

WETLAND WATER BALANCE RISK EVALUATION

Toronto and Region Conservation Authority
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1. INTRODUCTION

1.1 Purpose

The *Wetland Water Balance Risk Evaluation* (Hereafter *Risk Evaluation*) supports the Stormwater Management Criteria Document (*SWM document*; TRCA, 2012) that describes requirements for proposals to maintain the water balance of natural features designated for protection. The *Risk Evaluation* has been developed to aid proponents of development or infrastructure proposals in determining the level of risk a proposal has to the ecological integrity of a wetland through changes to its hydrology and is intended to be applied early in the planning process (Figure 1). The level of risk assigned to a particular proposal determines whether pre-development hydrological monitoring of the feature is required and the scope of the feature-based water balance analysis that is required. Proponents should refer to the *SWM document* for overarching guidance concerning the water balance requirements, in particular to Appendix D: Water Balance for Protection of Natural Features. The *Risk Evaluation* and other supporting tools under development or completed are indicated in relation to the corresponding steps in the *SWM document* in Figure 2.

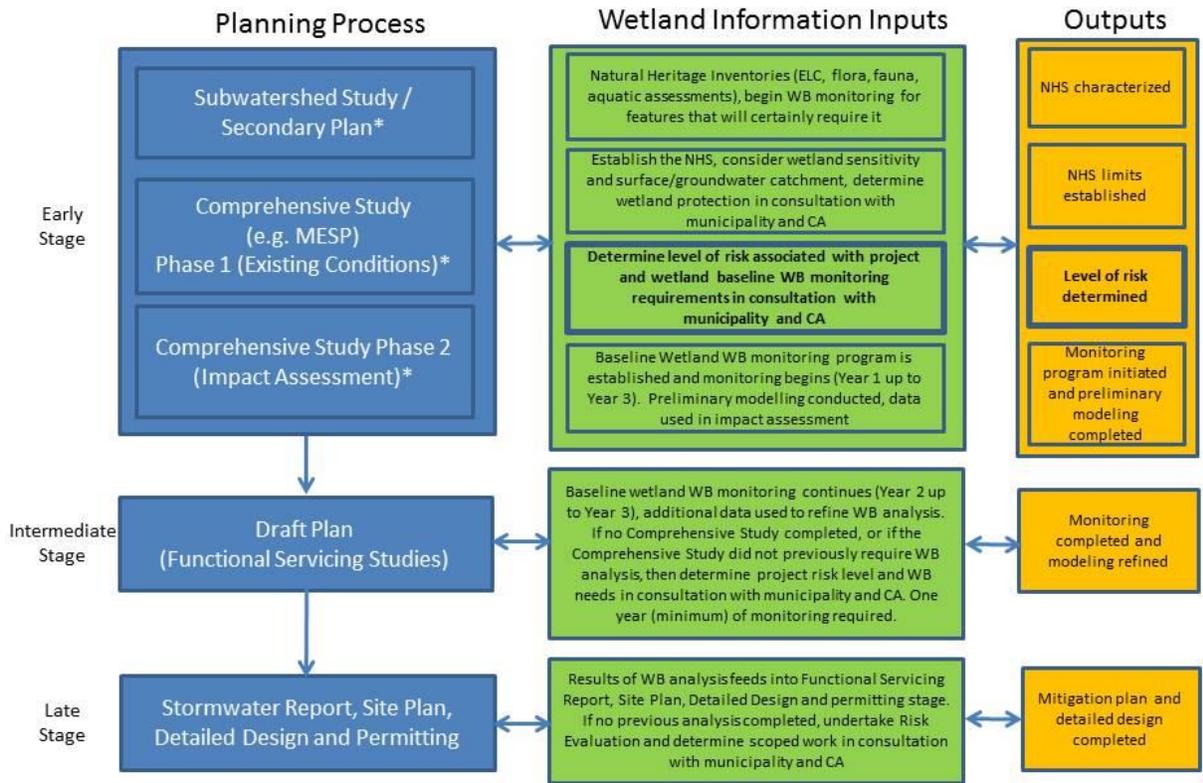
1.2 Applicability

The *Risk Evaluation* should be applied when a proposal has the potential to impact the water balance of a wetland that has been determined to be protected as part of a planning or infrastructure review and approval process. A water balance will not generally be required for linear infrastructure, such as roads and railways, where TRCA's regular permitting process would generally be sufficient to address potential impacts to natural features and associated mitigation options.

For the purposes of this document, impact to wetland water balance occurs in the following circumstances:

- When there is alteration to the surface water catchment of a wetland determined to be protected;
- When water taking requiring Ministry of Environment and Climate Change (MOECC) Environmental Activity and Sector Registry (EASR) registration (i.e. > 50,000 L/day) is anticipated within the surface water catchment of a wetland or on a property that contains a wetland determined to be protected

The *Risk Evaluation* should be applied to all wetlands determined for protection except for lacustrine wetlands on the Lake Ontario shoreline, riverine wetlands located on stream segments of Strahler order ≥ 4 or with catchments > 2500 ha, stormwater management ponds, or wastewater polishing wetlands.



*Note: The scale and level of detail of information provided for the early planning stage will vary by municipal jurisdiction.

Figure 1: Wetland Water Balance in the planning process. The Risk Evaluation is highlighted.

1.3 Relationship between wetland hydrology and ecology

The hydrology of a wetland directly determines many aspects of its physical, chemical, and ecological characteristics, and as such it is perhaps the most important variable influencing ecological function (Mitsch and Gosselink, 2007). Land development and infrastructure construction can affect the hydrology of a wetland in a number of ways, some of which may have a negative impact on the ecological function of a wetland. For example, water taking directly from a wetland or from an aquifer that discharges directly to a wetland has a clear potential to directly alter the wetland’s water balance. Land use change within the surface water catchment of a wetland may alter the water balance by changing the ratio of surface runoff to infiltration within the catchment as well as the proportion of water lost to evapotranspiration. This is an issue particularly when there is a substantial increase in the proportion of impervious cover such as paved surfaces and roofs (Hicks and Larson, 1997; Reinelt and Taylor, 2001). Alteration to the size of the catchment area draining to a wetland due to land grading activities or stormwater management system design also has the potential to significantly change the water balance.

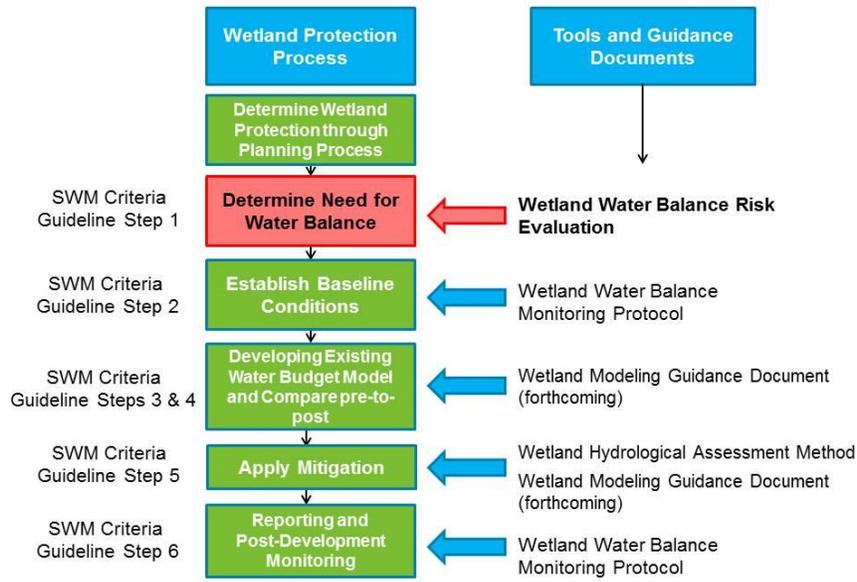


Figure 2: Wetland Water Balance tools and guidelines and their relation to steps in the SWM document.

It is important to note that wetland hydrology encompasses much more than the average annual depth of water in a wetland. Aspects of wetland hydrology such as the proportion of total inflow derived from surface water or groundwater, the timing and duration of inflows, and the timing of water level drawdown over the growing season all contribute to the maintenance of a particular ecological function. For example, amphibian species may require water for breeding during spring but may also require habitat to be seasonally dry to prevent predatory fish from establishing in this habitat. Similarly, some obligate wetland plants will be outcompeted by facultative upland plants if a wetland dries out too early, leading to shifts in the ecological community. Significant differences in wetland ecology and associated ecosystem services can occur between relatively small differences in hydrological regime on the order of tens of centimeters (Baldwin *et al.*, 2001; Mitsch and Gosselink, 2007; Moor *et al.*, 2017).

The term *hydroperiod* is used to refer to the pattern of water level change within a wetland over time, both above and below ground, and is a measure of the net sum of interaction between the different water balance components (i.e. the change in storage). The *hydroperiod* is a key measure by which to track changes in the water balance over time, and is the primary focus of wetland hydrological monitoring, as outlined in the *Wetland Water Balance Monitoring Protocol* (TRCA, 2016).

1.4 Classification of risk

The *Risk Evaluation* assigns a level of risk to a proposal considering two main factors:

- i) The potential magnitude of hydrological change that would occur in the absence of a mitigation strategy, and;
- ii) The sensitivity of the wetland to hydrological change.

The potential magnitude of change and the sensitivity of the wetland are evaluated together using a decision tree (Figure 3, page 18) which determines the overall level of risk of the proposal to the hydrology of the wetland. This level of risk is important as it determines:

- Whether pre-development water balance monitoring is required (refer to *Wetland Water Balance Monitoring Protocol*), and;
- The scope of modeling that is required to predict hydrological changes, and the corresponding effort required to develop a mitigation strategy

The *Risk Evaluation* recognizes that the effort put into analyzing potential changes to the water balance of a wetland, and designing a mitigation strategy, should be proportional to the magnitude of the potential impact of the proposal if the mitigation strategy is to be successful.

2. COMPLETING A WETLAND WATER BALANCE RISK EVALUATION

The *Risk Evaluation* follows a four step process:

- Step 1. Determine which retained wetland(s) may be impacted by the proposal.
- Step 2. Determine the magnitude of potential hydrological change.
- Step 3. Determine the sensitivity of the wetland and its associated flora and fauna to hydrological change.
- Step 4. Integrate information from step 1, 2, and 3 to assign a level of risk to the proposal.

All steps in the *Risk Evaluation* are completed using geospatial information and other data provided by the proponent (Table 1). The majority of the data is derived from previous, existing, or parallel studies. Some of the required data may be available from the appropriate conservation authority (CA).

Table 1: Data required to complete the Risk Evaluation.

All data are to be collected and compiled by the proponent. Some data may be available from the conservation authority (CA) (see suggested data source).

Criteria	Data	Definition and required information	Suggested data source
Magnitude of potential hydrological change	Wetland feature limits	The size and shape of the wetland feature(s) in question. Under normal circumstances this should be based on staked and surveyed feature limits.	Feature limits are delineated early in planning process in consultation with the CA, MNRF, and/or municipal staff.
	Extent and size of pre-development catchment	Surface water catchment of the wetland, delineated using appropriate methods.	The CA may be able to provide derived catchment boundaries or raw DEM.
	Total development area of catchment (C_{dev})	Area of the feature's catchment lying outside of any identified natural system (e.g. natural heritage areas, natural hazard zones, and their associated buffers), but inclusive of any existing developed areas within the catchment.	The CA may be able to provide spatial layers containing the natural system and natural hazard limits. Municipalities should be consulted for natural heritage system boundaries too.
	Area of the wetland catchment owned by the proponent	The development area of the wetland catchment (C_{dev}) that is owned by the proponent.	Provided by the proponent.
	Percent of impervious cover planned within the proponent's holdings (IC)	The anticipated proportion of impervious cover within the area of the wetland catchment owned by the proponent, as determined from average values for a given land cover type, or from knowledge of proponent's preliminary design.	Analysis conducted by the proponent. The CA and/or municipality can provide average values for given land cover type. Where no information is available, a conservative IC value will be assigned based on land use zoning.

	Proposed extent and size of post-development catchment	The anticipated size of the feature's catchment resulting from grade changes and/or implementation of the stormwater management plan, based on the best available information.	Provided by the proponent.
	Anticipated magnitude and duration of water taking	The magnitude and approximate duration of any water taking anticipated from groundwater or surface water bodies directly connected to the wetland, and associated discharge of this water. This is determined using the best data available about site conditions and the proposed development form at the time the <i>Risk Evaluation</i> is applied.	Provided by the proponent.
	Location and extent of any Locally Significant Recharge Areas	Locally Significant Recharge Areas are defined in this document as areas within the wetland's catchment covered by sand, gravel, or otherwise having high hydraulic conductivity. These may be identified through preliminary geotechnical site investigations, visual means, monitoring data, or numerical model outputs.	Provided by the proponent. Maps of areas identified as Ecologically Significant Groundwater Recharge Areas (GRAs), High Volume GRAs, or Significant GRAs may be available from the CA (e.g. TRCA SWM Criteria Document, Appendix C).
Sensitivity of the wetland	Vegetation community type	Classification according to the Ontario Ecological Land Classification System.	Classification may be available from the CA and/or municipality, and if not, should be carried out by the proponent.

Fauna species present	A list of species found in the wetland should be created and cross referenced with the sensitivity ranks defined by the CA (Appendix 3).	Data from existing wildlife surveys, or can be collected by the proponent using sampling protocols approved by the CA and/or municipality. The CA may require updated fauna data collection if existing records are considered too old to be reliably representative of current conditions.
Flora present	A list of floral species found in the wetland should be created and cross referenced with the sensitivity ranks defined by the CA (Appendix 3).	Data from existing surveys, or can be collected by the proponent using approved sampling protocols. The CA may require updated fauna data collection if existing records are considered too old to be reliably representative of current conditions.
Habitat features	The presence of features which provide habitat for wildlife and/or fish, including amphibian breeding, bird breeding, reptile or amphibian overwintering habitat (see OMNRF, 2014 for further details).	Data is to be collected and provided by the proponent. Interpretation of SWH to be determined by proponent in consultation with the CA and/or municipality.
Wetland hydrological type	The wetland is hydrologically classified as Isolated, Palustrine, Riverine, or Lacustrine. Hydrological type classification follows the convention of the Ontario Wetland Evaluation System, Southern Manual.	Wetland classification is performed by the proponent.

