methods outlined in the, "*The Stream Permanency Handbook for South-Central Ontario*" (Irwin et al. 2013), or methods included in the *"Evaluation, Classification and Management of Headwater Drainage Features Guidelines"* (TRCA 2013). Such an assessment will indicate if the drain, from that point upstream, is intermittent, but will not provide information on the segment(s) downstream.
3. Water-level loggers placed at the bottom end of a drain segment for a minimum of three months during the open-water period (May-June-July, or June-July-August; Irwin et al. 2013). As intermittency is most likely to occur as summer progresses, loggers are to be deployed during this time (i.e., early July – end of August). This will indicate if the drain, from that point upstream, is intermittent, but will not provide information on the segment(s) downstream.
4. Temperature loggers at the bottom end of a drain segment in an area of greatest water depth, for a minimum of three months during the open-water period (May-June-July, or June-July-August; Irwin et al. 2013). As intermittency is most likely to occur as summer progresses, it would be best if the loggers were deployed during this time. As water temperature is generally lower and varies diurnally less than air temperature, a thermograph of the data can be compared to data from a local weather station to determine if the temperature logger was exposed, to assess intermittency. This will indicate if the drain, from that point upstream, is intermittent, but will not provide information on the segment(s) downstream.
5. Bi-weekly site visits during the months of May, June, July and August with georeferenced photographic evidence demonstrating that the watercourse is dry. This information can be obtained from reliable sources (Drainage Superintendents, municipal staff, landowners, local residents), provided it is verified with georeferenced, photographic evidence. Such

data will indicate if the drain, from that point upstream, is intermittent, but will not provide information on the segment(s) downstream.

NOTE: If the flow is determined to be intermittent, the collection of fish and temperature data are not required as the drain will be automatically receiving an F classification.

Knowledge Gaps/Recommendations

- Landscape model to predict intermittency applied to a drain segmentation layer.
- Empirical evaluation of the temperature method (#4 above).

TEMPERATURE

If not intermittent, each watercourse must be classified as “coldwater”, “coolwater”, or “warmwater”. The relationship between water temperature, air temperature, and thermal classification has long been established (Stoneman and Jones 1996) and recently evaluated and refined (Chu et al. 2009). Other thermal classification methods have been developed that use longer-term thermal data or fish assemblage data (e.g., Wichert and Lin 1996; Lyons et al. 2009); however, they require much more data collection than the method outlined below. In particular, fish assemblage-based methods require sufficient sampling effort to collect a large proportion of the species present, which would be typically greater than effort required to detect a sensitive species (see below).

The following procedures are to be used to take standardized water and air temperature measurements. These are largely derived from the DFO/OMNR Habitat Management Series publication, “*A Simple Method to Determine the Thermal Stability of Southern Ontario Trout Streams*” and an evaluation of this method by Chu et al. (2009). Further guidance is available in Section 5 Module 1 of the Ontario Stream Assessment Protocol (Stanfield 2010).

- The sampling should take place from **July 1 to August 31**. Prior to, and after, these dates, overnight cooling of streams does not allow adequate separation of the thermal categories.
- Sample on days when maximum air temperatures have reached **at least 24.5°C** (Chu et al. 2009). Sample only when the previous 2-3 days are relatively similar in daily maximum air temperature (i.e., less than 5^{o}C warmer or cooler). For example, sampling would not occur on a 25°C day that was preceded by two days of 32°C or 20°C temperatures. This bias can occur when waiting for a day that is finally ‘hot enough”, or when a cold front moves in during the morning or early afternoon on a day scheduled for sampling.
- Water temperature sampling should not occur if it has rained in the three days prior to sampling, as rain events will alter water temperature.
- Take water temperature measurements between 16:00 and 18:00 h, which represent the maximum daily water temperature. Temperatures can be measured using a hand-held thermometer, a temperature logger, or minimum-maximum thermometer placed at the site before 16:00 h and removed and checked for maximum water temperature after 18:00 h. The temperature should be taken in the main flow of the stream, where waters are well mixed. Deployment methods from Jones and Allin (2010) should be used if temperature loggers are being used. All data points should be recorded (date, time and location of water temperature recordings, dates of maximum air temperatures, and devices used to record temperature) so that drain class determination may be automated and reviewed at a later date.

- Obtain the maximum air temperature for the day of sampling. This is ***not*** a measure of the air temperature at 16:00 h. Daily air temperature maximums are available from Environment Canada weather stations. Locate the weather station closest to the stream site being sampled. Alternatively, a reliable temperature recording device (e.g., HOBO temperature logger) or minimum-maximum thermometer can be placed at a nearby, shaded location in the morning and checked at the end of the day (after 18:00 h).
- Using the nomogram shown in Figure 2 below, plot the maximum air temperature against the 16:00-18:00 h water temperature. Determine the location of your data point on the nomogram as belonging to the coldwater, coolwater, or warmwater category.
- It is recommended that the first temperature measurements be done in the drain at the road crossing farthest downstream, then at the road crossing farthest upstream. If the thermal classification is the same at both sites, then the thermal classification of the drain segment(s) between those sites should be considered the same. If the thermal classification is different, then temperature measurements should be taken at the road crossing halfway up the drain and iteratively upstream and downstream until the extents of the thermal classes across the drain segments is determined.
- To increase the accuracy of the site classification, several measurements should be taken on different days, particularly if the water temperature is close to the boundary between thermal categories (e.g., within +/- 2°C).

Knowledge Gaps/Recommendations

- Landscape model to predict thermal class applied to a drain segmentation layer (sensu Lyons et al. 2009)
- Temperature sampling protocol for Northern Ontario.

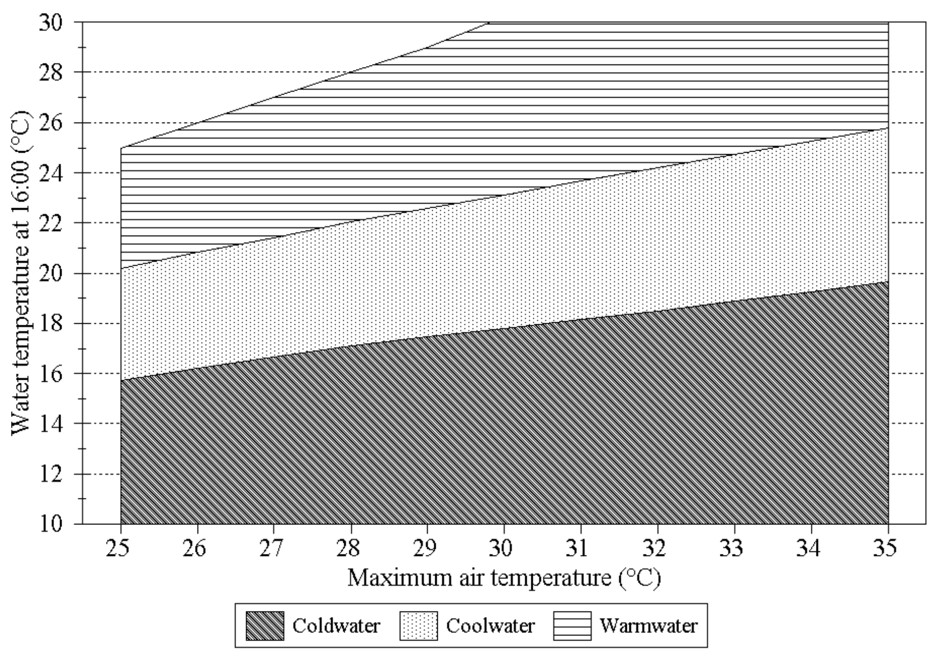

Figure 2. Nomogram used to determine thermal classification using maximum daily summer water and air temperatures (from Stoneman and Jones 1996).

