Miistakis Institute

Aquatic Condition Index Manual for the City of Calgary

A component of the Urban Wetland Conservation project

Dr. Felix Nwaishi, Dr. Jacqueline Dennett, Tracy S. Lee, Abisola Allison, Kaitlynn Bartlett, Holly Kinas, and Danah Duke

Document prepared for The City of Calgary

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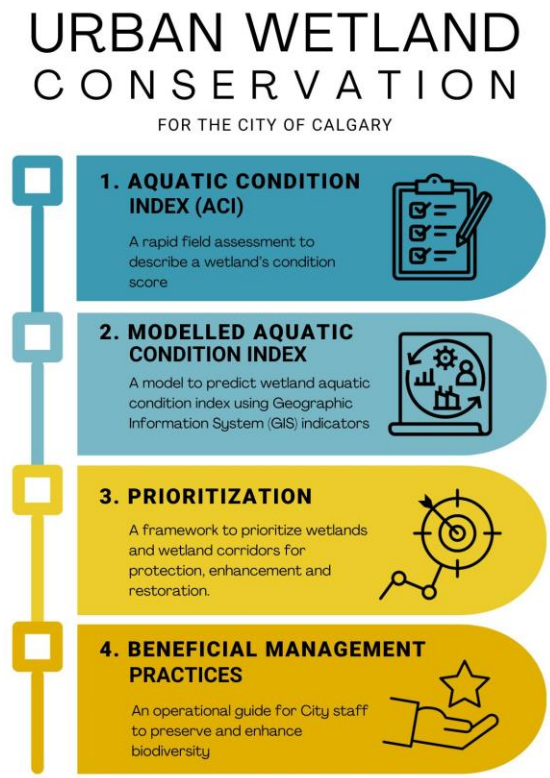

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Introduction

An aquatic habitat assessment provides information to target areas of attention for protection, to prioritize sites for restoration, and to identify beneficial management practices.

The City of Calgary uses a Habitat Condition Rating (HCR) tool to measure the condition of natural areas under its jurisdiction. The HCR tool, which includes a Human Disturbance Index (HDI), provides accurate prediction of human footprint impacts on local, natural environment parks (NEPs). Habitat condition is an indicator of the extent to which a site departs from full ecological integrity and can be measured from a benchmark condition or against an ecological disturbance gradient (Kentula & Paulsen, 2019). The predicted habitat condition from the HDI can be confirmed using a rapid field-based site assessment. The HCR tool is used to prioritize resources for protection and restoration and to track change in park terrestrial condition over time.

City of Calgary modelling has found, however, that the HCR tool cannot adequately predict park condition in NEP where 10% of the park consists of aquatic features. The aquatic and adjacent riparian environments have unique biophysical characteristics not well captured by the existing HCR model.

The purpose of this project was to compliment the HCR tool by developing a field based Aquatic Condition Index (ACI [1]). Given their prevalence within the city, vulnerability, and importance to both ecological and water management goals, the ACI focuses on lentic (still water) aquatic features, meaning wetlands and wet ponds. For the purposes of simplicity in reporting, all lentic features are referred to here as wetlands. We note that within the City the term "wet pond" is used to describe stormwater ponds that were not designed to provide meaningful ecological benefit, and typically contain 0 – < 30% cover of emergent vegetation over the entire waterbody area. Lotic features (flowing creeks, rivers, etc.) were not included in the development of this tool.

The specific objectives were to:

- Develop an ACI for Calgary's NEP wetlands and other aquatic features that can be rapidly assessed in the field, and
- Outline how the ACI aligns with, or integrates into, the existing HCR tool developed for terrestrial systems to rank parks and prioritize sites for restoration.

[1] We refer to field based rapid assessment as Actual-ACI as the condition scores from the field were used to develop a Predicted-ACI which predicts wetland condition for the full inventory.

Numerous published methodologies for aquatic condition assessments were reviewed and used as a foundation for developing the ACI (Wardrop et al., 2007; Kentula & Paulsen, 2019). Specifically, a review of 40 different wetland assessment methodologies revealed a common set of indicators used to assess wetland conditions. Thirty-three indicators were selected that represented primary drivers of wetland condition including hydrology, soil substrate, vegetation and landscape elements (Fennessy, Jacobs, & Kentula, 2007).

Aquatic condition can be considered at three scales that interconnect and inform each other: (1) a landscape assessment that requires a low level of assessment and makes use of digital data, (2) a rapid assessment that requires a field visit to complement the landscape assessment, and (3) an intensive assessment that includes detailed site level evaluations. The level of effort depends on the level of confidence needed in the results and resources available (Wardrop et al., 2007).

While developing an ACI it was important to consider the following issues:

- how the wetland assessment scale was defined,
- how different aquatic features were addressed,
- the type of scoring system used, and
- how results could be verified.

Methodology

To develop the ACI for the City of Calgary, we utilized a four-step process:

1. Established an Advisory Committee

To assist in the development and provide guidance on ACI development, an advisory team was established including:

- Dr. Irena Creed, University of Saskatchewan,
- Dr. Felix Nwaishi, Mount Royal University,
- Lea Randall, Calgary Zoo,
- Chris Manderson, City of Calgary,
- Lynette Hiebert, City of Calgary, and
- Heather Rudd, City of Calgary.

In addition, a wetland vegetation expert, Dr. Steven Tannas was consulted to oversee riparian indicators and plant species lists.

The Advisory Committee was engaged through a series of workshops focused on indicator development.

2. Jurisdictional review of wetland assessments

We reviewed the literature to document design considerations and case studies for context to develop a workshop and provide guidance on indicator development.
The following resources were reviewed:

- Alberta Wetland Rapid Evaluation Tool (Government of Alberta, 2015; Creed, Idred, Serran, & Accatino, 2018)
- Portland Watershed Managment Plan (Portland Bureau of Environmental Services, 2005)
- Oklahoma Rapid Assessment Method (OKRAM) (Gallaway, Davis, Dvorett, & Tramell, 2019)
- Montana Wetland Assessment (Berglund & McEldowney, 2008)
- Minnesota Wetland Assessment (Ehrenfeld, 2000)
- Alberta Cows and Fish Ripairan Assessment for Streams and Rivers (Fitch, Adams, & Hale, 2009)

For more information on each reference see Appendix 1.

3. Advisory Committee Workshops

A series of workshops were organized where discussions with the Advisory Committee provided guidance on the following:

- Aquatic condition index design considerations,
- identification of urban stressors, impacted functions and indicators,
- identification of indicators for functions of hydrology, water quality and ecological condition,
- assignment of subfunctions to indicators,
- indicator scoring review, and
- integration into HCR

4. Development and testing of aquatic condition index field methodology

In the summer of 2022, we field tested the ACI at 74 wetland sites. The field-testing team recommended adjustments to existing indicators, and addition of new indicators during the testing period. These recommendations have been integrated into the manual. The following steps were taken to field test the ACI:

- Randomly selected field survey sites,
- Desktop indicators were calculated prior to field surveys
- Field team visited survey sites and trained on ACI indicators,
- Field team recommended changes to indicators based on initial field assessment,
- Field team surveyed each wetland and documented scores,
- ACI scores, comprising ecological, hydrological and water quality function scores were generated for each survey site,
- Indicators were reviewed for sensitivity for consideration in reducing number of field indictors,
- Results presented in a technical report to City of Calgary.

ACI Design Considerations

Urban Uniqueness

When designing the ACI, it was important to recognize that urban wetlands differ from non-urban wetlands. Therefore, their assessment must take the urban context into account. The indicators used to evaluate wetland's condition need to "reflect both the ecological qualities of the aquatic feature and the realities of the urban context" (Ehrenfeld, 2000). The urban context considers the "aesthetic, emotional, and practical values" provided to urban residents by wetlands (Dwyer et al., 1994 as cited in Ehrenfeld, 2000), which are different from a strictly ecological approach with non-urban wetlands. It is important to note that some types of urban wetlands are designed to prioritize stormwater management values at the expense of ecological values (i.e., wet ponds and some other constructed stormwater features) and thus were not intended to provide ecological benefits. These wetlands will serve low ecological function and may act as ecological traps in some cases. Generalized features that vary between urban and non-urban contexts are outlined by Ehrenfeld (2000) in Table 1.

Table 1
Constraints on the specification of success criteria in natural vs. urban environments

Natural	Urban
Watershed-based approach is ideal	Municipality-based approach is often necessary
Ecological characteristics and functions are readily identified and are primary	Ecological functions may be less important than human values, which may be difficult to specify
Natural disturbance regimes are critical	Natural disturbance regimes may be impossible to restore
Restoration work is implemented by professionals or consultants, possibly supplemented by volunteers	Volunteers are extensively involved
Nutrient limitations are the norm	Nutrients are often present in abundant or over-abundant amounts, and cannot be reduced
Habitat patches can vary greatly in size and connectedness	Habitat patches are often small and isolated; connections are difficult or impossible to re-establish
Climate and microclimate reflect regional geography	Climate and microclimate are significantly altered from the geographically based expectations
Hydrology is a function of regional climate, geology, physiography	Hydrology is usually highly altered, in amounts, sources, and flow rates of water

Wetland Types Included in the Aquatic Condition Index

A typology based on the management regime of wet ponds and wetlands within the city describes five types of aquatic features that were included in the ACI assessment:

- **Utility Wet Pond**: Impoundment areas primarily designed to hold excess stormwater and encourage settling of sediment, limiting the discharge of pollutants downstream. There are minimal naturalization and habitat provisions as these ponds prioritize hydrological functions and have no wetland compensatory value.

- **Naturalized Wet Pond**: Impoundment areas designed to hold excess stormwater, promote settling, and reduce downstream discharge. Vegetation is expected to reduce maintenance of the pond edge and covers < 30% of the emergent zone and may or may not be comprised of native vegetation. These wetlands prioritize hydrological function, and no wetland compensatory value is associated with them.

- **Constructed Stormwater Wetland**: A wetland constructed in a location where there was no wetland or pond previously. These wetlands were designed to mimic at least some aspects of natural wetlands and reflect greater balance in the prioritization of ecological, social, and stormwater management benefits. A medium to full wetland compensatory value is associated with this feature; but note that the extent to which natural wetland properties were mimicked through design varies widely.

- **Existing Modified Wetland**: A wetland in a location where one existed previously, based on historical imagery, but has been modified to a noticeable extent (beyond just a pipe, often including the construction of a forebay or some level of grading). The characteristics of the previous wetland have been at least partly preserved and stormwater functions have been enhanced. The wetland compensatory value ranges from medium to high. The extent to which modifications were able to effectively retain natural wetland characteristics and function varies within this category.