Step 1: Determine which retained wetland(s) may be impacted

The catchment area of any and all potentially impacted wetlands should be delineated with appropriate techniques and using a high resolution digital elevation model. Impact to the catchment of a wetland occurs when the proposal changes the size of the catchment, the amount of impervious cover within the catchment, or when water taking is anticipated to require MOECC EASR registration (i.e. >50,000 L/day); see Section 1.2 (Applicability) for further details. In recognition of the hydrological connections between many wetland catchments (i.e. the catchment of downstream wetlands may contain those of upstream wetlands), determining which wetlands to evaluate should be done in consultation with CA staff and the municipality. Lacustrine wetlands on the Lake Ontario shoreline and Riverine wetlands located on stream segments of Strahler order ≥ 4 or catchments >2500 ha are excluded from the *Risk Evaluation*.

Step 2: Determine the magnitude of potential hydrological change

The following criteria are used to evaluate the magnitude of potential hydrological impact that a proposal may have on a wetland:

- i) The proportion of impervious cover in the catchment of the wetland that would result from the proposal.
- ii) The degree of change in the size of the wetland catchment.
- iii) Water taking from, or discharge to, surface water bodies or aquifers directly connected to the wetland.
- iv) The impact on locally significant recharge areas.

The data required to evaluate the magnitude of potential hydrological change (Table 1) are collected by the proponent and used as inputs for the criteria listed in Table 2 to evaluate the magnitude of potential hydrological change. The highest magnitude category with one or more criteria satisfied determines the potential magnitude of change (Table 2).

i) Impervious Cover

An increase in impervious cover within the catchment of a wetland will result in an increase in the volume of rain and snowmelt that reaches the wetland as runoff and a higher peak event runoff rate. Further, baseflow and/or interflow contributions may be reduced if infiltration and groundwater recharge are diminished. Untreated stormwater from road surfaces is also linked to increasing sediment loads and concentrations of contaminants such as salt and hydrocarbons. Research into the relationship between impervious cover (IC) within a wetland's catchment and its ecological integrity suggests that there are two thresholds governing wetland response. Between 3.5 and 10 % IC, plant density and the diversity of amphibians and macro-invertebrates begin to significantly decline (Taylor, 1993; Taylor *et al.*, 1995; Hicks and Larson, 1997; Reinelt and Taylor, 2001). A second threshold between 20 and 25 % IC, beyond which only certain hardy and/or exotic plant and amphibian species are able to persist within a wetland (Boward *et al.*, 1999; Reinelt and Taylor, 2001; Chin, 1996). The *Risk Evaluation* uses threshold

values of 10 and 25 % IC because there is relative certainty that exceeding these thresholds will lead to ecological degradation in the absence of a well-designed mitigation strategy.

In recognition of both the impact of any one development as well as the cumulative impact of all developments in the catchment of a wetland, an impervious cover score (S) is used to evaluate this criterion (Equation 1). The impervious cover score evenly distributes the proportion of impervious cover that represents a given threshold of hydrological disturbance across all the development land within the wetland's catchment regardless of the number of different landowners. The impervious cover score also considers the area of the catchment that is protected by natural heritage and natural hazard designations to ensure that the thresholds of disturbance that are determined by the score are not unduly restrictive. This creates a fair playing field for all proponents by ensuring that those developing later are not penalized by bearing the full cost of a water balance analysis that is triggered primarily by the actions of earlier developers, while still ensuring adequate protection of the wetland(s). See Appendix 1 for further rationale and example applications of this equation.

$$\text{Equation 1: } S = \frac{IC \cdot C_{dev}}{C}$$

Where S is the impervious cover score, IC is the proportion of impervious cover (as a percentage between 0 and 100) proposed within the area of wetland catchment that is within the proponent's holdings, C_{dev} is the total development area of the catchment (in ha), and C is the size of the wetland's catchment (in ha). In all cases, the pre-development catchment is used.

ii) Catchment Size

Increasing or decreasing the catchment size can change the timing, frequency, and volume of runoff reaching the wetland. The same magnitude thresholds used for impervious cover (10% and 25 %) are used as thresholds to define catchment size alteration. The value used to assess this criterion should be based on the best information available regarding the proposed development form at the time that the *Risk Evaluation* is applied. In all cases, the pre-development catchment size should be used to define changes to catchment size.

Some proposals may involve proposed changes to both catchment size and impervious cover. In such cases, the interaction between these two criteria may produce complex non-linear changes in catchment hydrology. Proposals involving a change in both catchment size and imperviousness may therefore require that the thresholds defining the potential magnitude of hydrological change be modified to reflect interactive effects between these two criteria, as deemed appropriate by a water resources engineer or other qualified CA staff.

iii) Water Taking

Where wetlands are directly connected to surface water bodies or to unconfined aquifers, water takings or associated discharges have potential to impact wetland hydrology, with corresponding impacts to ecology. For the purposes of the *Risk Evaluation*, a wetland within or adjacent to a proposed undertaking is considered impacted when water taking is anticipated to

require MOECC EASR registration (>50,000 L/day). This criterion will be assessed using the best available information about site conditions and the proposed undertaking. The key underlying variables of interest from an ecological perspective are the change in surface water or groundwater depth and the timing of drawdown that may result from the activity; this is because these variables are strongly linked to wetland ecology through both physical and biogeochemical parameters. As significant differences in wetland ecology and associated ecosystem services can occur between relatively small differences in hydrological regime on the order of tens of centimeters (Baldwin *et al.*, 2001; Mitsch and Gosselink, 2007; Moor *et al.*, 2017), any water taking which is likely to result in direct alteration of wetland water levels is of potential concern. If proponents anticipate that high volume dewatering will be required but do not believe that this dewatering poses a risk to nearby wetlands, the onus will be on the proponent to demonstrate that no impact to the wetland will occur.

iv) Recharge Areas

Certain areas within a wetland's surface water and groundwater catchments may be more sensitive to change than others, particularly where these areas act as locally significant groundwater recharge areas. When development or infrastructure occurs within these areas, there is an increased risk of a significant change to the wetland's water balance as these areas may contribute disproportionately to shallow groundwater discharge to the wetland. Identification of recharge areas will rely on preliminary site investigations and existing regional data sets, when these data are available (e.g. numerical model outputs). Impacts to recharge areas are defined here as replacement of existing soils with significantly less permeable materials.

Table 2: Criteria used to evaluate the probability and magnitude of hydrological change.

Criteria	High magnitude	Medium magnitude	Low magnitude
Impervious cover Score (S) within catchment, as determined using Equation 1	> 25 %	10-25 %	< 10 %
Increase or decrease in catchment size	> 25 %	10-25 %	< 10 %
Water taking or discharge	Dewatering exceeding MOECC EASR limits (> 400,000 L/day) for > 6 months anticipated	Dewatering within MOECC EASR limits (50,000 - 400,000 L/day) for > 6 months anticipated OR Dewatering exceeding MOECC EASR limits (>400,000 L/day) for < 6 months anticipated	Dewatering within MOECC EASR limits (50,000 - 400,000 L/day) for < 6 months anticipated*
Impact to recharge areas*	Impact (e.g. replacement with impervious cover) to >25% of locally significant recharge areas*	Impact (e.g. replacement with impervious cover) to 10-25% of locally significant recharge areas*	Impact (e.g. replacement with impervious cover) to <10% of locally significant recharge areas*
<p>Note: Where there is no proposed alteration to the catchment imperviousness or size and water taking is below MOECC EASR registration requirements (< 50,000 L/day), a feature-based water balance analysis as defined in the TRCA <i>SWM document</i> (2012) is not required. See section 1.4 (Applicability).</p> <p>* Defined in Table 1</p>			

Step 3: Determine the sensitivity of the wetland

The sensitivity of a wetland to hydrological change is assessed based on the abiotic and biotic characteristics of the wetland that are directly related to hydrology and/or ecology. Other aspects of wetland ecology not relating directly to hydrology may be evaluated through parallel processes external to this *Risk Evaluation*. To assess the sensitivity of a wetland to hydrological change five criteria are used:

- i) The vegetation community
- ii) Fauna species
- iii) Flora species
- iv) Significant wildlife habitat for hydrologically sensitive species
- v) Hydrological classification

The sensitivity of a wetland to hydrological change is assessed using the data listed in Table 1 which are compiled and provided by the proponent. The compiled data are then used to determine the sensitivity of the wetland using the criteria listed in Table 3. The highest magnitude sensitivity category in Table 3 with one or more criteria satisfied determines the overall sensitivity of the wetland to hydrological change.

i) Vegetation community

Vegetation communities vary due to abiotic variables including soils, climate, physiography, and hydrology. This variation is used to delineate areas of natural cover in the Ontario Ecological Land Classification (ELC) system. Different ELC communities vary in their sensitivity to hydrological change. Some vegetation communities can withstand some hydrological change without dramatic change to their composition, whereas others require specific hydrological conditions to persist. In recognition of the range of sensitivity between communities, CA ecologists have ranked ELC communities by their sensitivity to hydrological change into three levels (Appendix 2).

ii) Fauna species

Many fauna species are adapted to particular hydrological conditions, or are associated with specific vegetation within wetlands. Some of these fauna have adapted to wetlands with specific hydrology, with some species utilizing temporary pools as refuge from competitors and predators, some requiring permanent water, and others only requiring standing water during certain time periods that coincide with specific biological needs. There is considerable variation in the ability of species to withstand hydrological change of their habitats. Fauna species were categorized based on their sensitivity to hydrological change by CA ecologists into three levels of sensitivity (Appendix 3). The individual species with the highest sensitivity level determines the sensitivity of the fauna community to hydrological change.

iii) Flora species

There is a strong correlation between the hydrology of a wetland and the vegetation community present in the wetland. Some vegetation species require specific hydrological conditions while others can make use of a broader range of hydrological conditions. Vegetation species were categorized based on their sensitivity to hydrological change by CA ecologists into three levels of sensitivity (Appendix 3). The high sensitivity category is met when multiple high sensitivity species are detected at a feature, the medium sensitivity category is met when multiple species with medium sensitivity are detected, and the low sensitivity category is met in all other cases.

iv) Significant wildlife habitat for hydrologically sensitive species

Wetlands provide habitat for a large number of species and some of this habitat is very sensitive to hydrological change. For example, seasonal or vernal pools contain water for short periods of time, and some species have adapted to the seasonality of these pools because it excludes competitors or predators or provides habitat for juveniles. Other wetlands provide habitat during critical life stages at specific times of the year. If the hydrology of the wetland is altered, the timing between the need of the organism and habitat availability may be altered such that the habitat no longer functions for the species. Furthermore, wetlands provide habitat for some species that are difficult to detect at a particular feature because they are locally rare, cryptic, or use habitats seasonally. In recognition of the significant habitat wetlands may provide, and of the fact that some species may not be detected by surveys, CAs exercise the precautionary principle by stating that significant wildlife habitat *for species ranked as having high sensitivity to hydrological change (Appendix 3)* requires increased protection. See OMNRF (2014) for further details on significant wildlife habitat and significant wildlife habitat schedules for the appropriate ecoregion.

v) Hydrological classification

The hydrogeomorphic setting of a wetland influences its sensitivity to hydrological change. For instance, the hydroperiod of riverine wetlands is controlled predominantly by the water levels associated with a river or larger stream, and is therefore less likely to be affected by changes to local-scale hydrology. In contrast, isolated wetlands have no defined surface water outlet, and therefore any increased volume of runoff must either be infiltrated or lost to evapotranspiration, and similarly any reduction in surface water inflows will not be compensated for by any other inflow processes. This makes isolated wetlands more sensitive to hydrological change than other types of wetlands.

The *Risk Evaluation* uses four distinct hydrological wetland classifications defined in the Ontario Wetland Evaluation System (OMNR 2013): *isolated*, *palustrine*, *riverine*, and *lacustrine*. Isolated wetlands have no channelized surface water inlets or outlets, and are fed by local runoff and/or groundwater. Palustrine wetlands have either no or intermittent channelized surface water inflows and permanent or intermittent channelized surface water outflows. Lacustrine wetlands are associated with the shorelines of lakes (water bodies 8 ha or larger and deeper than 2 m in places during average low water conditions), and riverine wetlands are associated with the main

channel of a permanently flowing watercourse. In assessing the hydrological wetland classification it is important to distinguish true lacustrine and riverine wetlands (in which the hydrology is dominated by larger water bodies) from wetlands that are only ephemerally connected to lakes and rivers (where the hydrology is dominated by local surface water or groundwater). Wetlands classified as lacustrine or riverine may be reviewed by CA staff to ensure classification was appropriate.

Table 3: Criteria used to evaluate the sensitivity of the wetland to hydrological change.