NOTE: The use of temperature loggers would make the collection of temperature data more efficient. The method outlined above will not identify isolated pools, or the influence of coldwater seeps, tile drains, or other localized influences on water temperature present between road crossings. This method for determining water temperatures was developed and validated in Southern Ontario and has not been tested in the Northern Ontario or other parts of the country.

FISH SAMPLING

If the watercourse is not intermittent, then the occurrence of sensitive species must be determined (see Appendix 1 for list of sensitive species). As indicated above, field investigation may not always be necessary to obtain information about the fish assemblage present in the drain. OMNR, DFO, and the local Conservation Authority should be contacted to determine if they have the required data. The Royal Ontario Museum and Canadian Museum of Nature should be contacted to determine if they have any collections records for the drains in question. Fish sampling is necessary if there are no existing data, or if there is an expectation that the fish assemblage composition may have changed since the last time of sampling.

If fish sampling is required, the gear and effort to be used depends on the nature of the drains and objective of the sampling (e.g., sensitive species vs. whole assemblage). Wadeable sampling can be undertaken in habitats with water depths of less than 1.2 m (1 m for electrofishing) if the substrate is free from tripping hazards and firm enough for wading to occur. Non-wadeable sampling would be required where these conditions are not met.

In both wadeable and non-wadeable habitats, seining and electrofishing are considered the most efficient, readily available, sampling gears. However, seining may not be the most effective sampling method in habitat where debris, boulders or other obstacles are present. Electrofishing is not effective in habitats with high turbidity (>10 NTU) or low conductivity (<100 µS) or high conductivity (> 600 µS). Detailed descriptions of the dimensions and use of these gears can be found in Bonar et al. (2009). Electrofishing should only be undertaken by trained and certified individuals. Electrofishing training is offered through the Institute for Watershed Science or may be available through your local Conservation Authority. Although seining and electrofishing are the preferred sampling techniques, if it is not feasible to apply these techniques due to the limitations described above, sampling may be accomplished with the use of fyke nets or trap nets.

*An OMNR scientific collector permit is required for all fish sampling. Additionally, a federal SARA permit is required if a SARA-listed species is **present** and a provincial ESA permit is required if an ESA-listed species is **targeted**.* Depending on the objective, fish sampling can be conducted in a number of ways.

1. If the objective is to determine if sensitive species are present, then the whole fish assemblage does not need to be sampled. The following procedure is recommended.
    a. It is recommended that conventional site identification methods (e.g., Ontario Stream Assessment protocol; Stanfield 2010) be used; although it may not always be feasible to use this approach in drains as these methods rely on the presence of crossovers that are often not present in drain systems. When it is not possible to use conventional site identification methods, a site can be defined as 10 times wetted width (m) or 40 m, whichever is greater.
    b. It is recommended that the first fish sampling site be located in the drain upstream of the road crossing farthest downstream. The second fish sampling site should be located in the drain above the road crossing farthest upstream. If sensitive species are found at both sites, then sensitive species should be considered to be present

through the drain. If sensitive species are found at only one site, or at neither site, then fish sampling should be conducted at the road crossing halfway up the drain and iteratively upstream and downstream until the extent of sensitive species occurrence across the drain segments is determined. Sampling should only occur between road crossings if permission is granted.

c. If electrofishing, the site should be sampled using a minimum of three passes at each site. Once three passes have been completed, process fish. **If a sensitive species is caught in the first three passes, then no further sampling is required. Otherwise, sampling should continue**. Complete one pass at a time, processing fish after each pass until no new species have been caught in three consecutive passes or a sensitive species is caught, whichever comes first. The site should be sampled in an upstream direction, ensuring adequate coverage of different habitats moving from bank to bank if possible, at a rate of 2-5 sec·m^2. Fishes should be identified and field sheet completed after the first three passes, and then after each subsequent pass. Photographic documentation or vouchers should be kept for every species collected (see Appendix 2 for details).

d. If seining, the site should be sampled using a minimum of three sampling events at each site (i.e., one sampling event represents a seining survey across the entire site length, and may constitute multiple hauls). A seine net with a mesh size of 3 mm (1/8”) should be used. **If a sensitive species is caught in the first three sampling events, then no further sampling is required. Otherwise, sampling should continue** until no new species have been caught in three consecutive sampling events or a sensitive species is caught, whichever comes first. The site should be sampled in a downstream direction, sampling different habitats if possible. Fishes should be identified and field sheet completed after the first three sampling events, and then after each subsequent sampling event. Photographic documentation or vouchers should be kept for every species collected (see Appendix 2 for details).

e. If fyke or trap netting, the site should be sampled using three nets. The three nets should be set at the same time and remain for 24-h at each site. A net with a mesh size of 6 mm should be used. **If a sensitive species is caught in the first 24-h net sets, then no further sampling is required. Otherwise, sampling should continue** until no new species have been caught in three consecutive net sets or a sensitive species is caught, whichever comes first. Fishes should be identified and field sheet completed after each net is fished. Photographic documentation or vouchers should be kept for every species collected (see Appendix 2 for details).

NOTE: As many sensitive species have low detection probabilities, a minimum of three sampling events (e.g., a single pass, a single night of a net set) at each site is required for all gear types, as detection is unlikely to occur after a single sampling event. In addition, a minimum of three sampling events at each site will allow for additional detection analyses of sensitive species, allowing for a refinement of this protocol. Also, detection probability is known to vary by gear type, habitat characteristics, and abundance of the target species. The above protocol is meant to provide guidelines that are suitable for a majority of sensitive species. Sensitive species-specific detection probability estimates would allow for a refinement of the protocol but are currently not available.

2. If the objective is to determine the composition of the whole fish assemblage [e.g., for general survey purposes, or to determine thermal classification based on fish composition (e.g., Wichert and Lin 1996)], established, existing protocols should be used (e.g., Ontario Stream Assessment Protocol; Stanfield 2010). Smith and Jones (2005) provides guidance

on the number of passes required at a site to detect all species present, and the number of sites required to be sampled to determine the whole fish assemblage in a watershed (e.g., drain). Whole fish assemblage sampling should be conducted at randomly selected sites and, ideally, species accumulation curves will be calculated during the sampling to guide total effort required. Note that effort required for such sampling is dependent upon the effort required to detect the rarest species at the site or in the watershed and, therefore, will be substantially greater than the effort required to sample more common species (e.g., sensitive, but not rare, species).

3. If the objective is to determine the presence of a species at risk (SAR), Portt et al. (2008) provides guidance on the gear and effort required to detect fish SAR. Dextrase et al. (draft) provides further guidance on the effort required for a subset of fish SAR. Sampling should target the preferred habitat of the target fish SAR. Although it is dependent on the level of site occupancy and abundance, the effort required for fish SAR sampling may be greater than the effort required to sample more common species (e.g., sensitive, but not rare, species).