- **Existing Retained Wetland:** Natural wetlands that are in a relatively undisturbed state based on historical imagery but may, or may not, have piped infrastructure. These wetlands are often “fed” by an inlet pipe to ensure their continuity in a fragmented or otherwise disturbed landscape. These aquatic features have a full wetland compensatory value.

Using a typology based on the City’s water management regime permits a focus on wetland function. For example, if a wetland is typed as a retained existing wetland (with a primary purpose of supporting biodiversity) it is managed differently than a utility wet pond with a primary function of stormwater management. Similarly, utility wet ponds are designed, constructed, and managed differently than constructed stormwater wetlands intended to provide ecological benefits, such as habitat for various taxa. Utilizing these categories within the ACI promotes ease of communication, understanding within and across City departments and reflects active management and construction regimes that directly influence wetland outcomes, thus allowing us to interpreted ACI outcomes in the context of the design and management of the wetland.

Wetland Assessment Scale

Typically, wetlands are assessed at three scales: landscape, rapid, and detailed (Fennessy et al., 2007). A detailed site assessment requires a lengthy and rigorous field assessment and was out of scope for the ACI during the development period. The ACI for Calgary considers rapid levels of assessments. The development of an Aquatic Condition Index (ACI) will include landscape assessment.

Site level assessment includes both desktop indicators and field indicators and focused on wetland sites and their associated riparian area. The City of Calgary does not currently have a delineated riparian area associated with aquatic features. We therefore recommended that riparian areas be assessed in the field. We defined riparian area as the interface between the open water zone, where present, and the upland habitat. Put simply, we evaluated the area where the presence of water causes change in soil properties and vegetation communities. The distinction between terrestrial upland and riparian represents the boundary between the terrestrial HCR and ACI. This zone can be distinguished in the field using wetland zones and plant species that indicate wet soils.

The rapid assessment was conducted in the field, measuring various indicators in three categories: water quality, hydrology, and ecological condition. The rapid assessment is intended to take less than half a day to complete (Fennessy et al., 2007).

Determining a Reference Condition

A typical approach for aquatic assessments is to determine a 'reference condition'—a pristine and all-natural example of each aquatic feature type—to compare against other aquatic features as measure of their condition (Ehrenfeld, 2000). In Calgary, few natural wetlands remain within the city limits. Moreover, these few natural wetlands have been indirectly modified by their location, regardless of the presence or absence of infrastructure like pipes. As a result of their small number and range of variation in their level of impact, the City's natural wetlands were not an appropriate reference condition. To account for anthropogenic modifications inherent to the urban environment, Calgary's HCR incorporates an HDI that provides a predicted habitat condition score given a gradient of cumulative human disturbance. "The objective of creating a Human Disturbance Index (HDI) is to quantify anthropogenic disturbance within or adjacent to a site of interest in a way that allows for objective comparisons between sites" (Fiera Biological Consulting, 2015), therefore alleviating the need for a 'reference condition.'

We provide recommendations landscape scale indicators to inform development of a Modelled-Aquatic Condition Index (ACI) for the full wetland inventory. The ACI tool will provide a similar gradient of condition that would serve more as a sliding condition scale rather than a reference condition.

Functions and Subfunctions

We defined the three functions for the city, based on the Environmental Protection Agency (EPA) Watershed Assessments (Portland Bureau of Environmental Services, 2005) and ABWRET (Government of Alberta, 2015): Water Quality, Hydrological Condition and Ecological Condition. These functions were adapted from the Government of Alberta's wetland rapid evaluation tool (ABWRET) procedures for classifying and prioritizing wetlands, acknowledging that different wetlands function differently and that wetland areas are not all of equal value (Government of Alberta, 2015; Creed et al., 2018) (Figure 1).

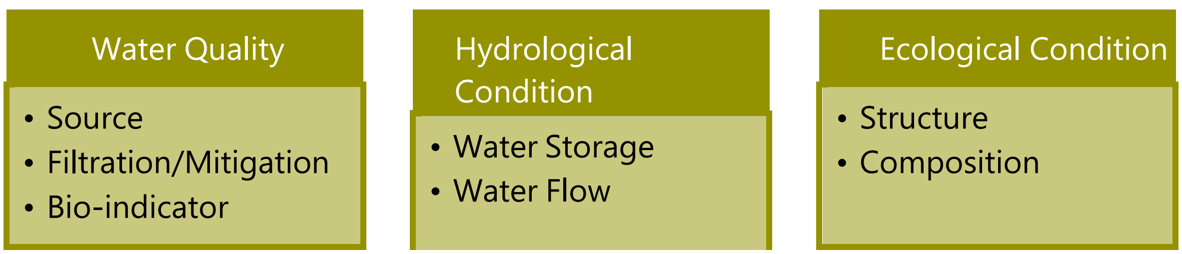

Figure 1: Calgary's Aquatic Condition Index functions (in dark brown boxes) and subfunctions (bulleted in light brown boxes)

Water Quality

Water quality refers to the retention or removal of sediment or nutrients provided by wetlands for purifying receiving waters. This function considers the source of pollutants, the ability of the aquatic feature to mitigate pollutants (by filtering, removing, or replacing pollutants), and biological indicators in the aquatic feature that indicate water quality.

- **Water source:** identifying near-by sources of pollutants that impact surface water quality.
- **Water filtration and mitigation:** the effectiveness of the aquatic feature to filter, remove or reduce the concentration of particulates, including suspended particles, parasites, bacteria, algae, viruses, and fungi, as well as other undesirable chemical and biological contamination.
- **Bio-indicator:** living organisms that can be used to assess environmental condition.

Hydrological Condition

Hydrological condition is defined by the water storage and delay functions provided by wetlands to impede and desynchronize the downslope movement of peak flows. This function includes water storage, water connectivity, and water manipulations to the aquatic feature.

- **Water storage:** the effectiveness of the aquatic feature to store surface water, recharge soils, and the downward movement of surface water.
- **Water flow:** the effectiveness of the aquatic feature to contribute water to downgradient streams during dry period.

Ecological Condition

The habitats provided by aquatic features for enhancing biodiversity. This function includes structure, composition, and the presence of native, non-native, and listed species.

- **Structure:** the structure and arrangement of vegetation.
- **Composition:** the presence or relative proportion of species in vegetation cover categories.

Other Consideration

These indicators are not included in the function scoring but are noted for interest.

- **Floodway and Riparian**: bonus points awarded to the water quality, ecological condition, and hydrology functions if the wetland falls within a floodway zone.
- **Dredging:** bonus points awarded to the hydrology function if the wetland has been dredged.
- **Fountains:** bonus points awarded to water quality if there is one or more fountains within a wetland
- **Rare animal species:** rare species supported during part of their life cycle by an aquatic feature.
- **Influential animal species:** influential species observed within and around the aquatic feature.

Urban stressors

Urban stressors that representing drivers of changing condition in urban areas were identified and evaluated (Table 2).

Table 2: Urban stressors

urban stressor
Impervious surfaces
Land use
Dam impacts (include structures such as dams, swale, berms)
Road networks
Water manipulation (stormwater reuse, draining wetlands)
Channel alterations (armouring, realigning systems, development alters channel, culverts)
Vegetation management
Discharges
Invasive species
Wetland management alterations
Human use impact
Building in flood plain

Indicators of urban stress were separated into the two assessment scales: landscape and site. Landscape scale indicators are revisited in the modelled ACI section to predict condition based on an index. The site level indicators were assigned to the appropriate aquatic feature function and subfunction in the ACI (Table 3). For each indicator, the direction of the relationship was identified as having either a positive or negative impact on condition.

ACI Development

A summary of the indicators for each function and sub-function are shown in Table 3.

Table 3: ACI functions, subfunctions (S), Filtration/ mitigation (FM), Bio-indicator (BI), Structure (STRC), Composition (COMP), Water Storage (WS), Water Flow (WF) and indicators.

Function	Water Quality Condition			Hydrological Condition		Ecological Condition	
Sub-function	S	FM	BI	WS	WF	STRC	COMP
Indicator							
Algae			-				-
Outlet present		+			+	+	
Inlet present					+		
Floodway and riparian (bonus)		*			*	*	
Percent northern aspect		+					
Percent of ponded water versus flowing		+			-		
Percent open ponded water	-			-			
Presence of fountains (bonus)		*					
Water permanence probability	+			+			
Water turbidity			-				
Wetland perimeter to area index		+					
Ground cover native		+			+	+	
Number of zones		+				+	
Riparian buffer width						+	
Riparian indicator species cover							+
Riparian non-native/un-desirable species							-
Surface area for emergent vegetation		+					+
Soil pH						+/-	
Soil texture		+/-		+/-		+/-	
Distance to nearest major road	-					-	
Distance to nearest minor road	-					-	
Distance to nearest pathway	-					-	
Distance to nearest industrial zone	-					-	
Distance to nearest residential zone	-					-	
Precent riparian hard altered		-			-	-	
Precent riparian soft altered		-			-		-
Percent of mowing		-			-		-
Shoreline substrate		-			-	-	
Presence of dredging (bonus)					*	*	
Presence of forebay		+			+		

Degree of slope	-						-
Animals of conservation concern (bonus)							*
Plants of conservation concern (bonus)							*

In table 3, the★ indicates an indicator not included in scoring. A + indicates a positive relationship between the subfunction and increasing classes of categorical indicators or yes in the case of binary responses, and **-** indicates a negative relationship between the subfunction and increasing classes of categorical indicators or yes in the case of binary responses. +/- indicates non-linear relationships between categories and subfunctions.

Approach to scoring

INDICATOR SCORING

A common approach to scoring aquatic condition is to combine values assigned to each aquatic condition indicator (Fennessy et al., 2007). For each indicator, we adopted the scoring system developed for the HCR, where indicators were assigned a class and associated value from 0 to 15, where 15 represents good condition (Table 4). Before applying values, each indicator was assessed for the direction of their relationship to condition (Table 3).