Criteria	High sensitivity	Medium sensitivity	Low sensitivity
Vegetation community type (ELC)*	Presence of a high sensitivity vegetation community	Presence of a medium sensitivity vegetation community	No high or medium sensitivity criteria satisfied
High sensitivity fauna species**	Presence of a high sensitivity species	Presence of a medium sensitivity species	No high or medium sensitivity species
High sensitivity flora species**	Presence of multiple high sensitivity species	Presence of multiple medium sensitivity species OR Presence of one high sensitivity species	No high or medium sensitivity criteria satisfied
Significant Wildlife Habitat	Presence of Significant Wildlife Habitat, as defined by OMNRF (2014), for high sensitivity species**	N/A	No high criteria satisfied
Hydrological classification considering ecology	Isolated/palustrine AND Presence of medium or high sensitivity vegetation communities* OR medium or high sensitivity flora or fauna species**	Isolated/palustrine AND No medium or high sensitivity vegetation communities* AND no medium or high sensitivity flora or fauna species** present	Riverine/lacustrine
<p>* See Appendix 2 for community rankings by hydrological sensitivity ** See Appendix 3 for species rankings by hydrological sensitivity</p>			

Step 4: Risk characterization

The risk of a proposal to the hydrological and ecological integrity of a wetland is determined using the criteria evaluated in Steps 2 and 3. The level of risk assigned to a proposal determines whether hydrological monitoring of the wetland is required before the proposal is executed and the scope of the feature-based water balance analysis that is appropriate. The level of risk assigned to a proposal is proportional to the magnitude of change that is likely to occur and the sensitivity of the wetland to hydrological change. In general, a higher risk category means increased water balance monitoring and more detailed modelling, in recognition of the fact that a significant disturbance to the wetland's hydrology is more likely for these scenarios unless the mitigation strategy is informed by a detailed understanding of the water balance. In all cases it is expected that the water balance of all risk-evaluated wetlands will be maintained (there may be some limited exceptions to this, as outlined in Section 3).

Using a decision tree (Figure 3), the proposal will be categorized into one of three possible levels of risk: Low, Medium, or High.

Low Risk: Low risk proposals occur when it is unlikely that the proposed activity will have a substantial impact on wetland hydrology. As the risk is low, pre-development water balance monitoring of wetland hydrology is not required. Proponents are required to calculate the alteration to the water balance that would result from any changes to the catchment size, runoff coefficients, or impervious cover resulting from the proposed activities using a non-continuous model (e.g. Thornthwaite-Mather method) with outputs reported at monthly resolution. A mitigation plan is required to demonstrate that the design and any associated stormwater management system will compensate for any changes to monthly water balance through appropriate mitigation strategies (e.g. low impact development features). The proponent may balance the overall wetland water balance using a variety of techniques, but clean sources of supplemental water (e.g. roof runoff, runoff from greenspace) are preferred. Determination of whether the post-development hydroperiod will be sufficiently close to the pre-development hydroperiod to achieve protection of the wetland should be made in consultation with CA staff and the municipality.

Medium Risk: Monitoring of wetland hydrology is required, as outlined in the *Wetland Water Balance Monitoring Protocol* (TRCA, 2016), to establish pre-development conditions and provide a baseline against which to measure any changes in water balance during and following completion of the proposed undertaking. An estimate of each of the individual terms of the pre- and post-development water balance is required, with the relative proportion of inflow derived from surface water and groundwater estimated using monitoring data in conjunction with other data collected in support of completing the *Risk Evaluation*.

Proponents are required to calculate the alteration to the water balance that would result from the proposal using a continuous model (e.g. EPA SWMM) at daily aggregated to weekly resolution. The model is to be calibrated using monitoring data and should use modeling techniques appropriate to the context of the application (appropriate CA staff can provide direction). If the water balance analysis concerns the impact of groundwater withdrawals on a

wetland, a model capable of accurately representing subsurface processes may be required to evaluate the anticipated effects and associated level of risk. All model outputs should be at daily aggregated to weekly resolution.

For medium risk proposals, the mitigation plan should provide details on the design features and water management techniques that will be used to maintain the overall water balance of the wetland in the post-development scenario, including maintaining the relative balance of surface to subsurface inflow processes at pre-development levels. The mitigation plan should include a comparison between: A) the pre-development wetland hydroperiod as derived by running a calibrated wetland model with a long-term climate dataset under pre-development land use, and; B) the post-development hydroperiod derived by running the same calibrated wetland model with a long-term climate dataset under post-development land use conditions, including all mitigation design measures. Determination of whether the post-development hydroperiod will be sufficiently close to the pre-development hydroperiod to achieve protection of the wetland should be made in consultation with CA staff and the municipality. CA staff may be able to provide tools for hydroperiod comparison and statistical analysis, in addition to long-term climate data, upon request.

For proposals in which the period between the start of construction and the implementation of functioning water balance mitigation measures is anticipated to exceed two years (i.e. there is an extended build-out phase), an interim mitigation plan may be required. Proponents should consult with CA and municipal staff to determine whether an interim mitigation plan is required. A mitigation plan should outline active management measures for supplementing the water balance during construction and define triggers for when action is required. Such measures may be necessary to protect the ecological and hydrological functions of the wetland from multi-year disturbances which degrade the wetland to a point where these functions cannot be restored. In the case where supplemental water is needed to augment the interim water balance, clean sources of water are preferred (e.g. roof runoff, runoff from greenspace).

High Risk: Pre-development monitoring of wetland hydrology is required, as outlined in the *Wetland Water Balance Monitoring Protocol* (TRCA, 2016), to establish pre-development conditions and provide a baseline against which to measure any changes in water balance during and following completion of the proposal. An estimate of each of the individual terms of the pre- and post-development water balance is required, with the relative proportion of inflow derived from surface water and groundwater estimated using monitoring data in conjunction with other data collected in support of completing the *Risk Evaluation*. This is also a requirement for Medium Risk undertaking; however additional emphasis is placed on the evaluation of the degree of interaction between the wetland and groundwater for High Risk undertakings.

For high risk proposals, a continuous hydrological model (e.g. EPA SWMM) with daily aggregated to weekly resolution is required. The model is to be calibrated using monitoring data and should use modeling techniques appropriate to the context of the application (appropriate CA staff can provide direction). Where groundwater processes constitute a significant proportion of the total inflows or outflows to the feature, an integrated model (e.g. GSFLOW, MIKE-SHE) may be required to appropriately address the impacts of the proposal and the effectiveness of

any associated mitigation measures. The decision by the CA to require an integrated model will always consider the scale of the proposal and the size of the wetland in question, in addition to the value added by integrated modeling of the water balance. If the only issue of concern with an application is the impact of groundwater withdrawals on a wetland, a model capable of accurately representing hydrogeologic processes (only) may be used in place of a fully integrated model to evaluate the anticipated effects of the proposal and mitigation on the feature water balance, as deemed appropriate through consultation with appropriate CA staff.

The mitigation plan for High Risk proposals should provide details on the design features and water management techniques that will be used to maintain a post-development water balance that is similar to the pre-development water balance. Maintaining the water balance requires maintaining a similar ratio of surface to subsurface inflow processes as in the pre-development condition. The mitigation plan should include a comparison between: A) the pre-development wetland hydroperiod as derived by running a calibrated wetland model with a long-term climate dataset under pre-development land use, and; B) the post-development hydroperiod derived by running the same calibrated wetland model with a long-term climate dataset under post-development land use conditions, including all mitigation design measures. Determination of whether the post-development hydroperiod will be sufficiently close to the pre-development hydroperiod to achieve protection of the wetland should be made in consultation with CA staff and the municipality. CA staff may be able to provide tools for hydroperiod comparison and statistical analysis in addition to long-term climate data upon request.

For proposals in which the period between the start of construction and the implementation of functioning water balance mitigation measures is anticipated to exceed two years (i.e. there is an extended build-out phase) , an interim mitigation plan may be required. Proponents should consult with CA and municipal staff to determine whether an interim mitigation plan is required. A mitigation plan should outline active management measures for supplementing the water balance during construction and define triggers for when action is required. Such measures may be necessary to protect the ecological and hydrological functions of the wetland from multi-year disturbances which degrade the wetland to a point where these functions cannot be restored. In the case where supplemental water is needed to augment the interim water balance, clean sources of water are preferred (e.g. roof runoff, runoff from greenspace).

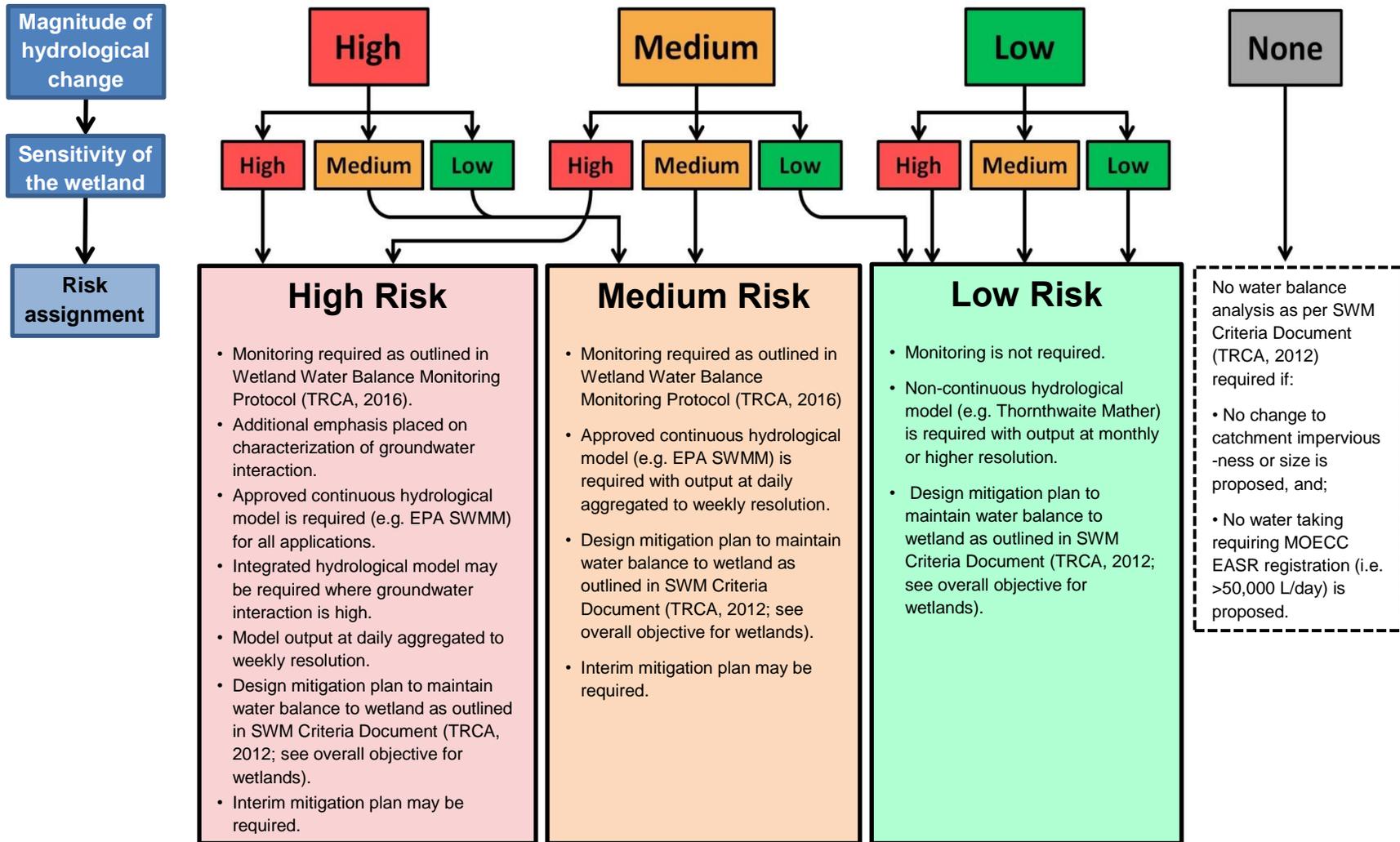


Figure 3: Wetland Risk Evaluation Decision Tree

3. ECOSYSTEM SERVICES AND ADDITIONAL CONSIDERATIONS

Wetlands provide many essential ecosystem services in urban and urbanizing areas. The focus of the *Risk Evaluation* is on protecting the ecology of a wetland by assessing the risk of a proposal to the maintenance of hydrological conditions. However, the focus on ecology does not reduce the importance of other functions wetlands provide such as flood attenuation and runoff detention, groundwater recharge to aquifers, groundwater discharge, nutrient retention, carbon sequestration, and erosion control. In fact, all of the aforementioned ecosystem functions are linked to wetland hydrology. Thus, altering hydrology has the potential to alter the capacity of a wetland to provide several ecosystem services that are of importance at a watershed scale. The intent of the *Risk Evaluation* is not to diminish the importance of any other ecosystem service provided by a wetland that is not explicitly addressed herein. That being said, biological indicators (fauna and flora) are used to characterize the capacity of wetlands to provide certain functions, and by focusing the *Risk Evaluation* on biological endpoints it is assumed that other functions will be protected. It is possible that in some cases particular functions will not be maintained, and in these cases impact on and maintenance of the additional service should be considered as well. If there is doubt about whether a particular ecosystem service will be maintained, the potential threat to that service should be evaluated in consultation with appropriate CA staff and the municipality.

In some cases where the existing level of wetland service provision or ecological function is low, it may be acceptable for there to be a divergence between the pre- and post-development hydroperiod such that the ecological function or other wetland services are enhanced. For example, where there is an opportunity to restore wetland habitat that is degraded or to create wetland habitat in an area with a limited amount of wetland habitat. The CA and municipality should be consulted in these cases to determine whether or not alteration to the water balance of a wetland is acceptable and appropriate.

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APPENDIX 1: CALCULATING THE IMPERVIOUS COVER SCORE

The *Risk Evaluation* uses a calculated value to classify the potential hydrological change that a given proportion of impervious cover within a wetland's catchment represents. Equation 1 allows a proponent to calculate the imperviousness cover score (S) that applies to a proposal, considering the proportion of impervious cover planned within the proponent's land (IC), the total catchment size (C), and the total development area of the catchment (C_{dev}). See Table 1 for definitions of these terms. The value of S is then compared to threshold values defining the boundaries between the low, medium, and high magnitude of potential hydrological change categories (10 % and 25 % respectively).

$$\text{Equation 1: } S = \frac{IC \cdot C_{dev}}{C}$$

This approach to determining the impact of impervious cover was selected over a simpler "total impervious cover within catchment" criterion for two main reasons:

- 1) The wetland's catchment may be controlled by multiple landowners who do not know each other's development intentions and timelines. This leaves the wetland vulnerable to degradation if none of the proposals individually requires a more stringent water balance analysis (i.e. has a high or medium risk outcome), but the cumulative impact of all proposals is nonetheless substantial and would have triggered a more stringent water balance analysis had they constituted a single proposal. The impervious cover score approach avoids unforeseen cumulative effects.
- 2) The use of a single "total impervious cover within catchment" criterion would mean that, in the case of multiple landowners within a catchment, it would be likely that those developing later would bear the costs of any more stringent water balance analyses required (i.e. a high or medium risk outcome), even if they have contributed a much smaller proportion of impervious cover to the wetland's catchment than those who developed earlier. The impervious cover score approach ensures that proponents do not have to pay for mistakes made in the past or by other actors.