Knowledge Gaps/Recommendations

- Effort by gear required to detect either a specific or any sensitive species in drains
- Effort by gear required to detect whole fish assemblage in drains
- Predictive models of sensitive species occurrence in drain segments

APPENDIX 1. SENSITIVE SPECIES CRITERIA

For the purposes of drain classification, the following criteria were used to classify all fish species in Ontario as sensitive or tolerant.

1. SARA, ESA, and COSEWIC Species

Any species listed under Schedule 1 of the federal Species at Risk Act (SARA), the provincial Endangered Species Act (ESA), or assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Extirpated, Endangered, Threatened, or Special Concern will be considered a sensitive species.

2. Non-native Species

Any species, other than game fishes, that is considered non-native to Ontario will be considered a tolerant species.

3. Environmental Tolerance

Any species considered to be tolerant of varying environmental conditions will NOT be considered a sensitive species based on the majority consensus of Barbour et al. (1999), Meador and Carlise (2007), and Trebitz et al. (2007). Area of study, variables used in tolerance classification, and classification categories for these three studies can be found in Table A1. In addition to primary tolerance classifications, Barbour et al. (1999) also provided ‘exceptions’ for each species when a study did not agree with the consensus of other cited literature. We considered these ‘exceptions’ in environmental tolerance classification if the review of Meador and Carlise (2007), and Trebitz et al. (2007) and primary classification of Barbour et al. (1999) was inconclusive, and only for species where the exclusions referenced Lyons (1992) or Haliwell et al. (1999) as these studies focused on studies within relatively close proximity to southern Ontario.

4. Expert Opinion Consensus

If a species could not be classified using criteria 1-3, expert opinion may be used to provide the species sensitivity classification. In addition, expert knowledge of the species in Ontario may override the classification resulting from the application of criteria 3 (Environmental Tolerance).

The results of applying these classification criteria to all Ontario freshwater fishes can be found in Table A2.

Table A1. Review of studies used in the environmental tolerance classification criteria.

Reference	Area of study	Variables used in ranking	Classification
Barbour et al. (1999)	Literature search including the following studies: - Midwestern United States (Karr et al. 1986) - Ohio (Ohio EPA 1987) - Midwestern United States (Plafkin et al. 1989) - Central Corn Belt Plain (Simon 1991) - Wisconsin Warmwater (Lyons 1992) - Maryland Coastal Plain (Hall et al. 1996) - Northeastern United States (Haliwell et al. 1999)		**Intolerant** (I) – Species that is sensitive to environmental or anthropogenic stresses. **Intermediate** (M) – Species that is neither particularly sensitive nor insensitive to environmental or anthropogenic stresses. **Tolerant** (T) – Species that is fairly insensitive or adaptive to environmental or anthropogenic stresses.
Meador and Carlisle (2007)	773 stream sites sampled from major river basins across the United States	- Ammonia - Chloride - Dissolved oxygen - Nitrite plus nitrate - pH - Phosphorus - Specific conductance - Sulfate - Suspended sediment - Water temperature	Same as Barbour et al. (1999).
Trebitz et al. (2007)	Great Lakes coastal wetlands	- Turbidity	**Intolerant** (I) – At most one occurrence at turbidity >10 NTU **Moderately intolerant** (MI) – Multiple occurrences at turbidity >10 NTU or At most one occurrence at turbidity >25 NTU **Moderately tolerant** (MT) – Multiple occurrences at turbidity >25 NTU or Shift from present to absent or reduced relative abundance above 50 NTU turbidity **Tolerant** (T) – Occurring across the turbidity gradient or No decline in relative abundance above 50 NTU

Table A2. Sensitive species classification of all fish species in Ontario. SARA or ESA listed species, as well as species designated by COSEWIC, are noted as Special Concern (SC), Threatened (THR), Endangered (END), Extirpated (EXP), Extinct (EXT), Data Deficient (DD), or Not at Risk (NAR). Two or more designations entered for a single species represents multiple designatable units present in Ontario. Non-native species are indicated with a 'Y'. Environmental tolerance criteria are given as Intolerant (I), Intermediate (M), Tolerant (T) or Not Applicable (na) for Meador and Carlisle (2007) and Barbour et al. (1999), and listed as Intolerant (I), Moderately Intolerant (MI), Moderately Tolerant (MT) and Tolerant (T) for Trebitz et al. (2007).

		(1) At Risk			(2)	(3) Environmental Tolerance				(4)		
Scientific Name	**Common Name**	**SARA Schedule 1 (July 2013)**	**COSEWIC (July 2013)**	**ESA**	**Non-native (Y=yes)**	**Meador and Carlisle (2007)**	**Trebitz et al. (2007)**	**Barbour et al. (1999)**	**Barbour et al. (1999) exceptions**	**Expert Opinion**	**Criteria Applied**	**Rank**
Sensitive Species												
Acipenser fulvescens	Lake Sturgeon		SC/END/THR	THR		na	na	M			1	Sensitive
Ammocrypta pellucida	Eastern Sand Darter	THR	THR	END		na	na	I			1	Sensitive
Anguilla rostrata	American Eel		THR	END		M	na	M			1	Sensitive
Catostomus catostomus	Longnose Sucker					M	na	M		Sensitive	4	Sensitive
Clinostomus elongatus	Redside Dace		END	END		na	na	I			1	Sensitive
Coregonus artedi	Cisco					na	na	M		Sensitive	4	Sensitive
Coregonus clupeaformis	Lake Whitefish					na	na	M	I		3	Sensitive
Coregonus hoyi	Bloater		NAR			na	na	M		Sensitive	4	Sensitive
Coregonus johannae	Deepwater Cisco		EXT			na	na	M			1	Sensitive
Coregonus kiyi	Kiyi		SC/EXT	SC		na	na	M			1	Sensitive
Coregonus nigripinnis	Blackfin Cisco		DD			na	na	I			3	Sensitive
Coregonus reighardi	Shortnose Cisco	END	END	END		na	na	I			1	Sensitive
Coregonus zenithicus	Shortjaw Cisco		THR	THR		na	na	M			1	Sensitive
Cottus bairdii	Mottled Sculpin					na	na	I			3	Sensitive
Cottus cognatus	Slimy Sculpin					na	na	M	I		3	Sensitive
Cottus ricei	Spoonhead Sculpin		NAR			na	na	M	I		3	Sensitive
Couesius plumbeus	Lake Chub					na	na	M		Sensitive	4	Sensitive
Erimystax x-punctata	Gravel Chub	EXT	EXP	EXT		na	na	M			1	Sensitive
Erimyzon sucetta	Lake Chubsucker	END	END	THR		na	na	M			1	Sensitive
Esox americanus vermiculatus	Grass Pickerel	SC	SC	SC		M	MI	M			1	Sensitive
Etheostoma caeruleum	Rainbow Darter					I	na	M			3	Sensitive
Etheostoma flabellare	Fantail Darter					I	na	M			3	Sensitive
Exoglossum maxillingua	Cutlip Minnow		NAR	THR		na	na	I			1	Sensitive