Table 4: Example percent cover classes and relationship to condition

Class	Positive Relationship	Negative Relationship
0	0	15
1–5	4	14
6–25	8	12
26–50	12	8
51–75	14	4
76–100	15	0

SUBFUNCTION AND FUNCTION SCORING

Many of the indicators appear in multiple functions and subfunctions. As well, scores assigned by class may differ among functions and subfunctions. The ACI framework allows users to score condition by subfunction and function as well as derive an overall aquatic condition score for a natural area. A function (F) is scored using the following equation:

F = (SF1(sum (indicator scores)/ sum (indicator maximum score))) + (SF2(sum(indicator field scores)/ sum (indicator maximum score)))+((SF3……)/ number of subfunctions)

Water Quality

The water quality function and subfunctions are derived using the following equations:

Source subfunction = (distance to major road score + distance to minor road score + distance to nearest pathway score + distance to nearest industrial zone score + distance to nearest residential zone score + water permanence probability score + degree of slope score + percent ponded open water score)/ maximum possible subfunction score (non- applicable removed)

Filtration/Mitigation subfunction = (percent northern aspect score + outlet present score + ground cover score + number of zones score + soil texture score + surface area for emergent vegetation score + percent riparian hard altered score + percent riparian soft altered score + percent of mowing score + shoreline substrate score + presence of forebay score + wetland area to perimeter ratio score + percent of water ponded vs flowing score)/ maximum possible subfunction score (non-applicable removed)

Bio-indicator subfunction = (algae score + water turbidity score)/ maximum possible subfunction score (non-applicable removed)

Water Quality function = (Source subfunction + Filtration/Mitigation subfunction + Bio-indicator subfunction)/ 3

Hydrology

The hydrological condition function and subfunctions are derived using the following equations:

Water storage subfunction = (percent ponded open water score + soil texture score + water permanence probability score)/ maximum possible subfunction score (non-applicable removed)

Water flow subfunction = (outlet present score + inlet present score + ground cover score + percent water ponded versus flowing score + percent riparian hard altered score + percent riparian soft altered score + percent of mowing score + shoreline substrate score + presence of forebay score) / maximum possible subfunction score (non-applicable removed)

Hydrological Condition function = (water storage subfunction + water flow subfunction)/ 2

Ecology

The ecological condition function and subfunctions will be derived using the following equations:

Structure subfunction = (outlet present score + distance to major road score + distance to minor road score +distance to pathway score + distance to nearest residential zone + ground cover score + percent riparian hard altered score + shoreline substrate score + soil texture score + soil pH score + water permanence probability score + number of wetland zones score + riparian buffer width score + presence of dredging score + shoreline substrate score + percent of water ponded vs flowing score)/ maximum possible subfunction score (remove non-appliable indicators)

Composition subfunction= (algae score + riparian indicator species score + riparian non- native score + surface area for emergent vegetation score + percent riparian soft altered score + percent mowing score + degree of slope score + rare plant score)/maximum possible subfunction score (removed non-appliable indicators)

Ecological Condition function = (Structure function + Composition function)/ 2

Aquatic Condition Index

To generate an overall ACI score, the three function scores are averaged:

ACI = (water quality score + hydrological condition score + ecological condition score)/ 3

We recommend the City experiment and consider two scoring alternatives in consideration of ACI (Accatino, Creed, & Weber, 2018):

- Use the maximum score for each subfunction and then average the subfunctions to derive a function score, or
- Calculate the average score for each subfunction and then average the subfunction values to derive a function score.

Integration into Terrestrial HCR

We assessed the HCR and identified key challenges to integrating the ACI into the HCR.

The first feature to assess was the dependence of the HCR tool on proportions of land cover types within an NEP. In the HCR tool, proportions are used to determine:

- field assessment survey routes using a combination of number of random navigation points and timed walk; and
- weightings for each land cover score to generate the overall HCR for a park.

The HCR tool relies on spatially depicted land cover categories that include grassland, shrubland, forest and aquatic features. Upland terrestrial (includes tall riparian shrubs) condition is considered in the existing HCR, but the riparian area (defined as the wet soil zone) is not. Our site assessment for aquatic features considers the riparian area, but there is no information in the landcover layer to calculate its proportion for determining survey routes. A riparian area may vary considerably in width, and therefore, the riparian areas for each aquatic feature will need to be assessed in the field.

The second feature to assess was our concern that using weighted scores based on proportions for integrating the ACI into the HCR will undervalue aquatic features.

Finally, our third HCR feature to assess was the Human Disturbance Index (HDI) used to predict terrestrial park conditions. The HDI included nine indicators either measured within the park boundary or within 300 meters outside the park boundary. However, aquatic condition is influenced by activities occurring within the water catchment of the aquatic feature, which may or may not align with park boundaries.

Integration Recommendations

We propose the following approaches to integrate ACI into the HCR:

- The ACI score should stand on its own. Although it may be easier to communicate an integrated ACI and HCR to the public (e.g., equally weight ACI and terrestrial HCR to obtain a single NEP score), we do not advise this step from a management perspective.
- If (as expected) the Human Disturbance Index does not accurately predict aquatic condition, a new tool should be developed that is sensitive to changes in aquatic condition should be developed. This recommendation is further explored in modelled-ACI recommendations (below).

Modelled-Aquatic Condition Index

A landscape scale assessment predicts current condition against a reference set of conditions or along a human disturbance gradient. We recommend development of a ACI based on an agreed upon buffer around each wetland (not a park scale) that enables the City to predict aquatic condition for three functions: water quality, hydrological condition, and ecological condition. Measuring at this scale will enable the City to compare the ACI scores among parks which, in the urban context, provides a reasonable comparison. The natural range of variation (or NRV) is commonly used in less impacted settings but presents greater challenges where development is more intense, as in cities.

For aquatic features in Calgary, we propose that landscape functions be assessed at a water catchment scale. Water catchments represent areas within the where water is collected by the topography and water flows naturally or via, infrastructure into an aquatic feature. Water catchment have been delineated by water management and areas range greatly in size (from 20 km^2 to 10,000 km^2) and will require further refinement prior to assessment. If water catchments are not refined for use w recommend a buffer approach be take around wetlands.

Table 5 lists candidate indicators and their associated functions for consideration in the ACI to predict wetland condition across Calgary's full wetland inventory.

Table 5: landscape scale metrics to consider.

Water Catchment Indicator	**Function**
Impervious area	Hydrological condition
Ground cover	Water quality
Non- native cover (manicured, golf course, bare ground)	Water quality
Residential	Hydrological condition, water quality
Industrial	Water quality
Bank hardening/armouring	Hydrological condition
Stream crossings/culverts	Hydrological condition
Roads	Hydrological condition
Represents amphibian core wetland or corridor	Ecological condition
Dams	Hydrological condition
Aquifer Vulnerability Index	Water quality
Springs or other groundwater discharge area	Hydrological condition, water quality, ecological condition
Wetland Density (open water only) within 1 km	Hydrological condition, water quality, ecological condition

Field Protocols – Site-Level Indicators

The ACI Field Assessment Form is attached in Appendix B.

Survey Methods

Sample site selection

Sample sites were selected to span the full range of wetland types within the City of Calgary. This was an intentional decision to move beyond wetlands found only within NEPs in order to capture a full gradient against which to assess the utility and sensitivity of the ACI. Sample locations included wetlands found within the transportation utility corridor, Parks-owned land including both natural and manicured spaces, City dumps, and relatively intact newly formed conservation areas.

Survey timing

We recommend the main field season include the growing season (mid-May to August), with consideration of some indicators that would benefit from surveys later in the year (e.g., peak algal biomass).

Field sampling

When determining the extent of the wetland area surveyed for each ACI assessment, we recommend the following be considered:

- For isolated aquatic features (i.e., single stormwater pond or wetland), walk around the entire feature.
- For natural areas with multiple aquatic features:
    - select a minimum of eight sampling points (compass rose distribution (N, NE, E, SE, S, SW, W, NW or evenly distributed around the wetland) on all sides of the wetland complex)

ACI Field Protocol

When completing an ACI survey, ensure to carry and refer to the City Aquatic Condition Index Field Protocol, animals of conservation concern list, and plants of conservation concern list.

The ecologist will need the following equipment to the field:

- Trowel
- pH paper
- 3 vials with distilled water
- Printed ACI Field Assessment Form

The following indicators require desktop analysis prior to the field visit:

- **Percent northern aspect:** use spatial data to determine the percent cover of north facing slopes surrounding the wetland.
- **Outlet present:** review stormwater infrastructure information from the City's Water Resources department to determine the presence or absence of an outlet pipe. The presence of outlet pipes can be difficult to determine or confirm in the field as they are often underwater.
- **Inlet present:** review stormwater infrastructure information from the City's Water Resources department to determine the presence or absence of an inlet pipe. The presence of inlet pipes can be difficult to determine or confirm in the field as they are often underwater.
- **Presence of a forebay:** review design plans from the City's Water Resources department to identify if there is a forebay associated with the aquatic feature.
- **Floodway:** review spatial datasets to determine if aquatic features are within a floodway or are isolated.
- **Wetland perimeter ratio:** use spatial datasets to calculate a ratio of area to perimeter index for lentic aquatic systems.
- **Presence of dredging:** identify if wetlands have been dredged using dreading records from the City's Water Resources department.
- **Distance to nearest road and pathway:** use spatial data to determine if there are roads or pathways close to the aquatic feature. This distance can be verified in the field.
- **Distance to nearest industrial and residential areas:** use spatial data to determine if there are industrial zones or residential housing close to the aquatic features. This distance can be verified in the field.

The following indicators require desktop analyses following field collection:

- **Riparian Indicator Species:** In the field, the ecologist lists the top four native species present in the riparian area and estimates their percent cover. From the desktop, the ecologist enters the results into the "2020_City of Calgary Wetland Indicators Cover Spreadsheet Final" to determine the native species scoring. The spreadsheet has been designed for the City and selects species that represent good condition from a list of 577 associated with aquatic features in Calgary.

- **Riparian noxious and prohibited noxious weed species:** In the field the ecologist lists the top four noxious and prohibited noxious weed species present in the riparian area and estimates their percent cover. From the desktop, the ecologist enters the results into the "2020_City of Calgary Wetland Indicators Cover Spreadsheet Final" to determine non-native species scoring. The spreadsheet has been designed for the City and selects species that represent good condition from a list of 577 associated with aquatic features in Calgary.

Site Details

Date (dd/mm/yyyy):
Completed by: (write all involved in the survey)
Asset ID (Park Code and/or Stormpond Number):
Aquatic Feature Type:

WATER

ALGAE [WQ, EC]

(Field)

DESCRIPTION

An assessment of water quality based on visual evidence of algal growth.

RELATIONSHIP TO CONDITION

Negative relationship with water quality (as algae growth increases, condition decreases).

METHOD

In the field the ecologist selects the statement that best describes condition of aquatic features through an algal assessment (i.e., presence of algae) and other water quality characteristics (colour and sheen). This indicator is not included in scoring for wetlands without water at the time of the survey. If you are unable to determine if the aquatic feature has been lined, assume it is not and proceed.

In the ACI Field Assessment Form, select the statement that best describes the feature condition:

- Water is clear with minimal to no algae.
- Algae growth is limited to small, localized areas.
- Algae found in large patches.
- Algae growing in large, continuous mats preventing light from reaching the bottom.
- Not applicable (lotic aquatic feature, presence of a fountain or no open water)

WATER TURBIDITY [WQ]

(Field)
DESCRIPTION

An assessment of water quality based on visual evidence of water clarity.