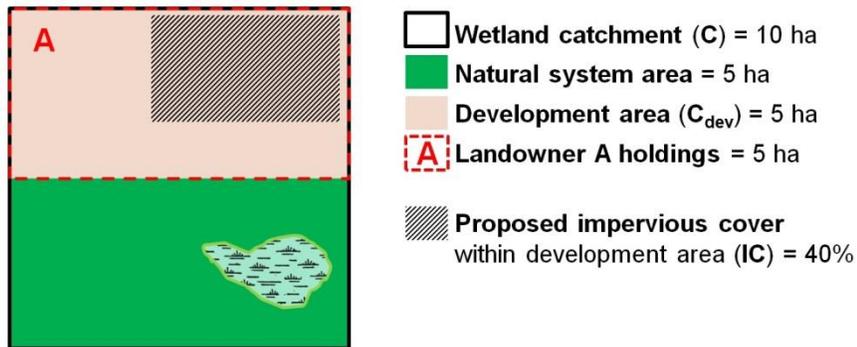
This approach to determining the potential of a proposal to cause hydrological change distributes the impervious cover representing a given threshold of disturbance evenly across all of the development land within the wetland's catchment, regardless of the number of different landowners (see Example 3). It also considers the area of the catchment that is protected by natural heritage or natural hazard designations so as not to be unduly restrictive to proponents in setting the disturbance thresholds for impervious cover. This creates a fair playing field for all developers by ensuring that those developing later are not penalized by bearing the full cost of a water balance analysis that is triggered primarily by the actions of earlier developers

Four examples illustrating the application of this approach to different development scenarios are presented in this appendix. In each example, the shaded area representing various

proposed impervious cover values illustrates the area of the catchment that would be covered if all of the impervious area were concentrated into one contiguous block.

Example 1 – One proponent with known impervious cover

Equation 1 can be applied to determine the impervious cover score (S) for a proposal if the proportion of impervious cover within the proponents holdings (IC) is known. Equation 1 considers the area of the wetland catchment that will not be developed by including the development area of the catchment (C_{dev}) as well as the total catchment area (C). In Example 1 the total catchment area is 10 hectares ($C = 10$), the total development area of the catchment is 5 hectares ($C_{dev} = 5$), and the proponent wishes to develop their holdings within the catchment to an impervious cover proportion of 40 percent ($IC = 40\%$):



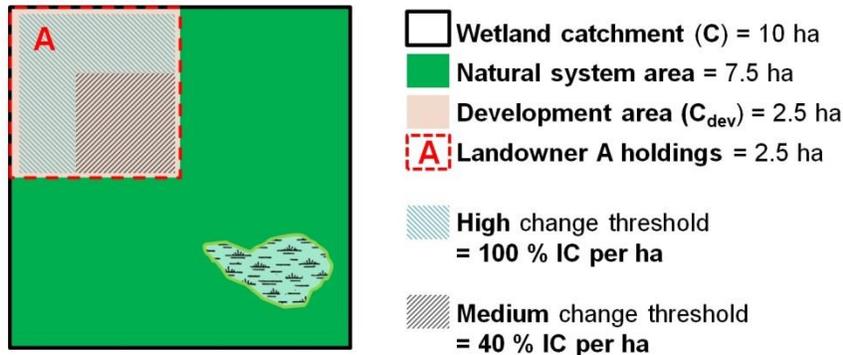
$$S = \frac{IC \cdot C_{dev}}{C} = \frac{40 \cdot 5 \text{ ha}}{10 \text{ ha}} = 20 \%$$

The impervious cover score is 20%, and therefore the proposal would be classified as having a medium magnitude of potential hydrological change, because S is greater than 10% but less than 25%.

Example 2a – Determining impervious cover that corresponds to thresholds

In order to find the impervious cover proportion within a landowner’s holdings (IC) that corresponds to the threshold impervious cover scores for either a high ($S = 25\%$) or medium ($S = 10\%$) magnitude of hydrological change classification, Equation 1 can be rearranged to solve for IC (Equation 2).

$$\text{Equation 2: } IC = \frac{S \cdot C}{C_{dev}}$$

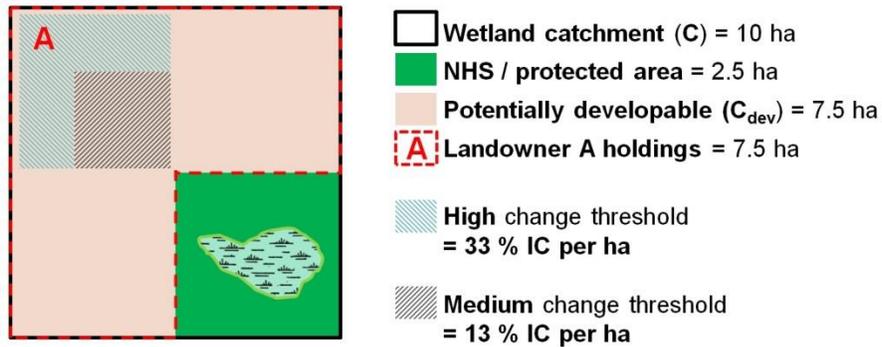


$$\text{High magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{25 \cdot 10}{2.5} = 100\%$$

$$\text{Medium magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{10 \cdot 10}{2.5} = 40\%$$

In Example 2, a “high magnitude of potential hydrological change” (high magnitude) classification is produced if the impervious cover in the proposal exceeds 100 % (that is, a high magnitude classification for the impervious cover criterion is not physically possible in this example). A medium magnitude outcome occurs if the proportion of impervious cover in the proposal is greater than or equal to 40 %. These impervious cover scores correspond to a *total* catchment (C) impervious cover value of 25 % for the lower boundary of the high magnitude category, and 10 % for the lower boundary of the medium magnitude category, in keeping with the threshold impervious cover values established in the scientific literature.

Example 2b – Determining impervious cover that corresponds to threshold scores



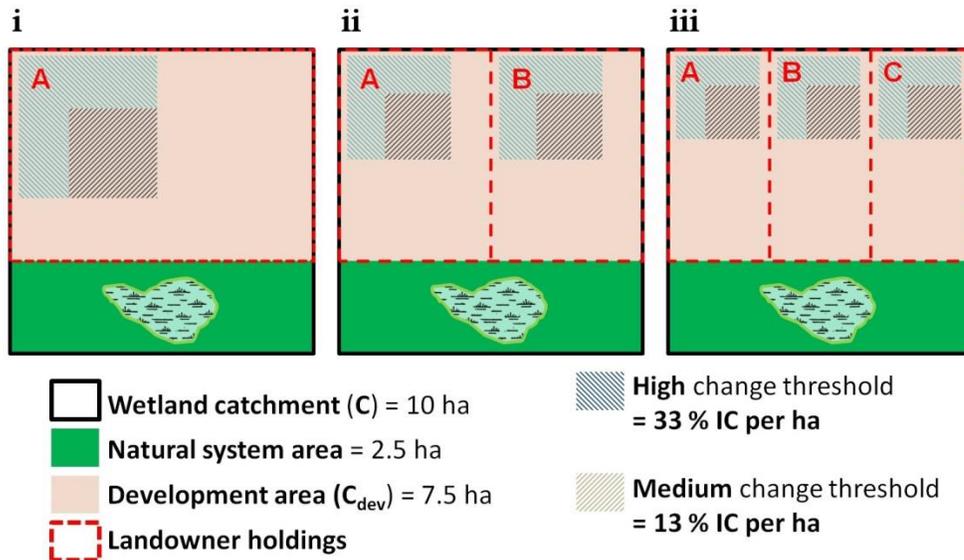
$$\text{High magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{0.25 \cdot 10}{7.5} = 0.33 \text{ or } 33\%$$

$$\text{Medium magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{0.1 \cdot 10}{7.5} = 0.13 \text{ or } 13\%$$

In Example 2b, a high magnitude classification is produced if the impervious cover in the proposal exceeds 33%, while a medium magnitude outcome occurs if the proportion of impervious cover in the proposal is between 13% and 33%. The impervious cover scores correspond to a *total* catchment (C) impervious cover value of 25% for the lower boundary of the high magnitude category, and 10% for the lower boundary of the medium magnitude category.

Example 3 – Multiple landowners and proposals

In many cases there will be multiple landowners and developers working within the same wetland catchment. The impervious cover value can be calculated for any of the individual landowners



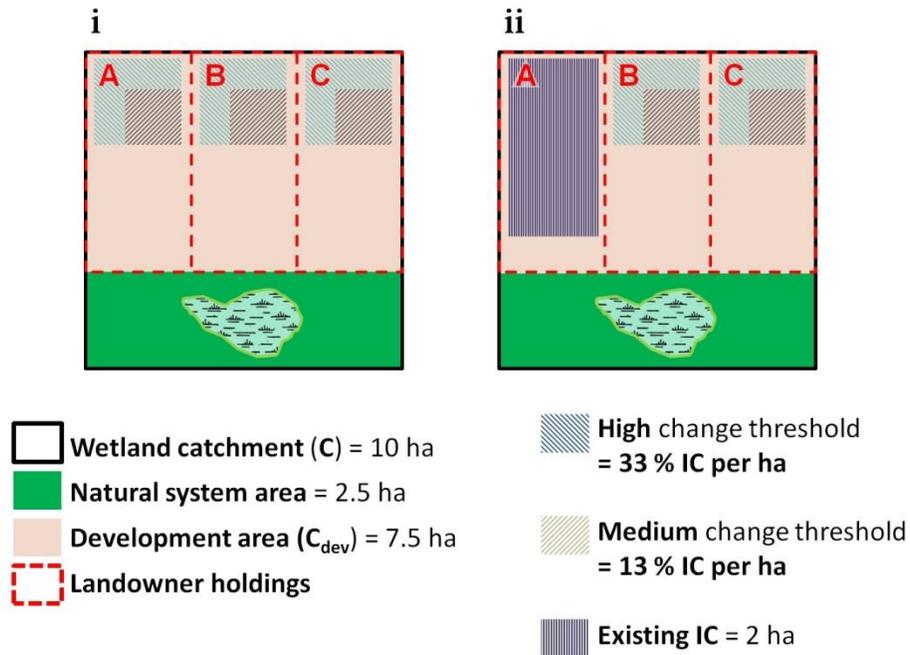
$$\text{High magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{0.25 \cdot 10}{7.5} = 33\%$$

$$\text{Medium magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{0.1 \cdot 10}{7.5} = 13\%$$

In Example 3, three different scenarios are shown with between one and three proponents owning land within the same wetland catchment. This example shows that in each case (i, ii, and iii) a high magnitude classification is produced if the impervious cover in the proposal exceeds 33%, and a medium magnitude outcome occurs if the proportion of impervious cover in the proposal is between 13% and 33%, regardless of the number of different proponents. The calculation does not consider the amount of land each individual land owner holds, it considers the total development area within the wetland catchment and returns a percent of impervious surface. In each case (i, ii, and iii) the impervious cover scores correspond to a *total* catchment (C) impervious cover value of 25% for the threshold of the high magnitude category, and 10% for the threshold of the medium magnitude category. The same impervious cover score thresholds for the high and medium magnitude categories apply to each landowner in (iii), irrespective of development or land acquisition timelines. This ensures that total catchment imperviousness does not exceed one of the potential hydrological change thresholds without requiring an appropriately scoped water balance study.

Example 4 – Existing development within catchment (infill scenario)

In some cases proposals to develop land within a wetland catchment with existing development will occur. Example 4 is similar to Example 3, except that in Example 4 (ii), there is existing development within the catchment.



$$\text{High magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{25 \cdot 10}{7.5} = 33\%$$

$$\text{Medium magnitude: } IC = \frac{S \cdot C}{C_{dev}} = \frac{10 \cdot 10}{7.5} = 13\%$$

The thresholds corresponding to the high and medium magnitude outcomes do not change between case (i) and case (ii) despite the higher existing total impervious cover within the catchment overall. The equation only considers the proportion of the catchment (C) that is considered development area (C_{dev}), i.e. the area of the catchment outside of the natural system, and does not consider any existing impervious cover. The impervious cover score approach allows the Risk Evaluation to be applied to infill development scenarios and existing urban areas in which a wetland has been determined to be protected. In many older semi-urbanized or fully urbanized areas, remaining wetland communities and functions may have already shifted to reflect the altered drainage conditions within the catchment. Baseline conditions may have changed, and the objective may be to maintain the new hydrological and ecological conditions.

APPENDIX 2: LIST OF WETLAND COMMUNITY TYPES WITHIN TORONTO AND REGION CONSERVATION AUTHORITY JURISDICTION BY HYDROLOGICAL SENSITIVITY

A list of wetland community types (Ecological Land Classification Ontario) ranked by sensitivity to hydrological change is used to evaluate the wetland sensitivity criteria in Step 3 of the *Risk Evaluation* (Section 2.3). Ranking of communities into different sensitivity categories was done by TRCA ecologists. Note that other CAs adopting this document may wish to modify Appendix 2 and Appendix 3 to suit the ecological communities and conservation priorities in their jurisdictions.

Wetland communities were sorted by L-rank (L1-L5) for the native communities and L+ and L+? for exotic communities. Generally, L1-L2 communities were assigned a high-sensitivity rating due to their stringent habitat needs, L3-L4 communities were assigned a medium sensitivity, and L5 communities were assigned a low sensitivity. Further details about this list and the methodology used to produce it can be provided by TRCA upon request.