Fundulus notatus	Blackstripe Topminnow	SC	SC	SC		T	na	M			1	Sensitive
Hiodon alosoides	Goldeye					na	na	I			3	Sensitive
Hiodon tergisus	Mooneye					na	na	I			3	Sensitive
Hybognathus regius	Eastern Silvery Minnow		NAR			na	na	M	I		3	Sensitive
Hypentelium nigricans	Northern Hog Sucker					M	na	I			3	Sensitive
Ichthyomyzon cataneus	Chestnut Lamprey		DD			na	na	M		Sensitive	4	Sensitive
Ichthyomyzon fossor	Northern Brook Lamprey	SC	SC	SC		na	na	I			1	Sensitive
Ichthyomyzon unicuspis	Silver Lamprey		SC	SC		na	na	M			1	Sensitive
Lepisosteus oculatus	Spotted Gar	THR	THR	THR		M	na	M			1	Sensitive
Lepomis gulosus	Warmouth	SC	SC	SC		M	MI	M			1	Sensitive
Lepomis peltastes	Northern Sunfish		NAR			M	na	I			3	Sensitive
Lethenteron appendix	American Brook Lamprey					na	na	I			3	Sensitive
Macrhybopsis storeriana	Silver Chub		END	THR		na	na	M			1	Sensitive
Minytrema melanops	Spotted Sucker	SC	SC	SC		M	MT?	M			1	Sensitive
Moxostoma carinatum	River Redhorse	SC	SC	SC		na	na	I			1	Sensitive
Moxostoma duquesnei	Black Redhorse		THR	THR		I	na	I			1	Sensitive
Moxostoma valenciennesi	Greater Redhorse					na	na	I			3	Sensitive
Myoxocephalus thompsonii	Deepwater Sculpin	SC	NAR/SC			na	na	M			1	Sensitive
Nocomis biguttatus	Hornyhead Chub		NAR			M	MI	I			3	Sensitive
Nocomis micropogon	River Chub		NAR			M	na	I			3	Sensitive
Notropis anogenus	Pugnose Shiner	END	THR	END		na	na	I			1	Sensitive
Notropis bifrenatus	Bridle Shiner	SC	SC			na	na	I			1	Sensitive
Notropis heterodon	Blackchin Shiner		NAR			na	I	I			3	Sensitive
Notropis heterolepis	Blacknose Shiner					na	MI	I			3	Sensitive
Notropis photogenis	Silver Shiner		THR	THR		I	na	I			1	Sensitive
Notropis rubellus	Rosyface Shiner		NAR			M	na	I			3	Sensitive
Noturus miurus	Brindled Madtom		NAR			na	na	I			3	Sensitive
Noturus stigmosus	Northern Madtom	END	END	END		na	na	I			1	Sensitive
Oncorhynchus gorbuscha	Pink Salmon				Y	na	na	M		Sensitive	4	Sensitive
Oncorhynchus kisutch	Coho Salmon				Y	na	na	M		Sensitive	4	Sensitive
Oncorhynchus mykiss	Rainbow Trout				Y	I	na	M			3	Sensitive
Oncorhynchus tshawytscha	Chinook Salmon				Y	na	na	M		Sensitive	4	Sensitive
Opsopoeodus emiliae	Pugnose Minnow	SC	THR	THR		na	na	I			1	Sensitive
Percina copelandi	Channel Darter	THR	THR	THR		na	na	I			1	Sensitive

Percopsis omiscomaycus	Trout-perch					na	MI	M			3	Sensitive
Polyodon spathula	Paddlefish	EXT	EXP	EXT		na	na	I			1	Sensitive
Prosopium coulteri	Pygmy Whitefish					na	na	M		Sensitive	4	Sensitive
Prosopium cylindraceum	Round Whitefish					na	na	M	I		3	Sensitive
Salmo salar	Atlantic Salmon		EXP			na	na	M			1	Sensitive
Salmo trutta	Brown Trout				Y	I	na	M			3	Sensitive
Salvelinus fontinalis	Brook Trout					I	na	M			3	Sensitive
Salvelinus fontinalis timagamiensis	Aurora Trout	END	Non-active			na	na				1	Sensitive
Salvelinus namaycush	Lake Trout					na	na	M	I		3	Sensitive
Sander vitreus glaucus	Blue Pike		EXT			na	na				1	Sensitive
Semotilus corporalis	Fallfish					M	na	M		Sensitive	4	Sensitive
Tolerant Species												
Alosa pseudoharengus	Alewife				Y	na	T	M			2	Tolerant
Alosa sapidissima	American Shad				Y	na	na	M			2	Tolerant
Ambloplites rupestris	Rock Bass					M	MT	M			3	Tolerant
Ameiurus melas	Black Bullhead					M	MT	M			3	Tolerant
Ameiurus natalis	Yellow Bullhead					T	T	T			3	Tolerant
Ameiurus nebulosus	Brown Bullhead					M	MT	T			3	Tolerant
Amia calva	Bowfin					M	T	M			3	Tolerant
Apeltes quadracus	Fourspine Stickleback				Y	na	na	M			2	Tolerant
Aplodinotus grunniens	Freshwater Drum					T	T	M			3	Tolerant
Campostoma anomalum	Central Stoneroller		NAR			M	na	M	T		3	Tolerant
Carassius auratus	Goldfish				Y	na	T	T			2	Tolerant
Carpiodes cyprinus	Quillback					M	T	M			3	Tolerant
Catostomus commersonii	White Sucker					T	MT	T			3	Tolerant
Chrosomus eos	Northern Redbelly Dace					na	na	M		Tolerant	4	Tolerant
Chrosomus neogaeus	Finescale Dace					na	na	M		Tolerant	4	Tolerant
Ctenopharyngodon idella	Grass Carp				Y	na	na	M			2	Tolerant
Culaea inconstans	Brook Stickleback					na	I	M		Tolerant	4	Tolerant
Cyprinella spiloptera	Spotfin Shiner					M	T	M			3	Tolerant
Cyprinus carpio	Common Carp				Y	T	T	T			2	Tolerant
Dorosoma cepedianum	Gizzard Shad					T	T	M			3	Tolerant
Esox lucius	Northern Pike					M	MT	M			3	Tolerant
Esox masquinongy	Muskellunge					na	MT?	M		Tolerant	4	Tolerant