RELATIONSHIP TO CONDITION

Negative relationship with water quality (greater turbidity is associated with lower water quality condition)

METHOD

Using the ACI Field Assessment Form the ecologist selects the appropriate class:

- no turbidity
- slight turbidity (water slightly milky)
- high turbidity (bottom no longer visible, water is milky or muddy)

OUTLET PRESENT [H, WQ, EC]

(Desktop and Field)

DESCRIPTION

Some aquatic features have no water outlet. Water leaves either by seeping into the ground (a form of groundwater discharge that may, or may not, be easily identified) or through evapotranspiration. Whether or not water can leave the aquatic feature and where it goes can also influence the structure and composition of wetland plant and animal communities.

RELATIONSHIP TO CONDITION

Positive relationship with hydrology, water quality and ecological condition (presence of an outlet improves condition).

METHOD

On the desktop, identify whether the aquatic feature has an outlet present. If any constructed or natural outlets are identified, select yes (outlet present), no (outlet not present) or not applicable on the ACI Field Assessment Form. Outlet presence can at times be verified in the field, but in some cases, outlets are submerged. Non-applicable applies to natural wetlands that have not been modified.

INLET PRESENT $^{H, WQ, EC}$

(Desktop and Field)

DESCRIPTION

Some aquatic features have water inlets. Water enters the aquatic feature through these inlets for consistent flow and recharge, which is important for the water storage function of wetlands.

RELATIONSHIP TO CONDITION

Positive relationship with hydrology (presence of an inlet improves condition).

METHOD

On the desktop, identify whether the aquatic feature has an inlet present. If any constructed or natural inlets are identified, select yes (inlet present), no (inlet not present) or not applicable on the ACI Field Assessment Form. At times the presence of an inlet can be verified in the field, but in some cases, they are submerged. Non-applicable applies to natural wetlands that have not been modified.

FLOODWAY AND RIPARIAN $^{H, WQ, EC}$

(Desktop and Field - Bonus)

DESCRIPTION

An assessment of whether the aquatic feature is connected to a river floodplain or riparian system that has hydrological, chemical and biological impacts on the landscape. Connected aquatic features can influence downstream aquatic systems through movement of water, heat energy, sediment, wood, organic matter, nutrients, chemical contaminants, and organisms. Streams support rivers by promoting invertebrate populations, enabling fish migration, providing cold-water refugia, storing water thereby delaying peak flow, and converting coarse material to fine material. Wetlands support rivers through promoting invertebrate populations, denitrification, flood attenuation and providing aquatic refugia during dry periods (Leibowitz et al., 2019).

RELATIONSHIP TO CONDITION

Positive relationship in a river or riparian area for hydrology, water quality and ecological condition (presence of a floodway improves condition).

METHOD

Using desktop methods, the ecologist assesses if the aquatic feature is within a river floodway area. Using the ACI Field Assessment Form, enter yes (the aquatic feature is in floodway) or no (aquatic feature not in floodway).

PERCENT OF WATER PONDED VERSUS FLOWING [H, WQ]

(Field)

DESCRIPTION

Ponding represents water in storage rather than moving downslope. For water quality, ponding allows more time for suspended solids to settle and supports a microclimate favourable to denitrification. For hydrology, greater volumes of ponded water represent less water flow, which can influence the amount of oxygen in the system. Increasing sedimentation in ponded water can also negatively affect water flow.

RELATIONSHIP TO CONDITION

Positive relationship with water quality, negative relationship with hydrology

METHOD

In the field, the ecologist assesses the percentage of the surface water that is ponded (stagnant or flows so slowly that fine sediment is not held in suspension) most of the time. This indicator is not included in scoring for wetlands without water at the time of survey. Using the ACI Field Assessment Form, select the percentage of the surface water that is ponded:

- <1% or no ponded water. Nearly all water is flowing or occupies <0.01 hectares in total.
- 1–5% of the water is ponded.
- 5–30% of the water is ponded.
- 31–70% of the water is ponded.
- 71–95% of the water is ponded.
- >95% of the water is ponded. Little or no visibly flowing water within the aquatic feature.

PERCENT OF OPEN PONDED WATER WITHOUT EMERGENT VEGETATION [H, WQ]

(Field)

DESCRIPTION

For hydrology, open ponded water is more likely to lead to evapotranspiration.
With respect to water quality, open ponded water is more likely to be heated by the sun, and is less likely to intercept or filter sediments, phosphorus, nitrates, and organic matter.

RELATIONSHIP TO CONDITION

Positive relationship with hydrology (as open water increases, condition improves). Negative relationship to water quality (as open water increases, condition declines).

METHOD

In the field the ecologist assesses the duck's-eye aerial view and determines the percentage of the ponded water that is open (lacking emergent vegetation during most of the growing season and not covered by a forest or shrub canopy). This indicator is not included in scoring for wetlands without water at the time of survey. Using the ACI Field Assessment Form select the percentage of the ponded water (ducks-eye aerial view) that is open most of the time:

- <1% or no open ponded water, or largest open pool occupies <0.01 hectares.
- 1–5% of the ponded water is open.
- 5–30% of the ponded water is open
- 31–70% of the ponded water is open
- 71–95% of the ponded water is open
- >95% of the ponded water is open.
- Not applicable

WATER PERMANENCE PROBABILITY $^{H, WQ}$

(Field)

DESCRIPTION

Water permanence probability is influenced by seasonal variation in rainfall, snow accumulation and melt, evapotranspiration, water table and the geomorphology of each basin. The duration of inundation plays a major role in the character of many wetland functions, including the diversity, structure and distribution of vegetation. Change in the duration of flooding within the wetland can be expressed as the number of weeks in a year that ponded water is present (Alberta Environment and Sustainable Resource Development (ESRD), 2014).

RELATIONSHIP TO CONDITION

Positive relationship with hydrology and water quality (longer water permanence improves condition).

METHOD

The field ecologist estimates the approximate duration of flooding in a typical year (Table 6). The duration of flooding also informs the class of the wetland. In addition, plant species presence and wetland zones can help determine permanence (refer to appendix C). For a full methodology, description refer to Guide for Assessing Permanence of Water Basins (Alberta Environment and Sustainable Resource Development (ESRD), 2014).

Table 6: Water permanence categories, where weeks denotes the number of weeks in a year the wetland would be expected to have surface water present.

Permanence	Wetland Class	Weeks
Temporary	Class 1	1–4
seasonally flooded	Class 2	5–17
semi-permanently flooded	Class 3	18–40
Intermittently exposed	Class 4	41–51
permanently flooded	Class 5	52

PRESENCE OF FOUNTAINS WQ

(Field-Bonus)

DESCRIPTION

Fountains are installed to help mix water to improve condition.

RELATIONSHIP TO CONDITION

Positive relationship with water quality (fountains installed as mitigation where water quality is poor and will help improve condition).

METHOD

In the field the ecologist notes if there is a fountain or not. Using the ACI Field Assessment Form, the ecologist identifies if the lentic aquatic feature has a fountain (yes), does not have a foundation (no), or not applicable.

PRESENCE OF FOREBAY WQ, H

(Desktop and Field)

DESCRIPTION

Forebays are basins or reservoirs designed to encourage the settling of sediments at the inlet of waterbodies, reducing the transfer of pollutants.

RELATIONSHIP TO CONDITION

Positive relationship with water quality and hydrology (forebays encourage sedimentation within controlled areas and thus improves the condition of the nearby waterbody).

METHOD

Using information from the City of Calgary's Water Resources department, the presence of a forebay can be identified in their design plans. If the water feature is not included in the storm pond inventory, use aerial imagery to determine if a forebay is present. Using the ACI Field Assessment Form, the ecologist identifies if the feature h as forebay (yes), does not have a forebay (no), is or is not applicable (natural unmodified wetland).

DEGREE OF SLOPE WQ, EC

(Field)

DESCRIPTION

Determine the average angle of the slope surrounding the aquatic feature. Steep slopes prevent vegetation growth and establishment and increase material flow into wetlands.

RELATIONSHIP TO CONDITION

Negative relationship with ecological condition and water quality (as the degree of slope increases, vegetation growth is limited, and soil is at risk of erosion).

METHOD

Use a compass to determine the angle of the slope that is representative of the entire area surrounding the aquatic feature. On the ACI Field Assessment Form the select the appropriate class:

- Low (0-15^{o})
- Low-Medium (16-45^{o})
- Medium-High (46-75^{o})
- High (76-90^{o})

PERCENT NORTHERN ASPECT WQ

(Desktop)

DESCRIPTION

Aspect refers to the orientation of, or the facing direction of, a landform. Northern aspects tend to support greater soil volumes, are wetter, and are more productive. An assessment of water quality considers that north-facing slopes are wetter, longer and have slower water filtration.

RELATIONSHIP TO CONDITION

Positive relationship with water quality (more north-facing slopes means improved condition).

METHOD

Using desktop methods, calculate the percent cover of north-facing slopes within 100m of the aquatic feature. In the field, the ecologist ground-truth the desktop estimates.

Select the percent cover of north aspect facing slopes within 100 m:
- 0–15
- 16–50
- 51–100

PRESENCE OF DREDGING [EC, H]

(Desktop - Bonus)

DESCRIPTION

The removal of material from a wetland.

RELATIONSHIP TO CONDITION

Negative relationship with ecological condition (dredging decreases natural habitat). Positive relationship with hydrology (dredging improves water storage).

METHOD

Using the ACI Field Assessment Form, the ecologist uses information provided by water management to determine if the aquatic feature has been dredged (yes) or not dredged (no). Aquatic features that are dredged will be allocated bonus points for hydrology but will lose points for ecological conditions.

WATER PERIMETER TO AREA RATIO [WQ]

(Desktop)

DESCRIPTION

Assessment of area available to support water filtration.

RELATIONSHIP TO CONDITION

Positive relationship with water quality (as perimeter to area ratio approaches 1 water quality improves)

METHOD

Indicator is only applied to lentic aquatic features. From a desktop, generate perimeter to-area ratio (0 to 1) and assign the appropriate score on the ACI Field Assessment Form:
- <0.1
- 0.1–0.24
- 0.25–0.49
- 0.50–1
- Not applicable (lotic aquatic feature)

VEGETATION

NUMBER OF ZONES EC, WQ

(Field)

DESCRIPTION

Wetlands can be broken down in zones depending on vegetation shifts. These zones can help assess a wetland's condition. This indicator is not applicable to other types of aquatic features.

RELATIONSHIP TO CONDITION

Positive relationship with water quality and ecological condition (wetland with more expected zones will have higher condition).

METHOD

In the field, the ecologist determines the number of wetland zones present. Indicator species presence and abundance help determine if the zones are present (Table 7, Figure 3 and appendix C). Appendix C provides photos and additional indicator species representative of each wetland zone. Please refer to species lists in Stewart and Kantrud (1971).