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
White Pine - Red Maple - Birch - Leatherleaf Treed Kettle Bog	BOT2-1A	High	Nutrient poor system. Community slow to recover from hydrological changes
Leatherleaf Shrub Kettle Bog	BOS2-1	High	Nutrient poor system. Community slow to recover from hydrological changes
Tamarack - Leatherleaf Treed Kettle Bog	BOT2-1	High	Nutrient poor system. Community slow to recover from hydrological changes
Slender Sedge Open Fen	FEO1-2	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Beaked Sedge Open Fen	FEO1-5	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Willow Shrub Fen	FES1-A	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Tamarack Treed Fen	FET1-1	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Leatherleaf - Forb Shrub Fen	FES1-4	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Low White Cedar Shrub Fen	FES1-9	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Tamarack - White Cedar Treed Fen	FET1-2	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Bog Buckbean - Sedge Open Fen	FEO1-4	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
Willow Shrub Mineral Fen	FES2-A	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
White Cedar - Scots Pine Low Treed Mineral Fen	FET2-B	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
White Cedar Low Treed Mineral Fen	FET2-A	High	Mineral rich community. Groundwater fed. Community slow to recover from hydrological changes
Bluejoint - Switchgrass Tallgrass Meadow Marsh	MAM6-A	High	Community slow to recover from hydrological changes
Nelson's Scouring Rush - Baltic Rush Coastal Fen	MAM4-A	High	Community slow to recover from hydrological changes
Unvegetated Mineral Vernal Pool	MAS2-H	High	Community slow to recover from hydrological changes
Narrow-leaved Sedge Organic Shallow Marsh	MAS3-3	High	Community slow to recover from hydrological changes
Unvegetated Organic Vernal Pool	MAS3-E	High	Community slow to recover from hydrological changes
Calla Lily Organic Shallow Marsh	MAS3-11	High	Community slow to recover from hydrological changes
Narrow-leaved Sedge Organic Meadow Marsh	MAM3-5	High	Community slow to recover from hydrological changes
Swamp Loosestrife Organic Shallow Marsh	MAS3-12	High	Community slow to recover from hydrological changes
Broad-leaved Sedge Organic Shallow Marsh	MAS3-4	High	Community slow to recover from hydrological changes
Bur-reed Organic Shallow Marsh	MAS3-7	High	Community slow to recover from hydrological changes
Horsetail Organic Shallow Marsh	MAS3-B	High	Community slow to recover from hydrological changes
Manna Grass Organic Shallow Marsh	MAS3-C	High	Community slow to recover from hydrological changes
Bluejoint Organic Meadow Marsh	MAM3-1	High	Community slow to recover from hydrological changes
Broad-leaved Sedge Organic Meadow Marsh	MAM3-6	High	Community slow to recover from hydrological changes
Mineral Fen Meadow Marsh	MAM5-1	High	Community slow to recover from hydrological changes
Forb Organic Shallow Marsh	MAS3-10	High	Community slow to recover from hydrological changes
Bulrush Organic Shallow Marsh	MAS3-2	High	Community slow to recover from hydrological changes
Rice Cut-grass Organic Shallow Marsh	MAS3-8	High	Community slow to recover from hydrological changes
Bur-reed Mixed Shallow Aquatic	SAM1-5	High	Community slow to recover from hydrological changes
Crowfoot Mixed Shallow Aquatic	SAM1-C	High	Community slow to recover from hydrological changes
Bladderwort Mixed Shallow Aquatic	SAM1-6	High	Community slow to recover from hydrological changes
Bushy Naiad Submerged Shallow Aquatic	SAS1-B	High	Community tolerant of slight hydrological change

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
Water Lily - Bullhead Lily Mixed Shallow Aquatic	SAM1-A	High	Community slow to recover from hydrological changes
Tamarack - Black Spruce Organic Coniferous Swamp	SWC4-1	High	Community slow to recover from hydrological changes
Tamarack - Balsam Fir - Spruce Organic Coniferous Swamp	SWC4-A	High	Community slow to recover from hydrological changes
Swamp Maple - Conifer Organic Mixed Swamp	SWM5-2	High	Community slow to recover from hydrological changes
Red (Green) Ash - Hemlock Mineral Mixed Swamp	SWMA-A	High	Community slow to recover from hydrological changes
Buttonbush Mineral Thicket Swamp	SWT2-4	High	Community slow to recover from hydrological changes
Mountain Maple Organic Thicket Swamp	SWT3-3	High	Community tolerant of slight hydrological change
Silky Dogwood Organic Thicket Swamp	SWT3-B	High	Community tolerant of slight hydrological change
Tamarack Organic Coniferous Swamp	SWC4-2	High	Community slow to recover from hydrological changes
Buttonbush Organic Thicket Swamp	SWT3-4	High	Community slow to recover from hydrological changes
Spiraea Organic Thicket Swamp	SWT3-A	High	Community slow to recover from hydrological changes
Hemlock Organic Coniferous Swamp	SWCA-A	High	Community slow to recover from hydrological changes
White Birch - Cottonwood Coastal Mineral Deciduous Swamp	SWD4-A	High	Community slow to recover from hydrological changes
Red Maple Organic Deciduous Swamp	SWD6-1	High	Community slow to recover from hydrological changes
Silver Maple Organic Deciduous Swamp	SWD6-2	High	Community slow to recover from hydrological changes
Red Maple - Conifer Organic Mixed Swamp	SWM5-1	High	Community slow to recover from hydrological changes
Poplar - Conifer Organic Mixed Swamp	SWM6-2	High	Community slow to recover from hydrological changes
Winterberry Mineral Thicket Swamp	SWT2-B	High	Community slow to recover from hydrological changes
Winterberry Organic Thicket Swamp	SWT3-7	High	Community slow to recover from hydrological changes
Swamp Maple - Conifer Mineral Mixed Swamp	SWM2-2	High	Community slow to recover from hydrological changes
Hemlock Mineral Coniferous Swamp	SWC2-2	High	Community slow to recover from hydrological changes
Red Maple - Conifer Mineral Mixed Swamp	SWM2-1	High	Community slow to recover from hydrological changes
Yellow Birch Organic Deciduous Swamp	SWD7-2	High	Community slow to recover from hydrological changes
White Cedar - Conifer Organic Coniferous Swamp	SWC3-2	High	Community slow to recover from hydrological changes
Birch - Conifer Organic Mixed Swamp	SWM6-1	High	Community slow to recover from hydrological changes
White Cedar - Hardwood Organic Mixed Swamp	SWM4-1	High	Community slow to recover from hydrological changes
Threesquare Mineral Shallow Marsh	MAS2-6	Medium	Community tolerant of slight hydrological change

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
Sweet Flag Mineral Shallow Marsh	MAS2-F	Medium	Community tolerant of slight hydrological change
Jewelweed Organic Meadow Marsh	MAM3-8	Medium	Community tolerant of slight hydrological change
Narrow-leaved Sedge Mineral Shallow Marsh	MAS2-3	Medium	Community tolerant of slight hydrological change
Horsetail Mineral Shallow Marsh	MAS2-C	Medium	Community tolerant of slight hydrological change
Rush Mineral Meadow Marsh	MAM2-C	Medium	Community tolerant of slight hydrological change
Rice Cut-grass Organic Meadow Marsh	MAM3-3	Medium	Community tolerant of slight hydrological change
Buejoint Mineral Meadow Marsh	MAM2-1	Medium	Community tolerant of slight hydrological change
Narrow-leaved Sedge Mineral Meadow Marsh	MAM2-5	Medium	Community tolerant of slight hydrological change
Broad-leaved Sedge Mineral Meadow Marsh	MAM2-6	Medium	Community tolerant of slight hydrological change
Horsetail Mineral Meadow Marsh	MAM2-7	Medium	Community tolerant of slight hydrological change
Forb Organic Meadow Marsh	MAM3-9	Medium	Community tolerant of slight hydrological change
Broad-leaved Sedge Mineral Shallow Marsh	MAS2-4	Medium	Community tolerant of slight hydrological change
Bur-reed Mineral Shallow Marsh	MAS2-7	Medium	Community tolerant of slight hydrological change
Broad-leaved Cattail Organic Shallow Marsh	MAS3-1A	Medium	Community tolerant of slight hydrological change
Bulrush Mineral Meadow Marsh	MAM2-E	Medium	Community tolerant of slight hydrological change
Rice Cut-grass Mineral Shallow Marsh	MAS2-8	Medium	Community tolerant of slight hydrological change
Manna Grass Mineral Shallow Marsh	MAS2-G	Medium	Community tolerant of slight hydrological change
Bulrush Mineral Shallow Marsh	MAS2-2	Medium	Community tolerant of slight hydrological change
Forb Mineral Shallow Marsh	MAS2-9	Medium	Community tolerant of slight hydrological change
Broad-leaved Cattail Mineral Shallow Marsh	MAS2-1A	Medium	Community tolerant of slight hydrological change
Watercress Mixed Shallow Aquatic	SAM1-3	Medium	Community tolerant of slight hydrological change
Water Milfoil Mixed Shallow Aquatic	SAM1-7	Medium	Community tolerant of slight hydrological change
Water Lily - Bullhead Lily Floating-leaved Shallow Aquatic	SAF1-1	Medium	Community tolerant of slight hydrological change
Wild Celery Submerged Shallow Aquatic	SAS1-5	Medium	Community tolerant of slight hydrological change
Pondweed Mixed Shallow Aquatic	SAM1-4	Medium	Community tolerant of slight hydrological change
Waterweed Submerged Shallow Aquatic	SAS1-2	Medium	Community tolerant of slight hydrological change
Water Milfoil Submerged Shallow Aquatic	SAS1-4	Medium	Community tolerant of slight hydrological change

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
Coon-tail Submerged Shallow Aquatic	SAS1-A	Medium	Community tolerant of slight hydrological change
Duckweed Floating-leaved Shallow Aquatic	SAF1-3	Medium	Community tolerant of slight hydrological change
Duckweed Mixed Shallow Aquatic	SAM1-2	Medium	Community tolerant of slight hydrological change
Pondweed Submerged Shallow Aquatic	SAS1-1	Medium	Community tolerant of slight hydrological change
Stonewort Submerged Shallow Aquatic	SAS1-3	Medium	Community tolerant of slight hydrological change
Spiraea Mineral Thicket Swamp	SWT2-6	Medium	Community tolerant of slight hydrological change
Nannyberry Mineral Thicket Swamp	SWT2-10	Medium	Community tolerant of slight hydrological change
Mountain Maple Mineral Thicket Swamp	SWT2-3	Medium	Community tolerant of slight hydrological change
White Cedar - Conifer Mineral Coniferous Swamp	SWC1-2	Medium	Community tolerant of slight hydrological change
Bur Oak Mineral Deciduous Swamp	SWD1-2	Medium	Community tolerant of slight hydrological change
Red Maple Mineral Deciduous Swamp	SWD3-1	Medium	Community tolerant of slight hydrological change
Willow Organic Deciduous Swamp	SWD7-A	Medium	Community tolerant of slight hydrological change
Birch - Conifer Mineral Mixed Swamp	SWM3-1	Medium	Community tolerant of slight hydrological change
Poplar - Conifer Mineral Mixed Swamp	SWM3-2	Medium	Community tolerant of slight hydrological change
Silky Dogwood Mineral Thicket Swamp	SWT2-8	Medium	Community tolerant of slight hydrological change
Yellow Birch Mineral Deciduous Swamp	SWD4-4	Medium	Community tolerant of slight hydrological change
Black Ash Organic Deciduous Swamp	SWD5-1	Medium	Community tolerant of slight hydrological change
Swamp Maple Organic Deciduous Swamp	SWD6-3	Medium	Community tolerant of slight hydrological change
Alder Organic Thicket Swamp	SWT3-1	Medium	Community tolerant of slight hydrological change
Red-osier Organic Thicket Swamp	SWT3-5	Medium	Community tolerant of slight hydrological change
White Cedar Organic Coniferous Swamp	SWC3-1	Medium	Community tolerant of slight hydrological change
Paper Birch - Poplar Organic Deciduous Swamp	SWD7-1	Medium	Community tolerant of slight hydrological change
Willow Organic Thicket Swamp	SWT3-2	Medium	Community tolerant of slight hydrological change
White Ash Mineral Deciduous Swamp	SWD2-A	Medium	Community tolerant of slight hydrological change
White Cedar Mineral Coniferous Swamp	SWC1-1	Medium	Community tolerant of slight hydrological change
Black Ash Mineral Deciduous Swamp	SWD2-1	Medium	Community tolerant of slight hydrological change
Swamp Maple Mineral Deciduous Swamp	SWD3-3	Medium	Community tolerant of slight hydrological change

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
White Elm Mineral Deciduous Swamp	SWD4-2	Medium	Community tolerant of slight hydrological change
Alder Mineral Thicket Swamp	SWT2-1	Medium	Community tolerant of slight hydrological change
Red (Green) Ash Mineral Deciduous Swamp	SWD2-2	Medium	Community tolerant of slight hydrological change
Silver Maple Mineral Deciduous Swamp	SWD3-2	Medium	Community tolerant of slight hydrological change
Paper Birch - Poplar Mineral Deciduous Swamp	SWD4-3	Medium	Community tolerant of slight hydrological change
Willow Mineral Thicket Swamp	SWT2-2	Medium	Community tolerant of slight hydrological change
White Cedar - Hardwood Mineral Mixed Swamp	SWM1-1	Medium	Community tolerant of slight hydrological change
Fowl Manna Grass Organic Meadow Marsh	MAM3-4	Medium	Maybe sensitive to hydrological change
Fowl Manna Grass Mineral Meadow Marsh	MAM2-4	Medium	Maybe sensitive to hydrological change
Rice Cut-Grass Mineral Meadow Marsh	MAM2-D	Medium	Maybe sensitive to hydrological change
Reed Canary Grass Organic Meadow Marsh	MAM3-2	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Common Reed Organic Meadow Marsh	MAM3-a	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Giant Manna Grass Mineral Shallow Marsh	MAS2-e	Medium	
Narrow-leaved Cattail Organic Shallow Marsh	MAS3-1b	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Common Reed Organic Shallow Marsh	MAS3-9	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Purple Loosestrife Organic Shallow Marsh	MAS3-a	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Reed Canary Grass Organic Shallow Marsh	MAS3-d	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Floating-heart Mixed Shallow Aquatic	SAM1-b	Medium	
Exotic Organic Thicket Swamp	SWT3-c	Medium	Substrate sensitive to change. Organic soils are slow to accumulate
Jewelweed Mineral Meadow Marsh	MAM2-9	Low	Community moderately tolerant of hydrological changes
Forb Mineral Meadow Marsh	MAM2-10	Low	Community moderately tolerant of hydrological changes
Liverwort Floating-leaved Shallow Aquatic	SAF1-A	Low	Community moderately tolerant of hydrological changes
Manitoba Maple Mineral Deciduous Swamp	SWD3-4	Low	Community moderately tolerant of hydrological changes
Willow Mineral Deciduous Swamp	SWD4-1	Low	Community moderately tolerant of hydrological changes