Etheostoma blennioides	Greenside Darter		NAR			M	na	M		Tolerant	4	Tolerant
Etheostoma exile	Iowa Darter					na	na	M		Tolerant	4	Tolerant
Etheostoma microperca	Least Darter		NAR			na	na	M		Tolerant	4	Tolerant
Etheostoma nigrum	Johnny Darter					T	MT	M			3	Tolerant
Etheostoma olmstedi	Tesselated Darter		NAR			M	na	M		Tolerant	4	Tolerant
Fundulus diaphanus	Banded Killifish		NAR			na	MT	T			3	Tolerant
*Gasterosteus aculeatus**	Threespine Stickleback (native)					na	MI	M		Tolerant	4	Tolerant
*Gasterosteus aculeatus**	Threespine Stickleback (non-native)				Y (see *)	na	MI	M			2	Tolerant
Gymnocephalus cernua	Ruffe				Y	na	MI	M			2	Tolerant
Hybognathus hankinsoni	Brassy Minnow					na	na	M		Tolerant	4	Tolerant
Ictalurus punctatus	Channel Catfish					T	T	M			3	Tolerant
Ictiobus bubalus	Smallmouth Buffalo				Y	T	na	M			2	Tolerant
Ictiobus cyprinellus	Bigmouth Buffalo		NAR			na	MT?	M			3	Tolerant
Ictiobus niger	Black Buffalo		DD		Y	na	na	M			2	Tolerant
Labidesthes sicculus	Brook Silverside		NAR			M	T	M			3	Tolerant
Lepisosteus osseus	Longnose Gar					T	T	M			3	Tolerant
Lepomis cyanellus	Green Sunfish		NAR			T	T	T			3	Tolerant
Lepomis gibbosus	Pumpkinseed					M	MT	M			3	Tolerant
Lepomis humilis	Orangespotted Sunfish		Non-active		Y	T	MT?	M			2	Tolerant
Lepomis macrochirus	Bluegill					M	MT	M			3	Tolerant
Lota lota	Burbot					na	na	M		Tolerant	4	Tolerant
Luxilus chrysocephalus	Striped Shiner		NAR			M	na	M	T		3	Tolerant
Luxilus cornutus	Common Shiner					M	T	M			3	Tolerant
Lythrurus umbratilis	Redfin Shiner		NAR			na	na	M	T		3	Tolerant
Margariscus nachtriebi	Northern Pearl Dace					na	na	M		Tolerant	4	Tolerant
Micropterus dolomieu	Smallmouth Bass					M	MT	M			3	Tolerant
Micropterus salmoides	Largemouth Bass					T	MT	M			3	Tolerant
Morone americana	White Perch				Y	na	T	M			2	Tolerant
Morone chrysops	White Bass					T	T	M			3	Tolerant
Moxostoma anisurum	Silver Redhorse					M	MI	M		Tolerant	4	Tolerant
Moxostoma erythrurum	Golden Redhorse		NAR			M	T	M			3	Tolerant
Moxostoma macrolepidotum	Shorthead Redhorse					M	MI	M		Tolerant	4	Tolerant

Neogobius melanostomus	Round Goby				Y	na	MT				2	Tolerant
Notemigonus crysoleucas	Golden Shiner					M	MT	T			3	Tolerant
Notropis atherinoides	Emerald Shiner					T	T	M			3	Tolerant
Notropis buchanani	Ghost Shiner		NAR			na	na	M		Tolerant	4	Tolerant
Notropis hudsonius	Spottail Shiner					M	T	M			3	Tolerant
Notropis stramineus	Sand Shiner					M	MT	M			3	Tolerant
Notropis volucellus	Mimic Shiner					M	MI	I		Tolerant	4	Tolerant
Noturus flavus	Stonecat					T	na	I		Tolerant	4	Tolerant
Noturus gyrinus	Tadpole Madtom					M	MI	M		Tolerant	4	Tolerant
Noturus insignis	Margined Madtom		DD		Y	M	na	M			2	Tolerant
Osmerus mordax	Rainbow Smelt				Y	na	na	M			2	Tolerant
Perca flavescens	Yellow Perch					M	T	M			3	Tolerant
Percina caprodes	Logperch					I	MT	M		Tolerant	4	Tolerant
Percina maculata	Blackside Darter					M	na	M		Tolerant	4	Tolerant
Percina shumardi	River Darter		NAR			na	na	M		Tolerant	4	Tolerant
Petromyzon marinus	Sea Lamprey				Y	na	na	M			2	Tolerant
Pimephales notatus	Bluntnose Minnow		NAR			M	MT	T			3	Tolerant
Pimephales promelas	Fathead Minnow					T	MT	T			3	Tolerant
Pomoxis annularis	White Crappie					T	na	M			3	Tolerant
Pomoxis nigromaculatus	Black Crappie					T	MT	M			3	Tolerant
Proterorhinus semilunaris	Tubenose Goby				Y	na	na				2	Tolerant
Pungitius pungitius	Ninespine Stickleback					na	na	M		Tolerant	4	Tolerant
Pylodictis olivaris	Flathead Catfish		DD		Y	T	na	M			2	Tolerant
Rhinichthys atratulus	Blacknose Dace					M	na	T			3	Tolerant
Rhinichthys cataractae	Longnose Dace					M	MT?	I		Tolerant	4	Tolerant
Sander canadensis	Sauger					na	na	M		Tolerant	4	Tolerant
Sander vitreus	Walleye					M	MT	M			3	Tolerant
Scardinius erythrophthalmus	Rudd				Y	na	na	T			2	Tolerant
Semotilus atromaculatus	Creek Chub					M	MI	T		Tolerant	4	Tolerant
Umbra limi	Central Mudminnow					na	MI	T		Tolerant	4	Tolerant

* Native and non-native range of *Gasterosteus aculeatus* have been ranked separately. Criteria 2 was applied to non-native range, while Criteria 4 was applied to native range. Both native and non-native ranges were ranked as Tolerant.

APPENDIX 2. FISH IDENTIFICATION AND VOUCHERING

Accurate identification and recording of fish species captured is essential. At least one field crew member should be trained in fish identification (e.g., Royal Ontario Museum Fish Identification course). Preliminary identifications should be conducted and recorded in the field, and vouchers (which may include photographs) of every species caught at a site should be kept for confirmation of identifications (unless otherwise stated on permits or authorizations). Vouchers are typically whole individuals preserved for further examination in the lab but, for some species, digital vouchers may be taken.

PRESERVED VOUCHERS

The following guidance is for preserving species that cannot be vouchered digitally (modified from Portt et al. 2008). All small juvenile fishes and all lampreys should be preserved in 95 to 100% ethanol to allow for in-laboratory identification verification, and subsequent genetic analysis, if required. All other fishes can be preserved in 10% formaldehyde (10% concentration of 37% formaldehyde solution available commercially). A syringe should be used to inject preservative into the body cavity and bulky tissue areas of large fishes. To reduce the amount of pain, fishes should be sacrificed in an anesthetic solution (e.g., sodium bicarbonate, tricaine methanesulfonate, clove oil) prior to preservation. All vouchers from a single site can be placed in a single container; it is essential that an indelible label (e.g., pencil, India ink) with the site data (field number, waterbody, latitude, longitude, date, collectors) be added to the container.

DIGITAL VOUCHERS

The following guidance is for taking digital vouchers (modified from Portt et al. 2008). Photography requires more time, equipment, a certain amount of fish handling expertise and photographic ability. A camera capable of macro-photography must be available in the field and, in some cases, the fish must be anaesthetized to keep it still. Sensitivity to handling varies from species to species and some individuals may die during vouchering due to increased handling time required to obtain photographs, or after it is released. Specialized aquaria ("fish viewers") may be used in the field to facilitate photography. The key identification characters differ from species to species; and therefore, the photographic views required also differ. The photographer must know these key identification characters so that they can be photographed, and the photographs must be of sufficient quality to allow someone else to positively identify the fish. Generally, it is easier to photograph large-bodied fish species. Table A3 provides guidance on whether a digital voucher is acceptable for a species and, if so, what features need to be photographed. Regardless of the type of photograph you are taking, it is imperative that the camera be zoomed in to ensure that the distinguishing characteristic fills the entire frame of the viewer.