Table 7: Wetland zones associated with different wetland types

Wetland type	**Indicator characteristics**	**# of Zones**
permanent wetland (open water) — five zones	open water	5
semi-permanent wetland (bull rushes/cattail) — four zones	bull rushes/cattails	4
seasonal wetlands (tall sedges) — three zones	tall sedges	3
temporary wetland (Baltic rush) — two zones	Baltic rush	2
ephemeral (Carex pellita/woody species) — one zone	*Carex pellita*/woody species	1

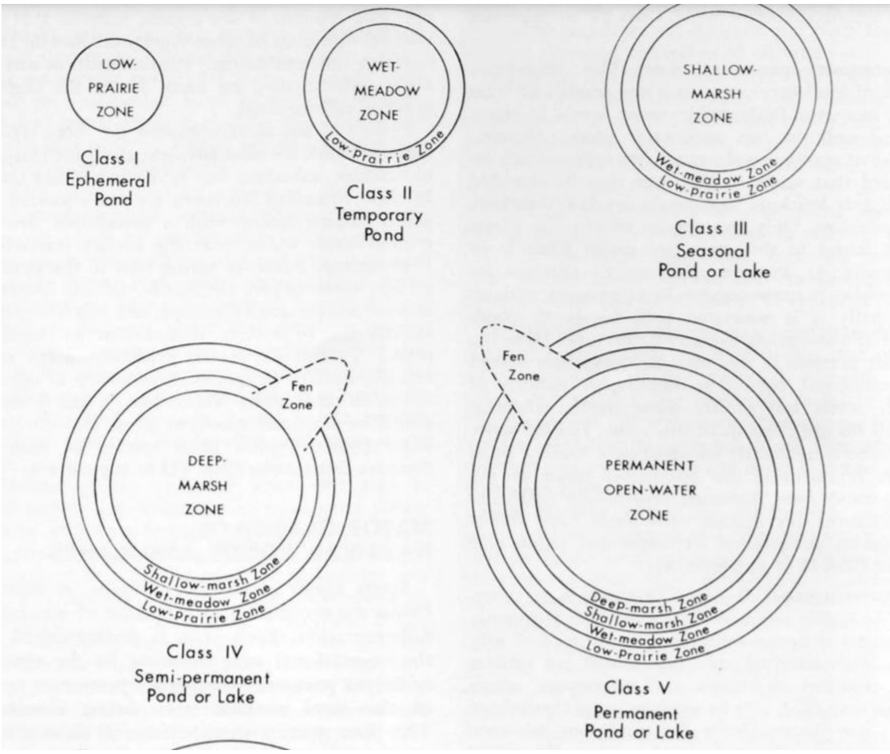

Figure 3: Wetland zones (Stewart & Kantrud, 1971).

Using the ACI Field Assessment Form select the category that most reflects the condition observed in the field:

- 1 zone
- 2 zones
- 3 zones
- 4 zones
- 5 zones
- Not applicable (lotic aquatic feature).

SURFACE AREA FOR EMERGENT VEGETATION WQ, EC

(Field)
DESCRIPTION

An assessment of emergent vegetation along the aquatic feature perimeter that can improve filtration and water quality.

RELATIONSHIP TO CONDITION

Positive relationship to water quality (as percent of emergent vegetation increases condition improves).

METHOD

In the field, the ecologist estimates the percent of wetland edge that supports emergent cattails, bulrushes, reeds, and sedges. Emergent vegetation is vegetation that is “emerging” from inundated soils, i.e., vegetation growing within surface water for at least some period of the year. Select the appropriate cover class on the ACI Field Assessment Form:

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

GROUND COVER [H, WQ, EC]

(Field)

DESCRIPTION

Percent of vegetated ground in the riparian area provides important habitat structure for amphibians, birds and plants.

RELATIONSHIP TO CONDITION

Positive relationship with hydrology and ecological condition (as natural cover increases conditions improve).

METHOD

In the field, the ecologist estimates the percent cover occurring within wet soil zone into upland habitat. Species do not need to be native. Using the ACI Field Assessment Form select the appropriate percent cover class:

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

RIPARIAN BUFFER WIDTH [EC]

(Field)

DESCRIPTION

A measure of the size (in meters) of the vegetated area associated with the wetland.

RELATIONSHIP TO CONDITION

Positive relationship with ecological condition (a wider vegetated zone leads to improved condition).

METHOD

In the field, the ecologist assesses the average width of vegetated area that separates adjoining uplands from open water within the aquatic feature.
Using the ACI Field Assessment Form select the distance (m) class:

- 0
- 1-5
- 6-10
- 11-15
- 16-20
- >20m

RIPARIAN FUNCTIONAL GROUP TYPES EC – INDICATOR IN DEVELOPMENT

(Field)

DESCRIPTION

Identify the appropriate percent cover class for each plant functional group type within aquatic features. This indicator is still in development.

RELATIONSHIP TO CONDITION

The cover of various functional group types is related to wetland condition. For example, greater sedge, cattail, and rush abundance is typically associated with a healthy riparian condition, and grass and forb cover tends to be higher in wetlands with thin riparian margins.

METHOD

In the field, the ecologist assesses the cover class of six functional groups; sedges, rushes, cattails, grasses, forbs, and shrubs. Using the ACI Field Assessment Form select the appropriate percent cover class of each functional group:

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

RIPARIAN INDICATOR SPECIES [EC]

(Field and Desktop)

DESCRIPTION

Evaluation of percent cover of top four native riparian species that represent good condition for a variety of aquatic feature types. This indicator is still in development.

RELATIONSHIP TO CONDITION

Positive relationship with ecological condition (as percent native species cover increases condition improves).

METHOD

In the field, the ecologist lists the top four native species present (include more species if difficult to determine top four) in the wet soil zone and estimates their percent cover. From the desktop, the ecologist enters the results into the “2020_City of Calgary Wetland Indicators Cover Spreadsheet Final” to determine percent cover of native species used to determine percent cover scoring of native species. The spreadsheet has been designed for the City and selects species that represent good condition from a list of 577 species associated with aquatic features in Calgary.

Using the ACI Field Assessment Form, list the four most common riparian species and identify the appropriate percent cover class for each of these species.

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

RIPARIAN NOXIOUS AND PROHIBITED NOXIOUS WEED SPECIES [EC]

(Field and Desktop)

DESCRIPTION

Evaluation of percent cover of the top four non-native wetland indicator species that represent poor condition for a variety of aquatic feature types. This indicator is still in development.

RELATIONSHIP TO CONDITION

Negative relationship with ecological condition (as percent cover of non-native species increases condition declines).

METHOD

In the field, the ecologist lists the top four non-native species observed in the wet soil zone and estimates their percent cover. From the desktop, the ecologist enters the results into the "2020_City of Calgary Wetland Indicators Cover Spreadsheet Final" to determine the percent cover of non-native species used to determine the percent cover score for non-native species. The spreadsheet has been designed for the City and selects species that represent poor condition form a list of 577 plants associated with aquatic features in Calgary.

Using the ACI Field Assessment Form list the four most common non-native or undesirable species and identify the appropriate percent cover class for each of these species.

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

SOIL

SOIL TEXTURE H, WQ, EC

(Field)

DESCRIPTION

Soil texture is important in aquatic features that determines water storage capability, water quality (through filtration) and plant productivity.

RELATIONSHIP TO CONDITION

Relationships vary among functions.

For hydrology, the soil texture impacts water storage capabilities, with organic soils and to a lesser extent, sandy soils leading to water storage with clay soils causing high run- off.

For water quality, the soil texture impacts the filtration rate, with organic soils and clay soils filtering more slowly than sandy soils.

For ecological conditions plant productivity is highest with organic soils, followed by clay and then sandy soils.

METHOD

In the wet soil zone without persistent water, the ecologist uses a trowel to dig into the uppermost layer and determines if texture (use hand test) is sticky, gritty or in- between. We recommend taking three samples in each NEP as far away from each other as possible and report on the most common class.

Using the ACI Field Assessment Form select the appropriate category:

- sandy (gritty)
- in-between sandy and clay (organic)
- clay (sticky)

SOIL PH [EC]

(Field)

DESCRIPTION

The relative Acidity or alkalinity of soil is indicated by its pH. A pH within range of 5–7 indicates a neutral soil. The pH is important because it influences the availability of essential nutrients affecting plant and animal productivity.

RELATIONSHIP TO CONDITION

A neutral pH improves condition for plants and animals.

METHOD

In the field, the ecologist takes a small sample of soil, places in distilled water, touches the test strip (pH litmus paper) to the water and waits for the colour to change. The test strip is compared to the test trip colour ramp and the pH is recorded. Sample location can be determined in a pre-field assessment. Suggestion to test three samples (as far from each other as possible) in each NEP to record the average on the ACI Field Assessment Form:

- <5
- 5–8 optimum
- >8

URBAN STRESSORS

DISTANCE TO NEAREST MAJOR ROAD (SKELETAL, ARTERIAL, COLLECTOR AND INDUSTRIAL) [WQ, EC]

(Desktop and Field)

DESCRIPTION

Major roads see the highest traffic volumes and are typically associated with wider ditch/verge habitat, i.e., have the largest development footprint among road types. Higher traffic volumes relate to being a greater source of vehicle-related contaminants and a greater area of impervious surface to promote runoff. Ecologically, roads act as sources and corridors for the introduction and dispersal of seeds, alter hydrological regimes, fragment habitat, are a cause of wildlife mortality, and limit wildlife movement.

RELATIONSHIP TO CONDITION

Positive relationship to ecological condition and water quality (as distance to road increases condition improves).

METHOD

On a desktop, identify if there are skeletal or arterial roads near aquatic features in the NEP. In the field the ecologist measures the distance in metres to the closest skeletal or arterial road and selects the appropriate category in the ACI Field Assessment Form:

- >100m
- 51–100m
- 11–50m
- ≤10m

DISTANCE TO NEAREST RESIDENTIAL ROAD [WQ, EC]

(Desktop and Field)

DESCRIPTION

Minor roads carry the same implications as major roads (described above), to a lesser extent. Minor roads tend to have lower vehicle traffic, smaller verge areas, and although still disruptive, may not alter hydrology or wildlife movement to the same degree as major roads. For these reasons, the two road types were considered separately.

RELATIONSHIP TO CONDITION

Positive relationship to ecological condition and water quality (as distance to paths increases, condition improves).

METHOD

On a desktop, identify if there are minor roads near aquatic features in the NEP. In the field, the ecologist measures the distance in metres to the closest minor road and selects the appropriate category in the ACI Field Assessment Form:

- >100m
- 51–100m
- 11–50m
- ≤10m

DISTANCE TO NEAREST PATHWAY [WQ, EC]

(Desktop and Field)

DESCRIPTION

Pathways can be related to issues such as hydrological alteration and increased sedimentation, depending on how they were constructed. More critically, pathways increase access to wetlands by people, pets, and wildlife. Greater human access typically results in greater damage to ecological condition, through trampling, feces, encampments, plant collection, and the accidental or intentional dispersal of invasive species. These issues also affect water quality, as does increased sedimentation resulting from runoff from pathway surfaces.