Vegetation Community	ELC Code	Sensitivity	Assumptions/Basis
Red-osier Mineral Thicket Swamp	SWT2-5	Low	Community moderately tolerant of hydrological changes
Red-top Mineral Meadow Marsh	MAM2-3	Low	Community moderately tolerant of hydrological changes
Reed Canary Grass Mineral Meadow Marsh	MAM2-2	Low	
Miscanthus Mineral Meadow Marsh	MAM2-f	Low	
Cool-season Grass Mineral Meadow Marsh	MAM2-g	Low	
Reed Canary Grass Mineral Shallow Marsh	MAS2-d	Low	
European Alder Mineral Deciduous Swamp	SWD4-b	Low	
Exotic Mineral Thicket Swamp	SWT2-a	Low	

APPENDIX 3: LIST OF HYDROLOGICALLY SENSITIVE FAUNA AND FLORA WITHIN TORONTO AND REGION CONSERVATION AUTHORITY JURISDICTION BY HYDROLOGICAL SENSITIVITY

This appendix contains two lists, one of hydrologically sensitive fauna (grouped into herpetofauna, birds, mammals and fish) and a second list of individual flora ranked by sensitivity. Fauna rankings were derived from the sources cited in the references section in addition to the professional experience of TRCA staff. Note that other CAs adopting this document may wish to modify Appendix 2 and Appendix 3 to suit the ecological communities and conservation priorities in their jurisdictions.

Flora rankings were assigned using a combination of co-efficient of Conservatism values (CC), L-Ranks and expert opinion. The Terrestrial Natural Heritage Access Database was queried to produce a list of all species sensitive to hydrology. The coefficient of wetness score (CW, range 5 to - 5), which defines a species' likelihood to occur in a wetland was then used to separate terrestrial species from wetland species (i.e. only facultative to obligate wetland species with a CW score of -2 to -5 were included). Species were then sorted in descending order based on their coefficient of conservatism value, CC (range 0 to 10). Conservatism value describes a species ability to persist and adapt to change in its habitat. Species with higher CC values are unlikely to tolerate change because they are specialists that are confined to specific environmental conditions and habitat types. Species with lower CC values are more generalist in nature, and can tolerate a wider range of conditions and habitats and as such are less sensitive to disturbance. Species with a CC value of 8 to 10 were deemed highly sensitive, 4 to 7 were deemed moderately sensitive and 0 to 3 were deemed mildly sensitive to changes in hydrology. Those species highlighted pale brown may be sensitive to hydrology (currently unclear). Where possible, species that act as groundwater indicators were indicated.

Fauna List			
Fauna	Sensitivity	Sensitive Periods	L-Rank
<i>Herpetofauna-</i>			
gray treefrog	High	late Apr-early Oct	L2
wood frog	High	late Mar-end Aug	L2
northern spring peeper	High	start Apr-end Sep	L2
western chorus frog	High	end Mar-end July	L2
northern leopard frog	High	late Sep-mid Aug	L3
mink frog	High	all year	L2
American bullfrog	High	all year	L2
pickerel frog	High	early Oct-late Aug	L2
mudpuppy	High	all year	LX
eastern newt	High	all year	L2

Fauna	Sensitivity	Sensitive Periods	L-Rank
blue-spotted salamander	High	Mar-Aug	LX
Jefferson salamander complex	High	early Mar-Sep	L1
yellow-spotted salamander	High	Mar-Oct	L1
Blanding's turtle	High	all year	L1
common map turtle	High	all year	L2
common musk turtle	High	all year	LX
common snapping turtle	High	all year	L2
midland painted turtle	High	all year	L3
green frog	Medium	all year	L4
American toad	Medium	late Apr-mid Sep	L4
northern watersnake	Medium	Apr-Oct	L2
<i>Birds-</i>			
American coot	High	early Apr-late Oct	L2
American bittern	High	early Apr-mid Oct	L2
least bittern	High	late Apr-late Oct	L2
common moorhen	High	early Apr-mid Sep	L2
pieb-billed grebe	High	early Apr-end Oct	L3
red-necked grebe	High	late Apr-mid Oct	L3
canvasback	High	late Apr-end Sep	L2
hooded merganser	High	mid Mar-late Oct	L3
Virginia Rail	Medium	early Apr-mid Sep	L3
Northern waterthrush	Medium	start May-mid Aug	L3
blue-winged teal	Medium	early Apr-early Oct	L3
green-winged teal	Medium	mid Apr-early Sep	L2
prothonotary warbler	Medium	early May-end Aug	L2
sora	Medium	early Apr-end Sep	L3
American black duck	Medium	early Mar-end Oct	L3
gadwall	Medium	end Mar-mid Oct	L4
marsh wren	Medium	late Apr-mid Sep	L3
wood duck	Medium	early Mar-end Oct	L4
great blue heron	Low	start Apr-early Oct	L3
great egret	Low	mid Apr-late Sep	L3
green heron	Low	early Apr-end Sep	L4
black-crowned night heron	Low	early Apr-late Oct	L3
alder flycatcher	Low	late May-late Aug	L4
Canada goose	Low	early Mar-early Oct	L5
common yellowthroat	Low	start May-late Aug	L4
mallard	Low	mid Mar-end Oct	L5
swamp sparrow	Low	early Apr-end Aug	L4
Wilson's snipe	Low	start Apr-early Sep	L3

Fauna	Sensitivity	Sensitive Periods	L-Rank
<i>Mammals-</i>			
muskrat	High	all year	L4
mink	Low	all year	L4
beaver	Low	all year	L4
star-nosed mole	Low	all year	L3
<i>Fish-</i>			
<i>northern pike</i>	High		
<i>blackchin minnow</i>	High		
<i>northern redbelly dace</i>	Medium		
<i>central mudminnow</i>	Medium		
<i>brook stickleback</i>	Low		
<i>fathead minnow</i>	Low		

Flora List							
Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Andromeda polifolia</i> var. <i>latifolia</i>	bog rosemary	High	L1	10	-5		
<i>Eriophorum gracile</i>	slender cotton-grass	High	L1	10	-5		
<i>Pogonia ophioglossoides</i>	rose pogonia	High	L1	10	-5		
<i>Woodwardia virginica</i>	Virginia chain-fern	High	L1	10	-5		
<i>Eriophorum tenellum</i>	rough cotton-grass	High	L1	10	-5		
<i>Eriophorum vaginatum</i> ssp. <i>spissum</i>	dense cotton-grass	High	L1	10	-5		
<i>Rhynchospora alba</i>	white beak-rush	High	L1	10	-5		
<i>Sarracenia purpurea</i>	pitcher-plant	High	L1	10	-5		
<i>Valeriana uliginosa</i>	swamp valerian	High	L1	10	-4		
<i>Equisetum palustre</i>	marsh horsetail	High	L1	10	-3		
<i>Carex buxbaumii</i>	dark-scaled sedge	High	L2	10	-5		
<i>Carex prasina</i>	drooping sedge	High	L2	10	-5		
<i>Eleocharis quinqueflora</i>	few-flowered spike-rush	High	L2	10	-5		
<i>Potamogeton oakesianus</i>	Oakes' pondweed	High	L2	10	-5		
<i>Carex tenuiflora</i>	sparse-flowered sedge	High	L2	10	-5		
<i>Symphotrichum boreale</i>	bog aster	High	L2	10	-5		
<i>Carex chordorrhiza</i>	creeping sedge	High	L2	10	-5		
<i>Carex limosa</i>	mud sedge	High	L2	10	-5		
<i>Carex magellanica</i> ssp. <i>irrigua</i>	stunted sedge	High	L2	10	-5		
<i>Eriophorum virginicum</i>	tawny cotton-grass	High	L2	10	-5		
<i>Kalmia polifolia</i>	bog laurel	High	L2	10	-5		
<i>Salix candida</i>	hoary willow	High	L2	10	-5		
<i>Scleria verticillata</i>	low nut-rush	High	L2	10	-5		
<i>Vaccinium macrocarpon</i>	large cranberry	High	L2	10	-5		
<i>Vaccinium oxycoccos</i>	small cranberry	High	L2	10	-5		
<i>Juncus brachycephalus</i>	small-headed rush	High	L2	10	-3		
<i>Carex garberi</i>	Garber's sedge	High	L2	10	-3		
<i>Maianthemum trifolium</i>	three-leaved false Solomon's seal	High	L3	10	-5		
<i>Carex lupulina</i>	hop sedge	High	L4	10	-4		
<i>Arethusa bulbosa</i>	dragon's mouth orchid	High	LX	10	-5		
<i>Carex pauciflora</i>	few-flowered sedge	High	LX	10	-5		
<i>Hippuris vulgaris</i>	mare's tail	High	LX	10	-5		
<i>Platanthera blephariglottis</i> var. <i>blephariglottis</i>	white-fringed orchis	High	LX	10	-5		
<i>Schoenoplectus smithii</i> var. <i>smithii</i>	Smith's club-rush	High	LX	10	-5		
<i>Triglochin palustris</i>	marsh arrow-grass	High	LX	10	-5		
<i>Scheuchzeria palustris</i>	bog arrow-grass	High	LX	10	-5		
<i>Triantha occidentalis</i> ssp. <i>brevistyla</i>	sticky false asphodel	High	LX	10	-5		
<i>Calypso bulbosa</i>	calypso	High	LX	10	-3		
<i>Galium labradoricum</i>	Labrador bedstraw	High	L1	9	-5		
<i>Lobelia kalmii</i>	Kalm's lobelia	High	L1	9	-5		
<i>Betula pumila</i>	dwarf birch	High	L1	9	-5		
<i>Parnassia parviflora</i>	small-flowered grass of Parnassus	High	L1	9	-5		
<i>Cladium mariscoides</i>	twig-rush	High	L1	9	-5		
<i>Calopogon tuberosus</i>	grass pink	High	L1	9	-5		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Spiranthes romanzoffiana</i>	hooded ladies' tresses	High	L1	9	-4	x	
<i>Viola sagittata</i> var. <i>ovata</i>	arrow-leaved violet	High	L1	9	-2		
<i>Carex schweinitzii</i>	Schweinitz' sedge	High	L2	9	-5	x	
<i>Salix pedicellaris</i>	bog willow	High	L2	9	-5		
<i>Eriophorum viridicarinatum</i>	thin-leaved cotton-grass	High	L2	9	-5	x	
<i>Rhododendron groenlandicum</i>	Labrador-tea	High	L2	9	-5		
<i>Menyanthes trifoliata</i>	bog buckbean	High	L2	9	-5		
<i>Solidago uliginosa</i>	bog goldenrod	High	L2	9	-5		
<i>Zizania palustris</i> var. <i>palustris</i>	northern wild rice	High	L2	9	-5		
<i>Spiranthes lucida</i>	shining ladies' tresses	High	L2	9	-4	x	
<i>Chamaedaphne calyculata</i>	leatherleaf	High	L3	9	-5		
<i>Peltandra virginica</i>	tuckahoe	High	L3	9	-5		
<i>Carex trisperma</i>	three-seeded sedge	High	L3	9	-5	x	
<i>Epilobium strictum</i>	downy willow-herb	High	L3	9	-5		
<i>Carex billingsii</i>	Billings' three-seeded sedge	High	LU	9	-5		
<i>Drosera intermedia</i>	spatulate-leaved sundew	High	LX	9	-5		
<i>Mimulus moschatus</i>	musk-flower	High	LX	9	-5		
<i>Pedicularis lanceolata</i>	swamp lousewort	High	LX	9	-4		
<i>Platanthera obtusata</i>	small northern bog orchis	High	LX	9	-3		
<i>Ribes hudsonianum</i>	northern black currant	High	L1	8	-5		
<i>Triglochin maritima</i>	seaside arrow-grass	High	L1	8	-5		
<i>Bidens beckii</i>	water-marigold	High	L1	8	-5		
<i>Eleocharis flavescens</i> var. <i>olivacea</i>	olive-fruited spike-rush	High	L1	8	-5		
<i>Cirsium muticum</i>	swamp thistle	High	L1	8	-5		
<i>Utricularia intermedia</i>	flat-leaved bladderwort	High	L1	8	-5		
<i>Vaccinium corymbosum</i>	highbush blueberry	High	L1	8	-3		
<i>Petasites frigidus</i>	palmete-leaved sweet coltsfoot	High	L1	8	-3		
<i>Platanthera psycodes</i>	small purple-fringed orchis	High	L1	8	-3		
<i>Gaultheria hispida</i>	creeping snowberry	High	L1	8	-3		
<i>Sparganium natans</i>	lesser bur-reed	High	L2	8	-5		
<i>Cardamine bulbosa</i>	spring cress	High	L2	8	-5		
<i>Torreyochloa pallida</i> var. <i>fernaldii</i>	Fernald's manna grass	High	L2	8	-5		
<i>Dichanthelium acuminatum</i> ssp. <i>lindheimeri</i>	Lindheimer's panic grass	High	L2	8	-5		
<i>Ilex mucronata</i>	mountain holly	High	L2	8	-5		
<i>Calla palustris</i>	water arum	High	L2	8	-5		
<i>Carex lasiocarpa</i>	slender woolly sedge	High	L2	8	-5		
<i>Utricularia minor</i>	small bladderwort	High	L2	8	-5		
<i>Calamagrostis stricta</i> ssp. <i>inexpansa</i>	northern reed grass	High	L2	8	-4		
<i>Carex grayi</i>	Gray's sedge	High	L2	8	-4		
<i>Listera cordata</i>	heart-leaved twayblade	High	L2	8	-3		
<i>Picea mariana</i>	black spruce	High	L2	8	-3		
<i>Chrysosplenium americanum</i>	golden saxifrage	High	L3	8	-5	x	
<i>Solidago patula</i>	rough-leaved goldenrod	High	L3	8	-5		
<i>Carex disperma</i>	two-seeded sedge	High	L3	8	-5	x	