Table A3. Guidance on vouchering method to be used for confirmation of species identification for all Ontario fishes (modified from Portt et al. 2008). Note that digital vouchers are typically not suitable for small juvenile fishes and that vouchers for such individuals should be preserved.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
Acipenser fulvescens	Lake Sturgeon		1 - Full side view.
Alosa pseudoharengus	Alewife		1 - Full side view. 2 - Close up side view of head.
Alosa sapidissima	American Shad		1 - Full side view. 2 - Close up side view of head.
Ambloplites rupestris	Rock Bass		1 - Full side view.
Ameiurus melas	Black Bullhead		1 - Full side view. 2 - Ventral view of head clearly showing barbels from base.
Ameiurus natalis	Yellow Bullhead		1 - Full side view. 2 - Ventral view of head clearly showing barbels from base.
Ameiurus nebulosus	Brown Bullhead		1 - Full side view. 2 - Ventral view of head clearly showing barbels from base.
Amia calva	Bowfin		1 - Full side view. 2 - Gular plate.
Ammocrypta pellucida	Eastern Sand Darter		1 - Full side view showing fins and side markings.
Anguilla rostrata	American Eel		1 - Full side view.
Apeltes quadracus	Fourspine Stickleback		1 - Full side view, dorsal spines erect.
Aplodinotus grunniens	Freshwater Drum		1 - Full side view.
Campostoma anomalum	Central Stoneroller		1 - Full side view. 2 - Close up side view of head.
Carassius auratus	Goldfish		1 - Full side view, dorsal fin erect. 2 - Ventral view of head clearly showing absence of barbels.
Carpiodes cyprinus	Quillback		1 - Full side view, dorsal fin erect.
Catostomus catostomus	Longnose Sucker		1 - Full side view. 2 - Ventral view of head with finger holding mouth closed.
Catostomus commersonii	White Sucker		1 - Full side view. 2 - Ventral view of head with finger holding mouth closed.
Chrosomus eos	Northern Redbelly Dace		1 - Full side view. 2 - Close up side view of head. 3 - Ventral view of closed mouth to show mouth size.
Chrosomus neogaeus	Finescale Dace		1 - Full side view. 2 - Close up side view of head. 3 - Ventral view of closed mouth to show mouth size.
Clinostomus elongatus	Redside Dace		1 - Full side view showing fins and side colouration and markings.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
			2 - Close-up side view of head.
Coregonus artedi	Cisco	Yes	
Coregonus clupeaformis	Lake Whitefish		1 - Full side view. 2 - Close up side view of head.
Coregonus hoyi	Bloater	Yes	
Coregonus johannae	Deepwater Cisco	Yes	
Coregonus kiyi	Kiyi	Yes	
Coregonus nigripinnis	Blackfin Cisco	Yes	
Coregonus reighardi	Shortnose Cisco	Yes	
Coregonus zenithicus	Shortjaw Cisco	Yes	
Cottus bairdii	Mottled Sculpin	Yes	
Cottus cognatus	Slimy Sculpin	Yes	
Cottus ricei	Spoonhead Sculpin	Yes	
Couesius plumbeus	Lake Chub		1 - Full side view, pectoral fins spread out. 2 - Close up side view of head (showing terminal barbel).
Ctenopharyngodon idella	Grass Carp	Yes	
Culaea inconstans	Brook Stickleback		1 - Full side view.
Cyprinella spiloptera	Spotfin Shiner		1 - Full side view, dorsal fin erect.
Cyprinus carpio	Common Carp		1 - Full side view. 2 - Ventral view of head clearly showing presence of barbels.
Dorosoma cepedianum	Gizzard Shad		1 - Full side view. 2 – Dorsal fin with extended last dorsal ray visible.
Erimystax x-punctata	Gravel Chub	Yes	
Erimyzon sucetta	Lake Chubsucker		1 - Side view that shows each scale for a lateral scale count as well as fins and side pigmentation. 2 - Close-up side view of head. 3 - Ventral view of closed mouth showing lips.
Esox americanus vermiculatus	Grass Pickerel		1 - Full side view. 2 - Close-up side view of head showing suborbital bar and cheek scalation. 3 - Ventral view of bottom jaw showing sub-mandibular pores.
Esox lucius	Northern Pike		1 - Full side view. 2 - Close-up side view of head showing suborbital bar and cheek scalation. 3 - Ventral view of bottom jaw showing sub-mandibular pores.
Esox masquinongy	Muskellunge		1 - Full side view. 2 - Close-up side view of head showing suborbital bar and cheek