RELATIONSHIP TO CONDITION

Positive relationship to ecological condition and water quality (as distance to paths increases, condition improves).

METHOD

On a desktop, identify if there are pathways near aquatic features in the NEP. In the field the ecologist measures the distance in metres to the closest pathway and selects the appropriate category in the ACI Field Assessment Form:

- >100m
- 51–100m
- 11–50m
- ≤10m

DISTANCE TO NEAREST INDUSTRIAL ZONE WQ, EC

(Desktop and Field)

DESCRIPTION

Industrial areas may produce runoff high in pollutants, increasing the risk of water contamination.

RELATIONSHIP TO CONDITION

A positive relationship to water quality (as distance to industrial area increases, the condition improves).

METHOD

On a desktop, identify if there is an industrial area near aquatic features in the NEP. In the field the ecologist measures the distance in metres to closest industrial zone and selects the appropriate category in the ACI Field Assessment Form:

- >100m
- 51–100m
- 11–50m
- ≤10m

DISTANCE TO NEAREST RESIDENTIAL ZONE WQ, EC

(Desktop and Field)

DESCRIPTION

Residential areas are often highly affected by a range of human activities, from at-home chemical disposal to lawn fertilization, increasing the risk of water contamination and the presence of pollutants.

RELATIONSHIP TO CONDITION

A positive relationship to water quality and hydrology (as distance to residential area increases, the condition improves).

METHOD

On a desktop, identify if there is a residential area near aquatic features in the NEP. In the field the ecologist measures the distance in metres to the closest residential zone and selects the appropriate category in the ACI Field Assessment Form:

- >100m
- 51–100m
- 11–50m
- ≤10m

PERCENT MOWING WQ, EC, H

(Field)

DESCRIPTION

Percent of mowed vegetation within a 30m buffer of the aquatic feature. Mowing eliminates plant diversity and reduces the interception and filtration capabilities of vegetation.

RELATIONSHIP TO CONDITION

Negative relationship to ecological condition and water quality (as percent area mowed increases, condition declines).

METHOD

On a desktop, identify if there an industrial area near aquatic features in the NEP. In the field the ecologist measures the distance in metres to closest industrial zone and selects the appropriate category in the ACI Field Assessment Form:

- >100m
- 51–100m
- 11–50m
- ≤10m

PERCENT RIPARIAN ALTERED (SOFT) H, WQ, EC

(Field)

DESCRIPTION

Percent of vegetation altered by soft alterations within 10m of the water feature. Soft alterations are alterations which result in minimal disturbances to the natural riparian area. This includes bare ground, gravel and rocks. Soft alterations reduce the area available for vegetation, which helps trap sediment, stabilize banks, absorb and recycle nutrients, and reduce the rate of evaporation (Fitch et al., 2009).

RELATIONSHIP TO CONDITION

Negative relationship to hydrology, water quality and ecological condition (as percent riparian altered increases conditions decline).

METHOD

In the field, the ecologist estimates the percent cover of soft and hard alterations within 10m of the water feature. Using the ACI Field Assessment Form select the percent cover class of riparian altered vegetation:

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

PERCENT RIPARIAN ALTERED (HARD) $^{H, WQ, EC}$

(Field)

DESCRIPTION

Percent of vegetation altered by hard alterations within 10m of the water feature. Hard alterations are those that have a great negative impact to the natural riparian feature. Docks, cement outlets and concrete structures are examples of hard features. Hard alterations reduce the area available for vegetation, which is supposed to help trap sediment, stabilize banks, absorb and recycle nutrients, and reduce the rate of evaporation (Fitch et al., 2009).

RELATIONSHIP TO CONDITION

Negative relationship to hydrology, water quality and ecological condition (as percent riparian altered increases conditions decline).

METHOD

In the field, the ecologist estimates the percent cover of soft and hard alterations within 10m of the water feature. Using the ACI Field Assessment Form select the percent cover class of riparian altered vegetation:

- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

SHORELINE SUBSTRATE [EC, W, HQ]

(Field)
DESCRIPTION
An estimate of the cover of engineered or non-natural shoreline substrates including riprap, concrete, and rock beds. Engineered shorelines serve as management techniques, preventing erosion and stabilizing surrounding slopes, but decrease vegetated area and promote runoff.

RELATIONSHIP TO CONDITION
Negative relationship with hydrology, water quality and ecological condition (as percent cover increases, conditions decrease).

METHOD
In the field, the ecologist estimates the percent cover of engineered or un-natural shoreline (riprap, concrete, and rocks). Using the ACI Field Assessment Form select the percent cover class of shoreline substrate:
- 0
- 1–5
- 6–25
- 26–50
- 51–75
- 76–100

Rare Species

RARE ANIMALS [EC]

(Field)

DESCRIPTION
Assessment of rare animals from the list provided in Table 8. Because sites are only visited once every five years, this is not a systematic field assessment of species at risk. The ACI score for each NEP is not discounted for not documenting these species. But they provide significant conservation value for an NEP if they are documented.

RELATIONSHIP TO CONDITION
Positive relationship to ecological condition (documentation of rare animal improves condition).

METHOD

In the field, the ecologist documents any rare animal species using Table 8 as a guide during the field survey. This indicator provides a potential bonus to overall ACI score if a rare species is observed.

Using the ACI Field Assessment Form, identify rare species present (yes) or rare species not present (no).

Table 8: Rare animals

Common Name
American bittern
American white pelican
black tern
black-crowned night heron
black-necked stilt
bull trout
Canadian toad
Caspian tern
Clark's grebe
Forster's tern
great blue heron
green-winged teal
harlequin duck
horned grebe
lesser scaup
long-billed curlew
northern leopard frog
northern pintail
osprey
pied billed grebe
piping plover
purple martin
red knot
rusty blackbird
sandhill crane
sedge wren

sora
trumpeter swan
western grebe
western toad
white-faced ibis
white-winged scoter
whooping crane
yellow rail

RARE PLANTS [EC]

(Field)

DESCRIPTION

Assessment of rare plants using the list provided (Table 9).

RELATIONSHIP TO CONDITION

Positive relationship to ecological condition (documentation of rare plants improves condition).

METHOD

In the field, the ecologist documents any rare plants (Table 9) during the field survey. Using the Using the ACI Field Assessment Form identify rare species present (yes) or rare species not present (no).

Table 9: plants of conservation concern

Scientific Name	**Common Name**
Almutaster pauciflorus	few-flower aster
Atriplex powellii	Powell's saltbush
Atriplex truncata	saltbush
Bacopa rotundifolia	water hyssop
Bidens frondosa	common beggarticks
Carex oligosperma	few-fruited sedge
Carex vulpinoidea	fox sedge
Chrysosplenium iowense	golden saxifrage
Coptis trifolia	goldthread
Dichanthelium acuminatum	hot-springs millet
Elatine triandra	waterwort
Eleocharis engelmannii	Engelmann’s spike-rush

Elodea bifoliata	two-leaved waterweed
Elodea canadensis	Canada waterweed
Epilobium campestre	smooth boisduvalia
Gratiola neglecta	clammy hedge-hyssop
Heliotropium curassavicum	spatulate-leaved heliotrope
Iris missouriensis	western blue flag
Isoetes bolanderi	Bolander's quillwort
Isoetes echinospora	northern quillwort
Lobelia dortmanna	water lobelia
Lycopus americanus	American water-horehound
Lysimachia hybrida	lance-leaved yellow loosestrife
Marsilea vestita	hairy pepperwort
Muhlenbergia asperifolia	scratch grass
Najas flexilis	slender naiad
Nymphaea tetragona	white water-lily
Physostegia parviflora	false dragonhead
Plantago maritima	sea-side plantain
Rhynchospora capillacea	slender beak-rush
Ruppia cirrhosa	widgeon-grass
Spartina pectinata	prairie cord grass
Suckleya suckleyana	poison suckleya
Utricularia cornuta	horned bladderwort
Wolffia borealis	northern ducksmeal
Wolffia columbiana	watermeal

INFLUENTIAL SPECIES [EC]

Document any influential species observe.

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Appendix A: Wetland Assessment Methods Reviewed

Name	Purpose	urban/non-urban	Scale of assessment	Elements Considered	Indicators
ABERWET	Alberta's new wetland policy requires simultaneous development of rapid assessment tools to (1) provide estimates of wetland functions and values at broad regional scales for planning purposes, and (2) provide site-based assessments for regulatory approval.	non-urban	two scales: landscape level assessment and rapid field level assessment	There are four core functions considered; 1) **Hydrologic condition** (HH); 2) **Water quality** (WQ); 3)**Ecological condition*** (EH); and 4) Human use (HU)	There were 73 indicators, but sensitivity analysis highlights 23 most influential
Portland Oregon Watershed Health Management Plan		non-urban		There are 6 core elements: 1) **Landscape Condition:** patterns of natural land cover, natural disturbance regimes, lateral and longitudinal connectivity of the aquaticenvironment and community of landscape processes. 2) **Habitat:** Aquatic, wetland, riparian, floodplain, lake, and shoreline habitat. Hydrological connectivity. 3) **Hydrology:** Hydrological regime: quantity and timing of flow or water level fluctuation. highly dependent on the natural flow (disturbance) regime and hydrological connectivity, including surface- ground water interactions. 4) **Geomorphology**: Stream channels with natural geomorphic dynamics. 5) **Water Quality:** Chemical and physical characteristics of water. and 6) **Biological Condition:** Biological community diversity, composition, relative abundance, trophic structure, condition, and sensitive species.	
Oklahoma Rapid Assessment Meth od (OKRAM)		non-urban	three scales EPA: level 1, 2 and 3. and included linear relationship between landscape disturbance index and wetland condition. 1000 m buffer used around wetlands	Three core elements at field level: **Hydrological**, **Water Quality** and **Biotic Condition**. **Landscape** considered as level 1 - and created LDI	nine metrics were used during field assessment

Minnesota	Practical assessment tool for helping make sound wetland management decisions based on wetland functions. MnRAM uses a numeric model to rank each wetland function. Includes some value-related aspects.		developed using the concept of ideal theoretical, pre-European-settlement wetland. Wetlands greater then .25 acres were included. condition as the baseline.	12 wetland functions/value characteristics evaluated	72 wetland parameters - output is qualitative.