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Carex leptalea</i>	bristle-staked sedge	High	L3	8	-5	x	
<i>Glyceria borealis</i>	northern manna grass	High	L3	8	-5		
<i>Glyceria septentrionalis</i>	eastern manna grass	High	L3	8	-5		
<i>Acorus americanus</i>	sweet flag	High	L3	8	-5		
<i>Carex laevivaginata</i>	smooth-sheathed sedge	High	L3	8	-5	x	
<i>Equisetum pratense</i>	thicket horsetail	High	L3	8	-3		
<i>Hydrophyllum canadense</i>	Canada waterleaf	High	L3	8	-2		
<i>Carex scabrata</i>	rough sedge	High	L4	8	-5	x	
<i>Samolus parviflorus</i>	Valerand's water-pimpernel	High	LU	8	-5		
<i>Potamogeton strictifolius</i>	narrow-leaved pondweed	High	LU	8	-5		
<i>Lonicera oblongifolia</i>	swamp fly honeysuckle	High	LX	8	-5		
<i>Potamogeton spirillus</i>	spiral pondweed	High	LX	8	-5		
<i>Sagittaria graminea</i> ssp. <i>graminea</i>	grass-leaved arrowhead	High	LX	8	-5		
<i>Toxicodendron vernix</i>	poison sumach	High	LX	8	-5		
<i>Stuckenia filiformis</i> ssp. <i>filiformis</i>	thread-leaved pondweed	High	LX	8	-5		
<i>Platanthera clavellata</i>	club-spur orchis	High	LX	8	-4		
<i>Salix myricoides</i>	blue-leaved willow	High	LX	10	-3		
<i>Agalinis paupercula</i>	small-flowered gerardia	High	L1	8	-5		
<i>Gentianopsis crinita</i>	fringed gentian	High	L2	8	-4	x	
<i>Platanus occidentalis</i>	sycamore	High	L2	8	-3		
<i>Physostegia virginiana</i> ssp. <i>virginiana</i>	false dragonhead	High	L3	8	-3		
<i>Carex trichocarpa</i>	hairy-fruited sedge	High	L3	8	-5		
<i>Elodea nuttallii</i>	Nuttall's water-weed	High	L3	8	-5		
<i>Myriophyllum verticillatum</i>	whorled water-milfoil	Medium	L1	7	-5		
<i>Brasenia schreberi</i>	water-shield	Medium	L1	7	-5		
<i>Carex echinata</i> ssp. <i>echinata</i>	little prickly sedge	Medium	L1	7	-5		
<i>Drosera rotundifolia</i>	round-leaved sundew	Medium	L1	7	-5		
<i>Selaginella eclipes</i>	meadow spike-moss	Medium	L1	7	-4		
<i>Corallorhiza trifida</i>	early coral-root	Medium	L1	7	-2		
<i>Glyceria canadensis</i>	rattlesnake grass	Medium	L2	7	-5		
<i>Myriophyllum heterophyllum</i>	variable water-milfoil	Medium	L2	7	-5		
<i>Potamogeton praelongus</i>	white-stem pondweed	Medium	L2	7	-5		
<i>Carex aquatilis</i>	water sedge	Medium	L2	7	-5		
<i>Dulichium arundinaceum</i>	three-way sedge	Medium	L2	7	-5		
<i>Gratiola neglecta</i>	clammy hedge-hyssop	Medium	L2	7	-5		
<i>Lobelia cardinalis</i>	cardinal flower	Medium	L2	7	-5		
<i>Ranunculus flabellaris</i>	yellow water crowfoot	Medium	L2	7	-5		
<i>Cardamine nymanii</i>	cuckoo-flower	Medium	L2	7	-5		
<i>Pontederia cordata</i>	pickerel-weed	Medium	L2	7	-5		
<i>Decodon verticillatus</i>	swamp loosestrife	Medium	L2	7	-5		
<i>Heteranthera dubia</i>	water star-grass	Medium	L2	7	-5		
<i>Potamogeton nodosus</i>	knotty pondweed	Medium	L2	7	-5		
<i>Rosa palustris</i>	swamp rose	Medium	L2	7	-5		
<i>Triadenum fraseri</i>	marsh St. John's-wort	Medium	L2	7	-5		
<i>Potamogeton perfoliatus</i>	clasping-leaved pondweed	Medium	L2	7	-5		
<i>Cypripedium reginae</i>	showy lady's slipper	Medium	L2	7	-4	x	
<i>Carex prairea</i>	fen paniced sedge	Medium	L2	7	-4		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Packera aurea</i>	golden ragwort	Medium	L2	7	-3		
<i>Eleocharis elliptica</i>	elliptic spike-rush	Medium	L2	7	-3		
<i>Viburnum nudum</i> var. <i>cassinoides</i>	withe-rod	Medium	L2	7	-3		
<i>Eleocharis intermedia</i>	matted spike-rush	Medium	L2	7	-3		
<i>Coptis trifolia</i>	goldthread	Medium	L2	7	-3	x	
<i>Veronica scutellata</i>	marsh speedwell	Medium	L3	7	-5		
<i>Carex diandra</i>	lesser paniced sedge	Medium	L3	7	-5		
<i>Epilobium leptophyllum</i>	narrow-leaved willow-herb	Medium	L3	7	-5		
<i>Cephalanthus occidentalis</i>	buttonbush	Medium	L3	7	-5		
<i>Sagittaria cuneata</i>	arum-leaved arrowhead	Medium	L3	7	-5		
<i>Comarum palustre</i>	marsh cinquefoil	Medium	L3	7	-5		
<i>Campanula aparinoides</i>	marsh bellflower	Medium	L3	7	-5		
<i>Equisetum fluviatile</i>	water horsetail	Medium	L3	7	-5		
<i>Osmunda regalis</i> var. <i>spectabilis</i>	royal fern	Medium	L3	7	-5		
<i>Rumex verticillatus</i>	swamp dock	Medium	L3	7	-5		
<i>Alopecurus aequalis</i>	short-awned foxtail	Medium	L3	7	-5		
<i>Carex canescens</i> ssp. <i>canescens</i>	silvery sedge	Medium	L3	7	-5		
<i>Carex tuckermanii</i>	Tuckerman's sedge	Medium	L3	7	-5		
<i>Carex utriculata</i>	beaked sedge	Medium	L3	7	-5		
<i>Carex vesicaria</i>	inflated sedge	Medium	L3	7	-5		
<i>Chelone glabra</i>	turtlehead	Medium	L3	7	-5	x	
<i>Geum rivale</i>	water avens	Medium	L3	7	-5	x	
<i>Lindernia dubia</i> var. <i>dubia</i>	false pimpernel	Medium	L3	7	-5		
<i>Rhamnus alnifolia</i>	alder-leaved buckthorn	Medium	L3	7	-5		
<i>Bolboschoenus fluviatilis</i>	river bulrush	Medium	L3	7	-5		
<i>Carex castanea</i>	chestnut-scaled sedge	Medium	L3	7	-4		
<i>Dryopteris clintoniana</i>	Clinton's wood fern	Medium	L3	7	-4	x	x
<i>Muhlenbergia glomerata</i>	marsh wild Timothy	Medium	L3	7	-4		
<i>Cardamine douglassii</i>	purple cress	Medium	L3	7	-3		
<i>Dryopteris x benedictii</i>	Benedict's wood fern	Medium	L3	7	-3		
<i>Carex brunnescens</i> ssp. <i>brunnescens</i>	brownish sedge	Medium	L3	7	-3		
<i>Equisetum sylvaticum</i>	woodland horsetail	Medium	L3	7	-3		
<i>Larix laricina</i>	tamarack	Medium	L3	7	-3		
<i>Osmundastrum cinnamomeum</i>	cinnamon fern	Medium	L3	7	-3		
<i>Viola renifolia</i>	kidney-leaved violet	Medium	L3	7	-3		
<i>Dryopteris cristata</i>	crested wood fern	Medium	L4	7	-5	x	
<i>Lysimachia thyrsiflora</i>	tufted loosestrife	Medium	L4	7	-5		
<i>Symplocarpus foetidus</i>	skunk cabbage	Medium	L4	7	-5	x	
<i>Veronica anagallis-aquatica</i>	water speedwell	Medium	L4	7	-5	x	x
<i>Hydrocotyle americana</i>	marsh pennywort	Medium	L4	7	-5	x	
<i>Carex bromoides</i>	brome-like sedge	Medium	L4	7	-4		
<i>Cinna latifolia</i>	nodding wood reed	Medium	L4	7	-4		
<i>Fraxinus nigra</i>	black ash	Medium	L4	7	-4	x	x
<i>Proserpinaca palustris</i>	mermaid-weed	Medium	LX	7	-5		
<i>Juncus canadensis</i>	Canada rush	Medium	L1	6	-5		
<i>Platanthera lacera</i>	ragged fringed orchis	Medium	L1	6	-3		
<i>Juncus brevicaudatus</i>	short-tailed rush	Medium	L2	6	-5		
<i>Juncus acuminatus</i>	sharp-fruited rush	Medium	L2	6	-5		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Salix serissima</i>	autumn willow	Medium	L2	6	-5		
<i>Myrica gale</i>	sweet gale	Medium	L2	6	-5		
<i>Myriophyllum sibiricum</i>	northern water-milfoil	Medium	L2	6	-5		
<i>Potamogeton illinoensis</i>	Illinois pondweed	Medium	L2	6	-5		
<i>Lathyrus palustris</i>	marsh vetchling	Medium	L2	6	-3		
<i>Rubus hispidus</i>	swamp dewberry	Medium	L2	6	-3		
<i>Lindera benzoin</i>	spice-bush	Medium	L2	6	-2		
<i>Lysimachia terrestris</i>	swamp candles	Medium	L3	6	-5		
<i>Callitriche palustris</i>	marsh water starwort	Medium	L3	6	-5		
<i>Rumex britannica</i>	great water dock	Medium	L3	6	-5		
<i>Schoenoplectus acutus</i> var. <i>acutus</i>	hard-stemmed bulrush	Medium	L3	6	-5		
<i>Carex lurida</i>	sallow sedge	Medium	L3	6	-5		
<i>Ribes triste</i>	swamp red currant	Medium	L3	6	-5		
<i>Alnus incana</i> ssp. <i>rugosa</i>	speckled alder	Medium	L3	6	-5	x	x
<i>Angelica atropurpurea</i>	angelica	Medium	L3	6	-5		
<i>Carex atherodes</i>	awned sedge	Medium	L3	6	-5		
<i>Carex interior</i>	fen star sedge	Medium	L3	6	-5	x	
<i>Eleocharis palustris</i>	Small's spike-rush	Medium	L3	6	-5		
<i>Galium obtusum</i>	obtuse bedstraw	Medium	L3	6	-5		
<i>Viola macloskeyi</i>	northern white violet	Medium	L3	6	-5		
<i>Carex alopecoidea</i>	foxtail wood sedge	Medium	L3	6	-4		
<i>Carex crinita</i>	fringed sedge	Medium	L3	6	-4		
<i>Lobelia siphilitica</i>	great blue lobelia	Medium	L3	6	-4	x	x
<i>Ribes glandulosum</i>	skunk currant	Medium	L3	6	-3		
<i>Doellingeria umbellata</i> var. <i>umbellata</i>	flat-topped aster	Medium	L3	6	-3	x	x
<i>Bidens discoidea</i>	small beggar's-ticks	Medium	L3	6	-3		
<i>Bromus ciliatus</i>	fringed brome grass	Medium	L3	6	-3	x	
<i>Circaea alpina</i>	smaller enchanter's nightshade	Medium	L3	6	-3		
<i>Mitella nuda</i>	naked mitrewort	Medium	L3	6	-3	x	
<i>Ribes hirtellum</i>	smooth gooseberry	Medium	L3	6	-3		
<i>Carex formosa</i>	handsome sedge	Medium	L3	6	-2		
<i>Teucrium canadense</i> ssp. <i>canadense</i>	wood-sage	Medium	L3	6	-2		
<i>Asclepias incarnata</i> ssp. <i>incarnata</i>	swamp milkweed	Medium	L4	6	-5		
<i>Carex pseudocyperus</i>	pseudocyperus sedge	Medium	L4	6	-5		
<i>Mimulus ringens</i>	square-stemmed monkey-flower	Medium	L4	6	-5		
<i>Myosotis laxa</i>	smaller forget-me-not	Medium	L4	6	-5		
<i>Veronica americana</i>	American speedwell	Medium	L4	6	-5		
<i>Cardamine pensylvanica</i>	bitter cress	Medium	L4	6	-4		
<i>Viola sororia</i> var. <i>affinis</i>	Le Conte's violet	Medium	L4	6	-3		
<i>Sparganium americanum</i>	Nuttall's bur-reed	Medium	LU	6	-5		
<i>Scirpus hattorianus</i>	smooth-sheathed black-fruited bulrush	Medium	LU	6	-3		
<i>Alisma gramineum</i>	grass-like water-plantain	Medium	LX	6	-5		
<i>Sagittaria rigida</i>	sessile-fruited arrowhead	Medium	LX	6	-5		
<i>Cyperus diandrus</i>	low umbrella-sedge	Medium	LX	6	-4		
<i>Helianthus giganteus</i>	tall sunflower	Medium	LX	6	-3		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Potamogeton pusillus</i> ssp. <i>pusillus</i>	small pondweed	Medium	L1	5	-5		