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
			scalation. 3 - Ventral view of bottom jaw showing sub-mandibular pores.
Etheostoma blennioides	Greenside Darter		1 - Full side view. 2 - Spiny dorsal fin erect.
Etheostoma caeruleum	Rainbow Darter		1 - Full side view. 2 - Spiny dorsal fin erect.
Etheostoma exile	Iowa Darter		1 - Full side view. 2 - Spiny dorsal fin erect.
Etheostoma flabellare	Fantail Darter		1 - Full side view. 2 - Spiny dorsal fin erect.
Etheostoma microperca	Least Darter		1 - Full side view. 2 - Spiny dorsal fin erect.
Etheostoma nigrum	Johnny Darter	Yes, from Lake Ontario/St. Lawrence drainage	1 - Full side view. 2 - Spiny dorsal fin erect.
Etheostoma olmstedi	Tessellated Darter	Yes, from Lake Ontario/St. Lawrence drainage	1 - Full side view. 2 - Spiny dorsal fin erect.
Exoglossum maxillingua	Cutlip Minnow		1 - Full side view. 2 - Ventral view of head clearly showing trilobe lower lip.
Fundulus diaphanus	Banded Killifish		1 - Full side view.
Fundulus notatus	Blackstripe Topminnow		1 - Full side view.
Gasterosteus aculeatus	Threespine Stickleback		1 - Full side view, dorsal spines erect.
Gymnocephalus cernua	Ruffe	Yes	
Hiodon alosoides	Goldeye	Yes	
Hiodon tergisus	Mooneye	Yes	
Hybognathus hankinsoni	Brassy Minnow		1 - Full side view, dorsal fin erect. 2 - Close up side view of head.
Hybognathus regius	Eastern Silvery Minnow		1 - Full side view, dorsal fin erect. 2 - Close up side view of head.
Hypentelium nigricans	Northern Hog Sucker		1 - Full side view. 2 - Ventral view of head with finger holding mouth closed.
Ichthyomyzon cataneus	Chestnut Lamprey	Yes	
Ichthyomyzon fossor	Northern Brook Lamprey	Yes	
Ichthyomyzon unicuspis	Silver Lamprey	Yes	
Ictalurus punctatus	Channel Catfish		1 - Full side view. 2 - Caudal fin spread.
Ictiobus bubalus	Smallmouth Buffalo		1 - Full side view showing fins and lateral line scales. 2 - Close-up of dorsal fin and side view of head.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
			3 - Close-up of mouth showing absence of barbels. 4 - Side and ventral view of closed mouth showing lips.
Ictiobus cyprinellus	Bigmouth Buffalo		1 - Full side view showing fins and lateral line scales. 2 - Close-up of dorsal fin and side view of head. 3 - Close-up of mouth showing absence of barbels. 4 - Side and ventral view of closed mouth showing lips.
Ictiobus niger	Black Buffalo		1 - Full side view showing fins and lateral line scales. 2 - Close-up of dorsal fin and side view of head. 3 - Close-up of mouth showing absence of barbels. 4 - Side and ventral view of closed mouth showing lips.
Labidesthes sicculus	Brook Silverside		1 - Full side view.
Lepisosteus oculatus	Spotted Gar		1 - Full side view showing fins, lateral scales, and side markings. 2 - Full dorsal view showing body profiles and markings. 3 - Full ventral view showing body profiles and markings. 4 - Close-up dorsal view of head. 5 - Dorsal view between head and origin of dorsal fin to count mid-dorsal scales. Dry photographed area with cloth to show scales.
Lepisosteus osseus	Longnose Gar		1 - Full side view showing fins, lateral scales, and side markings. 2 - Full dorsal view showing body profiles and markings. 3 - Full ventral view showing body profiles and markings. 4 - Close-up dorsal view of head. 5 - Dorsal view between head and origin of dorsal fin to count mid-dorsal scales. Dry photographed area with cloth to show scales.
Lepomis cyanellus	Green Sunfish		1 - Full side view, dorsal fins erect.
Lepomis gibbosus	Pumpkinseed		1 - Full side view, dorsal fins erect.
Lepomis gulosus	Warmouth		1 - Full side view that shows body profile as well as fins and side pigmentation. 2 - Close-up side view of head. 3 - Close-up view of dorsal fins. 4 - Close-up view of anal fin.
Lepomis humilis	Orangespotted Sunfish		1 - Full side view, dorsal fins erect.
Lepomis macrochirus	Bluegill		1 - Full side view, dorsal fins erect.
Lepomis peltastes	Northern Sunfish		1 - Full side view, dorsal fins erect.
Lethenteron appendix	American Brook Lamprey	Yes	
Lota lota	Burbot		1 - Full side view.
Luxilus chrysocephalus	Striped Shiner		1 - Full side view. 2 - Close up dorsal view of head to dorsal fin origin.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
Luxilus cornutus	Common Shiner		1 - Full side view. 2 - Close up dorsal view of head to dorsal fin origin.
Lythrurus umbratilis	Redfin Shiner		1 - Full side view, dorsal fins erect.
Macrhybopsis storeriana	Silver Chub	Yes	
Margariscus nachtriebi	Northern Pearl Dace		1 - Full side view. 2 - Close up side view of head.
Micropterus dolomieu	Smallmouth Bass		1 - Full side view (mouth closed), dorsal fins erect.
Micropterus salmoides	Largemouth Bass		1 - Full side view (mouth closed), dorsal fins erect.
Minytrema melanops	Spotted Sucker		1 - Full side view that shows each scale for a lateral line scale count as well as fins and side pigmentation. 2 - Close-up side view of head. 3 - Side and ventral view of closed mouth showing lips.
Morone americana	White Perch		1 - Full side view. 2 - Close up of anal fin clearly showing anal spines.
Morone chrysops	White Bass		1 - Full side view. 2 - Close up of anal fin clearly showing anal spines.
Moxostoma anisurum	Silver Redhorse		1 - Both sides of the caudal peduncle. 2 - Dorsal and caudal fins spread out to see shape and colour. 3 - Side view that shows each scale for a lateral line scale count. 4 - Ventral view of closed mouth showing lips to see the traverse lines on the plicae.
Moxostoma carinatum	River Redhorse		1 - Both sides of the caudal peduncle. 2 - Dorsal and caudal fins spread out to see shape and colour. 3 - Side view that shows each scale for a lateral line scale count. 4 - Ventral view of closed mouth showing lips to see the traverse lines on the plicae.
Moxostoma duquesnei	Black Redhorse		1 - Both sides of the caudal peduncle. 2 - Dorsal and caudal fins spread out to see shape and colour. 3 - Side view that shows each scale for a lateral line scale count. 4 - Ventral view of closed mouth showing lips to see the traverse lines on the plicae.
Moxostoma erythrurum	Golden Redhorse		1 - Both sides of the caudal peduncle. 2 - Dorsal and caudal fins spread out to see shape and colour. 3 - Side view that shows each scale for a lateral line scale count. 4 - Ventral view of closed mouth showing lips to see the traverse lines on the plicae.
Moxostoma macrolepidotum	Shorthead Redhorse		1 - Both sides of the caudal peduncle. 2 - Dorsal and caudal fins spread out to see shape and colour. 3 - Side view that shows each scale for a lateral line scale count.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
			4 - Ventral view of closed mouth showing lips to see the traverse lines on the plicae.
Moxostoma valenciennesi	Greater Redhorse		1 - Both sides of the caudal peduncle. 2 - Dorsal and caudal fins spread out to see shape and colour. 3 - Side view that shows each scale for a lateral line scale count. 4 - Ventral view of closed mouth showing lips to see the traverse lines on the plicae.
Myoxocephalus thompsonii	Deepwater Sculpin	Yes	
Neogobius melanostomus	Round Goby		1 - Full side view, dorsal fins erect.
Nocomis biguttatus	Hornyhead Chub		1 - Full side view. 2 - Close up side view of head.
Nocomis micropogon	River Chub		1 - Full side view. 2 - Close up side view of head.
Notemigonus crysoleucas	Golden Shiner		1 - Full side view, all fins extended. 2 - Close up of keel to show scales.
Notropis anogenus	Pugnose Shiner	Yes	
Notropis atherinoides	Emerald Shiner		1 - Full side view, dorsal and pelvic fins extended.
Notropis bifrenatus	Bridle Shiner	Yes	
Notropis buchanani	Ghost Shiner	Yes	
Notropis heterodon	Blackchin Shiner	Yes	
Notropis heterolepis	Blacknose Shiner	Yes	
Notropis hudsonius	Spottail Shiner		1 - Full side view.
Notropis photogenis	Silver Shiner	Yes	
Notropis rubellus	Rosyface Shiner		1 - Full side view, dorsal and pelvic fins extended.
Notropis stramineus	Sand Shiner	Yes	
Notropis volucellus	Mimic Shiner	Yes	
Noturus flavus	Stonecat		1 - Full side view, all fins extended. 2 - Full ventral view.
Noturus gyrinus	Tadpole Madtom		1 - Full side view, all fins extended. 2 - Full ventral view.
Noturus insignis	Margined Madtom	Yes	
Noturus miurus	Brindled Madtom	Yes	
Noturus stigmosus	Northern Madtom	Yes	
Oncorhynchus gorbuscha	Pink Salmon		1 - Full side view. 2 - Anal fin extended (especially on juveniles). 3 - Spots on caudal fin. 4 - Close up of head with mouth open.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
Oncorhynchus kisutch	Coho Salmon		1 - Full side view. 2 - Anal fin extended (especially on juveniles). 3 - Spots on caudal fin. 4 - Close up of head with mouth open.
Oncorhynchus mykiss	Rainbow Trout		1 - Full side view. 2 - Anal fin extended (especially on juveniles). 3 - Spots on caudal fin. 4 - Close up of head with mouth open.
Oncorhynchus tshawytscha	Chinook Salmon		1 - Full side view. 2 - Anal fin extended (especially on juveniles). 3 - Spots on caudal fin. 4 - Close up of head with mouth open.
Opsopoeodus emiliae	Pugnose Minnow	Yes	
Osmerus mordax	Rainbow Smelt		1 - Full side view, adipose fin visible.
Perca flavescens	Yellow Perch		1 - Full side view.
Percina caprodes	Logperch		1 - Full side view showing fins. 2 - Close-up side view of head 3 - Close-up of mouth 4 - Downward frontal view of mouth showing protractile premaxillaries.
Percina copelandi	Channel Darter		1 - Full side view showing fins. 2 - Close-up side view of head 3 - Close-up of mouth 4 - Downward frontal view of mouth showing protractile premaxillaries.
Percina maculata	Blackside Darter		1 - Full side view.
Percina shumardi	River Darter	Yes	
Percopsis omiscomaycus	Trout-perch		1 - Full side view, adipose fin visible.
Petromyzon marinus	Sea Lamprey	Yes	
Pimephales notatus	Bluntnose Minnow		1 - Full side view, dorsal fin erect. 2 - Dorsal view anterior to dorsal fin showing crowded scales. 3 - Close up side view of head.
Pimephales promelas	Fathead Minnow		1 - Full side view, dorsal fin erect. 2 - Dorsal view anterior to dorsal fin showing crowded scales. 3 - Close up side view of head.
Polyodon spathula	Paddlefish		1 - Full side view showing profile and fins. 2 - Dorsal view showing snout and body shape.
Pomoxis annularis	White Crappie		1 - Full side view, dorsal and anal fins erect.