Appendix B: ACI Field Assessment Form

Date (dd/mm/yyyy):		Completed by:
When completing AHI Survey ensure you have the City of Calgary Aquatic Health Indicator Field Protocol, animals of conservation concern list, and plants of conservation concern list. **H** superscript indicates the hydrology function, **WQ** superscript indicates the water quality function, **EC** superscript indicates the ecological condition function.		
Site Description		
Asset Code/Pond Number:		
Aquatic feature typology	☐	Utility wet pond
	☐	Naturalized wet pond
	☐	Constructed stormwater wetland
	☐	Existing modified wetland
	☐	Existing retained wetland
WATER		
Indicator		
Algae WQ Select statement that best describes condition of feature:	☐	Water is clear with minimal to no algae
	☐	Algae growth limited to small, localized areas
	☐	Algae found in large patches
	☐	Algae growing in large, continuous mats preventing light from reaching the bottom
	☐	Not applicable (lotic aquatic feature, presence of a fountain or no open water)
Water turbidity WQ Select the appropriate class:	☐	No turbidity
	☐	Slight turbidity (water slightly milky)
	☐	High turbidity (bottom no longer visible, water is milky or muddy)
Outlet Present H, WQ, EC	☐	Outlet: yes
	☐	Outlet: no
	☐	Not applicable (lotic aquatic feature)

Floodway and riparian [H, WQ, EC] Is the aquatic feature in a floodway or riparian system?	☐	Yes	
	☐	No	
Percent of water ponded versus flowing [H, WQ, EC] Select the percentage of surface water that is ponded (stagnant) or flows so slowly that fine sediment is not held in suspension	☐	<1% or no ponded water. Nearly all water is flowing.	
	☐	1-5% of the water is ponded. The rest is flowing.	
	☐	5-30% of the water is ponded	
	☐	31-70% of the water is ponded	
	☐	71-95% of the water is ponded	
	☐	>95% of the water is ponded. Little or no visibly flowing water within the aquatic feature	
	☐	Not applicable (lotic aquatic feature or presence of a fountain)	
Percent of open ponded water without emergent vegetation [H, WQ] Select the percentage of the ponded water (ducks-eye aerial view) that is lacking emergent vegetation and unhidden by a forest or shrub canopy	☐	<1% or no open ponded water	
	☐	1–5% of the ponded water is open	
	☐	5-30% of the ponded water is open	
	☐	31-70% of the ponded water is open	
	☐	71-95% of the ponded water is open	
	☐	>95% of the ponded water is open	
	☐	Not applicable (lotic aquatic feature or presence of a fountain)	
Water permanence probability [H, WQ, EC] Use the Steward and Kantrud system to estimate the approximate duration of flooding in a typical year	☐	Class 1	Temporary (1-4 weeks)
	☐	Class 2	Seasonally flooded (5-17 weeks)
	☐	Class 3	Semi-permanently flooded (18-40 weeks)
	☐	Class 4	Intermittently exposed (41-51 weeks)
	☐	Class 5	Permanently flooded (52 weeks)

Presence of fountains [WQ]	☐	Fountain: yes
	☐	Fountain: no
	☐	Not applicable (lotic aquatic feature or no open water)
Presence of a forebay [WQ, H]	☐	Forebay: yes
	☐	Forebay: no
	☐	Not applicable (lotic aquatic feature)
Degree of slope [H, WQ, EC] Use a compass to select the appropriate class of the side slopes of the feature	☐	Low (0-15°)
	☐	Low-Medium (15-45°)
	☐	Medium-High (45-75°)
	☐	High (75-90°)

VEGETATION		
Indicator		
Number of zones [EC] Record the number of vegetation zones present in the feature. Use the Stewart and Kantrud system as a reference.	☐	1 zone
	☐	2 zones
	☐	3 zones
	☐	4 zones
	☐	5 zones
	☐	Not applicable (lotic aquatic feature)

Surface area for emergent vegetation [WQ, EC] Estimate the percent of wetland edge that supports emergent vegetation	0	1-5	6-25	26-50	51-75	76-100
	☐	☐	☐	☐	☐	☐
Ground Cover [H, WQ, EC] Estimate the percent cover of vegetated ground occurring within the wet soil zone into the upland habitat. Species do not need to be native. Select the appropriate percent cover class.	0	1-5	6-25	26-50	51-75	76-100
	☐	☐	☐	☐	☐	☐

Riparian buffer width EC Estimate the average width of the vegetated area in the wet soil zone. Select the distance (m) class		0	1-5	6-10	11-15	16-20	>20
		☐	☐	☐	☐	☐	☐
Riparian functional group types EC Identify the appropriate percent cover class for each plant functional group types	Functional group type	0	1-5	6-25	26-50	51-75	76-100
	Sedges	☐	☐	☐	☐	☐	☐
	Rushes	☐	☐	☐	☐	☐	☐
	Cattails	☐	☐	☐	☐	☐	☐
	Grasses	☐	☐	☐	☐	☐	☐
	Forbs	☐	☐	☐	☐	☐	☐
	Shrubs	☐	☐	☐	☐	☐	☐
Riparian indicator species EC List four most common riparian species and identify the appropriate percent cover class for each of these species	Species	0	1-5	6-25	26-50	51-75	76-100
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
Riparian noxious and prohibited noxious weed species EC List the four most common riparian noxious and prohibited weed species and identify the appropriate percent cover class for each species	Species	0	1-5	6-25	26-50	51-75	76-100
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

SOIL		
Indicator		
Soil texture H, WQ, EC In the wet soil zone that lacks persistent water, use a trowel to dig into the uppermost layer and determine if the texture (use hand test) is sticky, gritty or in-between. Take three samples (as far apart as possible) per assessment area and report on the most common soil texture	☐	sandy (gritty)
	☐	in-between sandy and clay (organic)
	☐	clay (sticky)
Soil pH EC Take a small sample of soil, place in distilled water, touch the test strip (pH litmus paper) to the water and wait for the colour to change. Compare the colour of the test strip to the pH colour ramp and then record the value. Test three samples (as far apart as possible) per assessment area and record the average	☐	<5
	☐	5-8
	☐	>8
URBAN STRESSORS		
Indicator		
Distance to nearest major road WQ, EC Determine the distance in metres to the nearest major road (skeletal, arterial, collector and industrial) and select the appropriate category	☐	>100m
	☐	51-100m
	☐	11-50m
	☐	<=10m
Distance to nearest residential road WQ, EC Determine the distance in metres to the nearest residential road and select the appropriate category	☐	>100m
	☐	51-100m
	☐	11-50m
	☐	<=10m
Distance to nearest pathway WQ, EC Determine the distance in metres to the nearest pathway (paved, gravel or dirt) and select the appropriate category	☐	>100m
	☐	51-100m
	☐	11-50m
	☐	<=10m
Distance to nearest industrial zone WQ, EC Determine the distance to the nearest industrial zone/infrastructure and select the appropriate category	☐	>100m
	☐	51-100m
	☐	11-50m
	☐	<=10m

Distance to nearest residential zone WQ, EC Determine the distance to the nearest residential zone and select the appropriate category	☐	>100m					
	☐	51-100m					
	☐	11-50m					
	☐	<=10m					
Percent of mowing H, WQ, EC Select the percent cover class of mowed vegetation within 30m of the feature		0	1-5	6-25	26-50	51-75	76-100
		☐	☐	☐	☐	☐	☐
Percent riparian altered H, WQ, EC Estimate the percent of the riparian area that is altered. Include soft and hard alterations present within 10m of the feature. Bare ground and trails are examples of soft alterations. Hard alterations are docks, cement outlets, concrete structures and etc.		Soft alterations					
		0	1-5	6-25	26-50	51-75	76-100
		☐	☐	☐	☐	☐	☐
		Hard alterations					
		0	1-5	6-25	26-50	51-75	76-100
		☐	☐	☐	☐	☐	☐
Shoreline substrate H, WQ Estimate the percent cover of engineered or non-natural shoreline substrates. This includes riprap, concrete and rock beds.		0	1-5	6-25	26-50	51-75	76-100
		☐	☐	☐	☐	☐	☐
SPECIES							
Indicator							
Rare Animals EC Document any rare animal species using Table 8 as a guide during the field survey.	☐	Rare animal observed: Yes					
	☐	Rare animal observed: No					
	Species found:						

<table>
<tr><td rowspan="3">Rare Plants EC
Document any rare plant species using Table 9 as a guide during the field survey.</td><td>☐</td><td>Rare plant observed: Yes</td></tr>
<tr><td>☐</td><td>Rare plant observed: No</td></tr>
<tr><td colspan="2">Species found:</td></tr>
<tr><td rowspan="3">Influential species EC
Document any influential species observed during the field survey.</td><td>☐</td><td>Influential animal observed: Yes</td></tr>
<tr><td>☐</td><td>Influential animal observed: No</td></tr>
<tr><td colspan="2">Species found:</td></tr>
<tr><td colspan="3">Additional Notes:</td></tr>
<tr><td colspan="3"></td></tr>
</table>

Appendix C: Identifying Wetland Zones and Water Permanence

Photo Guide (provided by Tannas Conservation Services) *Ephemeral (Low Prairie Zone)*

Temporary Zone (Wet Meadow Zone)

Seasonal Zone (Shallow Wetland Zone)

Semi-Permanent (Deep Wetland Zone)

Permanent (Open Water Zone)

Species Guide (extracted from Steward and Kantrud)

The more important plant species characteristic of classes and subclasses of prairie ponds and lakes are listed here. Major groupings are the vegetational zones and phases. In Classes III, IV, and VII, dominant and subdominant categories are referred to. Dominant species are relatively tall emergents that form the canopy, or overstory, of plant associations; subdominants are submerged, floating, or short, emergent species that ordinarily compose the understory. Plants are grouped as primary and secondary species to show their prevalence as related to cover under normal conditions within a plant community.

Except for a few extralimital species, the identification of vascular plants is according to the eighth edition of Gray's Manual (Fernald, 1950). A few western species of vascular plants not treated in Gray's Manual follow the nomenclature used by Stevens (1963). References to algae are according to Smith (1950), while names of mosses and liverworts follow Conard (1956). Altogether, 174 plant species are listed here. Scientific and common names of all plants referred to are listed in appendix B. Voucher specimens for all of these are preserved in the herbarium at the Northern Prairie Wildlife Research Center.