<i>Potamogeton epihydrus</i>	ribbon pondweed	Medium	L2	5	-5		
<i>Nymphaea odorata</i> ssp. <i>odorata</i>	fragrant water-lily	Medium	L2	5	-5		
<i>Persicaria sagittata</i>	arrow-leaved tear-thumb	Medium	L2	5	-5		
<i>Ranunculus aquatilis</i> var. <i>diffusus</i>	white water crowfoot	Medium	L2	5	-5		
<i>Hypericum majus</i>	larger Canada St. John's-wort	Medium	L2	5	-3		
<i>Viburnum opulus</i> ssp. <i>trilobum</i>	American highbush cranberry	Medium	L2	5	-3		
<i>Potamogeton amplifolius</i>	large-leaved pondweed	Medium	L3	5	-5		
<i>Carex comosa</i>	bristly sedge	Medium	L3	5	-5		
<i>Iris virginica</i> var. <i>shrevei</i>	southern blue flag	Medium	L3	5	-5		
<i>Nymphaea odorata</i>	fragrant water lily (sensu lato)	Medium	L3	5	-5		
<i>Potamogeton richardsonii</i>	redhead pondweed	Medium	L3	5	-5		
<i>Carex flava</i>	yellow sedge	Medium	L3	5	-5	x	
<i>Eleocharis acicularis</i>	needle spike-rush	Medium	L3	5	-5		
<i>Galium tinctorium</i>	stiff marsh bedstraw	Medium	L3	5	-5		
<i>Iris versicolor</i>	blue flag	Medium	L3	5	-5		
<i>Ludwigia palustris</i>	water purslane	Medium	L3	5	-5		
<i>Najas flexilis</i>	bushy naiad	Medium	L3	5	-5		
<i>Nymphaea odorata</i> ssp. <i>tuberosa</i>	tuberous water-lily	Medium	L3	5	-5		
<i>Potamogeton natans</i>	floating pondweed	Medium	L3	5	-5		
<i>Potamogeton zosteriformis</i>	flat-stemmed pondweed	Medium	L3	5	-5		
<i>Sparganium emersum</i>	green-fruited bur-reed	Medium	L3	5	-5		
<i>Ilex verticillata</i>	winterberry	Medium	L3	5	-4		
<i>Liparis loeselii</i>	Loesel's twayblade	Medium	L3	5	-4	x	
<i>Salix lucida</i>	shining willow	Medium	L3	5	-4	x	x
<i>Cornus amomum</i> ssp. <i>obliqua</i>	silky dogwood	Medium	L3	5	-4		
<i>Galium trifidum</i> ssp. <i>trifidum</i>	small bedstraw	Medium	L3	5	-4		
<i>Carex scoparia</i>	pointed broom sedge	Medium	L3	5	-3		
<i>Physocarpus opulifolius</i>	ninebark	Medium	L3	5	-2		
<i>Caltha palustris</i>	marsh marigold	Medium	L4	5	-5	x	
<i>Carex hystericina</i>	porcupine sedge	Medium	L4	5	-5	x	x
<i>Carex lacustris</i>	lake-bank sedge	Medium	L4	5	-5		
<i>Cicuta bulbifera</i>	bulblet-bearing water-hemlock	Medium	L4	5	-5		
<i>Persicaria amphibia</i>	swamp smartweed (sensu lato)	Medium	L4	5	-5		
<i>Ranunculus hispidus</i> var. <i>caricetorum</i>	swamp buttercup	Medium	L4	5	-5		
<i>Viola cucullata</i>	marsh blue violet	Medium	L4	5	-5		
<i>Carex projecta</i>	necklace sedge	Medium	L4	5	-4		
<i>Carex tribuloides</i>	blunt broom sedge	Medium	L4	5	-4		
<i>Thelypteris palustris</i> var. <i>pubescens</i>	marsh fern	Medium	L4	5	-4		
<i>Abies balsamea</i>	balsam fir	Medium	L4	5	-3	x	x
<i>Bidens vulgata</i>	tall beggar's-ticks	Medium	L4	5	-3		
<i>Equisetum variegatum</i> ssp. <i>variegatum</i>	variegated scouring-rush	Medium	L4	5	-3	x	
<i>Pilea fontana</i>	spring clearweed	Medium	L4	5	-3		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Cystopteris bulbifera</i>	bulblet fern	Medium	L4	5	-2	x	
<i>Galium palustre</i>	marsh bedstraw	Medium	L5	5	-5		
<i>Juncus articulatus</i>	jointed rush	Medium	L5	5	-5		
<i>Platanthera hyperborea</i>	northern green orchis	Medium	LU	5	-4		
<i>Anthoxanthum nitens</i> ssp. <i>nitens</i>	sweet grass	Medium	LX	5	-3		
<i>Zannichellia palustris</i>	horned pondweed	Medium	L1	4	-5		
<i>Persicaria punctata</i>	dotted water-pepper	Medium	L2	4	-5		
<i>Potamogeton pusillus</i> ssp. <i>tenuissimus</i>	least pondweed	Medium	L2	4	-5		
<i>Nuphar variegata</i>	bullhead lily	Medium	L3	4	-5		
<i>Beckmannia syzigachne</i>	slough grass	Medium	L3	4	-5		
<i>Persicaria hydropiperoides</i>	mild water-pepper	Medium	L3	4	-5		
<i>Potamogeton gramineus</i>	grass-like pondweed	Medium	L3	4	-5		
<i>Utricularia vulgaris</i>	common bladderwort	Medium	L3	4	-5		
<i>Carex stricta</i>	tussock sedge	Medium	L4	4	-5	x	x
<i>Elodea canadensis</i>	common water-weed	Medium	L4	4	-5		
<i>Juncus effusus</i>	soft rush	Medium	L4	4	-5		
<i>Penthorum sedoides</i>	ditch stonecrop	Medium	L4	4	-5		
<i>Potamogeton foliosus</i>	leafy pondweed	Medium	L4	4	-5		
<i>Stuckenia pectinata</i>	sago pondweed	Medium	L4	4	-5		
<i>Sagittaria latifolia</i>	common arrowhead	Medium	L4	4	-5		
<i>Sium suave</i>	water-parsnip	Medium	L4	4	-5		
<i>Spirodela polyrhiza</i>	greater duckweed	Medium	L4	4	-5		
<i>Scirpus cyperinus</i>	woolly bulrush	Medium	L4	4	-5		
<i>Rubus pubescens</i>	dwarf raspberry	Medium	L4	4	-4	x	x
<i>Salix bebbiana</i>	Bebb's willow	Medium	L4	4	-4	x	x
<i>Cuscuta gronovii</i>	swamp dodder	Medium	L4	4	-3		
<i>Onoclea sensibilis</i>	sensitive fern	Medium	L5	4	-3	x	x
<i>Viola labradorica</i>	dog violet	Medium	L5	4	-2		
<i>Malaxis monophyllos</i> var. <i>brachypoda</i>	white adder's mouth	Medium	L1	7	-3		
<i>Pyrola asarifolia</i>	pink pyrola	Medium	L2	7	-3		
<i>Aronia melanocarpa</i>	black choke-berry	Medium	L2	7	-3		
<i>Carex cryptolepis</i>	small yellow sedge	Medium	L2	7	-5		
<i>Spartina pectinata</i>	prairie cord grass	Medium	L3	7	-4		
<i>Agalinis tenuifolia</i>	slender gerardia	Medium	L3	7	-3		
<i>Cinna arundinacea</i>	tall wood reed	Medium	L3	7	-3		
<i>Impatiens pallida</i>	yellow touch-me-not	Medium	L4	7	-3		
<i>Salix nigra</i>	black willow	Medium	L3	6	-5		
<i>Carex lacustris</i> x <i>trichocarpa</i>	hybrid Paludosae sedge	Medium	L3	6	-5		
<i>Gentiana andrewsii</i>	bottle gentian	Medium	L3	6	-3		
<i>Vallisneria americana</i>	tape-grass	Medium	L3	6	-5		
<i>Viola blanda</i>	sweet white violet	Medium	L3	6	-2		
<i>Carex intumescens</i>	bladder sedge	Medium	L4	6	-4		
<i>Leersia virginica</i>	white grass	Medium	L4	6	-3		
<i>Salix amygdaloides</i>	peach-leaved willow	Medium	L4	6	-3		
<i>Schoenoplectus pungens</i> var. <i>pungens</i>	three-square	Medium	L4	6	-5		
<i>Symphotrichum puniceum</i> var. <i>puniceum</i>	swamp aster	Medium	L5	6	-5		
<i>Cicuta maculata</i>	spotted water-hemlock	Medium	L5	6	-5		
<i>Scutellaria galericulata</i>	common skullcap	Medium	L5	6	-5		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Carex viridula</i> ssp. <i>viridula</i>	greenish sedge	Medium	L3	5	-5		
<i>Cyperus odoratus</i>	fragrant umbrella-sedge	Medium	L3	5	-3		
<i>Carex sychnocephala</i>	dense long-beaked sedge	Medium	L3	5	-4		
<i>Cyperus strigosus</i>	straw-coloured umbrella-sedge	Medium	L3	5	-3		
<i>Eleocharis obtusa</i>	blunt spike-rush	Medium	L3	5	-5		
<i>Juncus alpinoarticulatus</i>	Richardson's rush	Medium	L3	5	-5		
<i>Juncus arcticus</i> ssp. <i>balticus</i>	Baltic rush	Medium	L4	5	-5		
<i>Acer saccharinum</i>	silver maple	Medium	L4	5	-3		
<i>Acer x freemanii</i>	hybrid swamp maple	Medium	L4	5	-4		
<i>Juncus nodosus</i>	knotted rush	Medium	L4	5	-5		
<i>Schoenoplectus tabernaemontani</i>	soft-stemmed bulrush	Medium	L4	5	-5		
<i>Arisaema triphyllum</i>	Jack-in-the-pulpit	Medium	L5	5	-2	x	x
<i>Dryopteris carthusiana</i>	spinulose wood fern	Medium	L5	5	-2		
<i>Glyceria grandis</i>	tall manna grass	Medium	L5	5	-5		
<i>Lycopus uniflorus</i>	northern water-horehound	Medium	L5	5	-5		
<i>Pilea pumila</i>	dwarf clearweed	Medium	L5	5	-3		
<i>Poa palustris</i>	fowl meadow-grass	Medium	L5	5	-4		
<i>Scutellaria lateriflora</i>	mad-dog skullcap	Medium	L5	5	-5		
<i>Carex debilis</i> var. <i>rudgei</i>	white-edged sedge	Medium	L3	4	-3		
<i>Cyperus bipartitus</i>	two-parted umbrella-sedge	Medium	L3	4	-4		
<i>Boehmeria cylindrica</i>	false nettle	Medium	L4	4	-5		
<i>Carex aurea</i>	golden-fruited sedge	Medium	L4	4	-4		
<i>Carex pellita</i>	woolly sedge	Medium	L4	4	-5		
<i>Ceratophyllum demersum</i>	coontail	Medium	L4	4	-5		
<i>Lycopus americanus</i>	cut-leaved water-horehound	Medium	L4	4	-5		
<i>Thuja occidentalis</i>	white cedar	Medium	L4	4	-3	x	x
<i>Bidens tripartita</i>	three-parted beggar's-ticks	Medium	L5	4	-3		
<i>Eleocharis erythropoda</i>	creeping spike-rush	Medium	L5	4	-5		
<i>Impatiens capensis</i>	orange touch-me-not	Medium	L5	4	-3	x	x
<i>Salix eriocephala</i>	narrow heart-leaved willow	Medium	L5	4	-3		
<i>Scirpus microcarpus</i>	barber-pole bulrush	Medium	L5	4	-5		
<i>Sparganium eurycarpum</i>	great bur-reed	Low	L3	3	-5		
<i>Typha latifolia</i>	broad-leaved cattail	Low	L4	3	-5		
<i>Salix eriocephala</i> x <i>petiolaris</i>	hybrid shrub willow	Low	L4	3	-3		
<i>Salix discolor</i>	pussy willow	Low	L4	3	-3	x	x
<i>Alisma triviale</i>	water-plantain	Low	L5	3	-5		
<i>Carex stipata</i>	awl-fruited sedge	Low	L5	3	-5		
<i>Eutrochium maculatum</i> var. <i>maculatum</i>	spotted Joe-Pye weed	Low	L5	3	-5	x	x
<i>Stellaria longifolia</i>	long-leaved chickweed	Low	L3	2	-4		
<i>Eupatorium perfoliatum</i>	boneset	Low	L4	2	-4	x	x
<i>Bidens cernua</i>	nodding bur-marigold	Low	L5	2	-5		
<i>Scirpus pendulus</i>	drooping bulrush	Low	L3	3	-5		
<i>Salix petiolaris</i>	slender willow	Low	L4	3	-4		
<i>Juncus torreyi</i>	Torrey's rush	Low	L4	3	-3		

Scientific Name	Common Name	Sensitivity	L-Rank	CC	CW	GW Indicator	Facultative
<i>Persicaria pensylvanica</i>	Pennsylvania smartweed	Low	L4	3	-4		
<i>Spiraea alba</i>	wild spiraea	Low	L4	3	-4		
<i>Bidens frondosa</i>	common beggar's-ticks	Low	L5	3	-3		
<i>Epilobium coloratum</i>	purple-leaved willow-herb	Low	L5	3	-5		
<i>Leersia oryzoides</i>	rice cut grass	Low	L5	3	-5		
<i>Scirpus atrovirens</i>	black-fruited bulrush	Low	L5	3	-5		
<i>Equisetum hyemale</i> ssp. <i>affine</i>	scouring-rush	Low	L5	2	-2	x	x
<i>Persicaria lapathifolia</i>	pale smartweed	Low	L5	2	-4		