Scientific Name	Common Name	Preserved Specimen Essential*	Photography Recommended**
Pomoxis nigromaculatus	Black Crappie		1 - Full side view, dorsal and anal fins erect.
Prosopium coulteri	Pygmy Whitefish	Yes	
Prosopium cylindraceum	Round Whitefish	Yes	
Proterorhinus semilunaris	Tubenose Goby		1 - Full side view. 2 - Close-up of tubular nostrils.
Pungitius pungitius	Ninespine Stickleback		1 - Full side view, dorsal fins erect.
Pylodictis olivaris	Flathead Catfish		1 - Full side view. 2 - Dorsal view of head.
Rhinichthys atratulus	Blacknose Dace		1 - Full side view. 2 - Close-up side view of head. 3 - Ventral view of mouth. 4 - Downward frontal view of mouth showing frenum.
Rhinichthys cataractae	Longnose Dace		1 - Full side view. 2 - Close-up side view of head. 3 - Ventral view of mouth. 4 - Downward frontal view of mouth showing frenum.
Salmo salar	Atlantic Salmon		1 - Full side view.
Salmo trutta	Brown Trout		1 - Full side view.
Salvelinus fontinalis	Brook Trout		1 - Full side view.
Salvelinus fontinalis timagamiensis	Aurora Trout		1 - Full side view.
Salvelinus namaycush	Lake Trout		1 - Full side view.
Sander canadensis	Sauger		1 - Full side view. 2 - Dorsal fin extended. 3 - Lower lobe of caudal fin visible.
Sander vitreus	Walleye		1 - Full side view. 2 - Dorsal fin extended. 3 - Lower lobe of caudal fin visible.
Scardinius erythrophthalmus	Rudd		1 - Full side view, all fins extended. 2 - Close up of keel to show scales.
Semotilus atromaculatus	Creek Chub		1 - Full side view, dorsal fin erect.
Semotilus corporalis	Fallfish		1 - Full side view, dorsal fin erect.
Umbra limi	Central Mudminnow		1 - Full side view.

*Preserved specimens are always recommended; however, this table provides guidance to allow confirmation of identification for some species using photography.

**All fin views assumed to be with spread or flared fins.

REFERENCES CITED

Barbour, M.T., Gerritsen, J., Snyder, B.D., and Stribling, J.B. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. 2nd edition. U.S. Environmental Protection Agency, Office of Water, Washington, D.C., USA.

Bonar, S.A., Hubert, W.A., and Willis, D.W. 2009. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bathesda, MD. 335 p.

Chu, C., Jones, N., Piggott, A., and Buttle, J. 2009. Evaluation of a simple method to classify the thermal characteristics of streams using a nomogram of daily maximum air and water temperature. N. Am. J. Fish. Manage. 29: 1605-1619.

Dextrase, A.J., Mandrak, N.E., Barnucz, J., Bouvier, L.D., Gaspardy, R., Reid, S.M. 2014. Sampling Effort Required to Detect Fishes at Risk in Ontario. Can. Manuscr. Rep. Fish. Aquat. Sci. 3024: v + 50 p.

DFO. 2002. Agricultural drain maintenance in Southern Ontario - guidance to meeting requirements of the Fisheries Act. Fisheries and Oceans Canada, January 2002 (Accessed: 27 August 2013).

Irwin, K., Bergmann, B., and Boos, J. 2013. The stream permanency handbook for south-central Ontario, second edition. Ontario Ministry of Natural Resources. 30 p.

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, ON. 28 p.

Lyons, J., Zorn, T., Stewart, J., Seelbach, P., Wehrly, K., and Wang, L. 2009. Defining and characterizing coolwater streams and their fish assemblages in Michigan and Wisconsin, USA. N. Am. J. Fish. Manage. 29: 1130-1151.

Meador, M.R., and Carlisle, D.M. 2007. Quantifying tolerance indicator values for common stream fish species of the United States. Ecol. Indic. 7: 329-338.

Portt, C.B., Coker, G.A., Mandrak, N.E., and Ming, D. 2008. Protocol for the detection of fish Species At Risk in Ontario Great Lakes Area (OGLA). DFO Can. Sci. Advis. Sec. Res. Doc. 2008/026. v + 37 pp.

Smith, K.L., and Jones, M.L. 2005. Watershed-level sampling effort requirements for determining riverine fish species composition. Can. J. Fish. Aquat. Sci. 62: 1580-1588.

Stanfield, L. 2010. Ontario stream assessment protocol. Version 8.0. Fisheries Policy Section. Ontario Ministry of Natural Resources. Peterborough, ON. 376 p.

Stoneman, C.L., and Jones, M.L. 1996. A simple method to classify stream thermal stability with single observations of daily maximum water and air temperature. N. Am. J. Fish. Manage. 16: 728-737.

TRCA. 2013. Evaluation, classification and management of headwater drainage features guidelines. Toronto and Region Conservation Authority and Credit Valley Conservation. 24 p.

Trebitz, A.S., Brazner, J.C., Brady, V.J., Axler, R., and Tanner, D.K. 2007. Turbidity tolerances of Great Lakes coastal wetland fishes. N. Am. J. Fish. Manage. 27: 619-633.

Wichert, G.A., and Lin, P. 1996. A species tolerance index of maximum temperature. Water Qual. Res. J. Can. 31: 875-893.