Class I - Emphemeral Ponds | Class II - Temporary Ponds | Class III - Seasonal Ponds and Lakes |
Class IV - Semipermanent Ponds and Lakes | Class V - Permanent Ponds and Lakes |
Class VI - Alkali Ponds and Lakes | Class VII - Fen Ponds

Class I - Emphemeral Ponds:
Central Wetland-low-prairie Zone:

- Normal Emergent Phase:
  - Primary Species:
    - *Poa pratensis*
    - *Agropyron trachycaulum*
    - *Anemone canadensis*
    - *Symphoricarpos occidentalis*
    - *Solidago altissima*
    - *Aster ericoides*
    - *Ambrosia psilostachya*
  - Secondary Species:
    - *Panicum virgatum*
    - *Andropogon gerardi*
    - *Carex brevior*
    - *Zigadenus elegans*
    - *Lilium philadelphicum*
    - *Rosa woodsii*
    - *Glycyrrhiza lepidota*
    - *Zizia aptera*
    - *Helianthus maximiliani*
    - *Artemisia ludoviciana*
    - *Taraxacum officinale*
    - *Agoseris glauca*
    - *Crepis runcinata*
- Cropland Tillage Phase:
  - Primary species:
    - *Setaria glauca*
    - *Polygonum convolvulus*
    - *Kochia scoparia*
  - Secondary species:
    - *Agropyron smithii*
    - *Agropyron repens*
    - *Salsola kali*
    - *Amaranthus retroflexus*
    - *Thlaspi arvense*
    - *Brassica kaber*
    - *Descurainia sophia*
    - *Rosa arkansana*
    - *Androsace occidentalis*
    - *Ellisia nyctelea*
    - *Erigeron canadensis*
    - *Iva xanthifolia*

Class II - Temporary Ponds:

Subclass A - Fresh:

Central Wet-meadow Zone:

- Normal Emergent Phase:
  - Primary Species:
    - *Poa palustris*
    - *Carex praegrACI lis*
    - *Carex sartwellii*
    - *Carex lanuginosa*
    - *Boltonia latisquama*
    - *Aster simplex*
  - Secondary Species:
    - *Hordeum jubatum*
    - *Calamagrostis canadensis var. macouniana*
    - *Calamagrostis inexpansa*
    - *Spartina pectinata*
    - *Hierochloe odorata*
    - *Carex vulpinoidea*
    - *Carex laeviconica*
    - *Juncus balticus*
    - *Juncus dudleyi*
    - *Juncus interior*
    - *Rumex mexicanus*
    - *Rumex occidentalis*
    - *Ranunculus macounii*
    - *Rorippa islandica*
    - *Potentilla norvegica*
    - *Epilobium glandulosum*
    - *Lysimachia hybrida*
    - *Apocynum sibiricum*
    - *Asclepius speciosa*
    - *Teucrium occidentale*
    - *Stachys palustris*
    - *Mentha arvensis*
    - *Vernonia fasciculata*
    - *Helenium autumnale*
    - *Artemisia biennis*
    - *Cirsium arvense*
    - *Sonchus arvensis*
- Cropland Drawdown Phase:
  - Primary Species:
    - *Agropyron repens*
    - *Echinochloa crusgalli*
    - *Polygonum lapathifolium*
    - *Veronica peregrina*
  - Secondary Species:
    - *Hordeum jubatum*
    - *Plagiobothrys scopulorum*
    - *Xanthium italicum*
    - *Bidens frondosa*

- Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Subclass B - Slightly Brackish:

Central Wet-meadow Zone:

- Normal Emergent Phase:
  - Primary Species:
    - *Hordeum jubatum*
    - *Calamagrostis inexpansa*
    - *Spartina pectinata*
    - *Carex sartwellii*
    - *juncus balticus*

        - *Aster simplex*
    - Secondary Species:
        - *Poa palustris*
        - *Carex praegrACI lis*
        - *Carex lanuginosa*
        - *Juncus interior*
        - *Juncus dudleyi*
        - *Juncus torreyi*
        - *Rumex mexicanus*
        - *Epilobium glandulosum*
        - *Stachys palustris*
        - *Lycopus asper*
        - *Mentha arvensis*
        - *Artemisia biennis*
        - *Cirsium arvense*
        - *Sonchus arvensis*
- Cropland Drawdown Phase: The species composition is the same as that of the cropland drawdown phase of the central wet-meadow zone in fresh temporary ponds (Class II-A).

- Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Class III - Seasonal Ponds and Lakes:
Subclass A - Fresh:
Central Shallow-marsh Zone:
- Normal Emergent Phase:
    - Dominants:
        - Primary Species:
            - *Sparganium eurycarpum*
            - *Alisma triviale*
            - *Glyceria grandis*
            - *Beckmannia syzigachne*
            - *Carex atherodes*
            - *Polygonum coccineum*
        - Secondary Species:
            - *Alopecurus aequalis*
            - *Phalaris arundinacea*
            - *Sium suave*
    - Subdominants:
        - Primary Species:
            - *Riccia fluitans*
            - *Lemna trisulca*
            - *Utricularia vulgaris*
        - Secondary Species:
            - *Drepanocladus* spp.
            - *Lemna minor*
- Open-water Phase:
    - Primary Species:
        - *Potamogeton gramineus*
        - *Callitriche palustris*
        - *Utricularia vulgaris*
    - Secondary Species:
        - *Drepanocladus* spp.
        - *Potamogeton pusillus*
        - *Eleocharis ACI cularis*, submerged form.
        - *Ranunculus trichophyllus*

- Natural Drawdown Phase:

- Primary Species:
  - *Eleocharis ACI cularis*, terrestrial form.
- Secondary Species:
  - *Rumex maritimus*
  - *Kochia scoparia*
  - *Xanthium italicum*
  - *Senecio congestus*

- Cropland Drawdown Phase:
  - Primary Species:
    - *Eleocharis engelmanni*
    - *Eleocharis ACI cularis*
    - *Gratiola neglecta*
  - Secondary Species:
    - *Marsilea mucronata*
    - *Cyperus acuminatus*
    - *Bacopa rotundifolia*
    - *Lindernia dubia*

- Peripheral Wet-meadow Zone: The species composition is the same as that of the central wet-meadow zone of fresh temporary ponds. (Class II-A)

- Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Subclass B - Slightly Brackish

Central Shallow-marsh Zone:

- Normal Emergent Phase:
  - Dominants:
    - Primary Species:
      - *Alisma triviale*
      - *Scolochloa festucacea*
      - *Beckmannia syzigachne*
      - *Eleocharis palustris*
      - *Carex atherodes*
      - *Polygonum coccineum*
    - Secondary Species:
      - *Sparganium eurycarpum*
      - *Alisma gramineum*
      - *Sagittaria cuneata*
      - *Alopecurus aequalis*
      - *Phalaris arundinacea*
      - *Polygonum amphibium*, terrestrial form
      - *Sium suave*
  - Subdominants:
    - Primary Species:
      - *Drepanocladus* spp.
      - *Ricciocarpus natans*
      - *Lemna trisulca*
      - *Lemna minor*
      - *Utricularia vulgaris*
    - Secondary Species:
      - *Riccia fluitans*
      - *Ranunculus sceleratus*

- *Ranunculus cymbalaria*

- Open-Water Phase:
  - Primary Species:
    - *Drepanocladus* spp.
    - *Ranunculus trichophyllius*
    - *Utricularia vulgaris*
  - Secondary Species:
    - *Potamogeton pusillus*
    - *Eleocharis ACI cularis*, submerged form
    - *Polygonum amphibium*, aquatic form

- Natural Drawdown Phase:
  - Primary Species:
    - *Eleocharis ACI cularis*
  - Secondary Species:
    - *Hordeum jubatum*
    - *Rumex maritimus*
    - *Chenopodium rubrum*
    - *Kochia scoparia*
    - *Xanthium italicum*
    - *Senecio congestus*

- Cropland Drawdown Phase: The species composition is the same as that of the cropland drawdown phase of fresh seasonal ponds (Class III-A).

- Peripheral Wet-meadow Zone: The species composition is the same as that of the central wet-meadow zone of slightly brackish temporary ponds (Class II-B).

- Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Subclass C - Moderately Brackish:

Central Shallow-marsh Zone

- Normal Emergent Phase:
  - Dominants:
    - Primary Species:
    - *Alisma gramineum*
    - *Scolochloa festucacea*
    - *Beckmannia syzigachne*
    - *Eleocharis palustris*
    - Secondary Species:
      - *Scirpus americanus*
      - *Carex atherodes*
  - Subdominants:
    - Primary Species:

- *Lemna minor*
- Secondary Species:
  - *Drepanocladus* spp.
  - *Lemna trisulca*
  - *Ranunculus cymbalaria*
  - *Utricularia vulgaris*

- Open-water Phase:
  - Primary Species:
    - None
  - Secondary Species:
    - *Chara* spp.
    - *Drepanocladus* spp.
    - *Ranunculus trichophyllus*
    - *Utricularia vulgaris*

- Natural Drawdown Phase:
  - Primary Species:
    - *Hordeum jubatum*
  - Secondary Species:
    - *Eleocharis ACI cularis*
    - *Rumex maritimus*
    - *Chenopodium rubrum*
    - *Kochia scoparia*

- Cropland Drawdown Phase:
  - Primary species:
    - *Eleocharis ACI cularis*
  - Secondary Species:
    - *Gratiola neglecta*

Peripheral Wet-meadow Zone:

- Normal Emergent Phase:
  - Primary Species:
    - *Hordeum jubatum*
    - *Calamagrostis inexpansa*
    - *Spartina pectinata*
    - *Juncus balticus*
  - Secondary Species:
    - *Distichlis stricta*
    - *Atriplex patula*
    - *Potentilla anserina*
    - *Glaux maritima*
    - *Lycopus asper*
    - *Plantago eriopoda*
    - *Aster simplex*
    - *Artemisia biennis*

- Cropland Drawdown Phase:
  - Primary Species:
    - *Agropyron repens*
  - Secondary Species:
    - *Hordeum jubatum*
    - *Echinochloa crusgalli*

            - *Xanthium italicum*

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie azone fo ephemeral ponds (Class I)

Class IV - Semipermanent Ponds and Lakes:
Subclass A - Fresh:
Central Deep Marsh Zone:

- Normal Emergent Phase:
    - Dominants:
        - Primary Species:
            - *Scirpus heterochaetus*
        - Secondary Species:
            - *Typha latifolia*
            - *Scirpus fluviatilis*
    - Subdominants:
        - Primary Species:
            - *Riccia fluitans*
            - *Lemna trisulca*
            - *Utricularis vulgaris*
        - Secondary Species:
            - *Drepanocladus* spp.
            - *Ricciocarpus natans*
            - *Lemna minor*
- Open-water Phase:
    - Primary Species:
        - *Potamogeton pusillus*
        - *Utricularia vulgaris*
    - Secondary Species:
        - *Potamogeton richardsonii*
        - *Ceratophyllum demersum*
        - *Ranunculus trichophyllus*
        - *Myriophyllum exalbescens*
- Natural Drawdown Phase:
    - Primary Species:
        - *Eleocharis ACI cularis*
        - *Senecio congestus*
    - Secondary Species:
        - *Kochia scoparia*

Peripheral Shallow-marsh Zone: The species composition is the same as that of the central shallow-marsh zone of fresh seasonal ponds and lakes (Class III-A).

Peripheral Wet-meadow Zone: The species composition is the same as that of the central wet-meadow zone of fresh temporary ponds (Class II-A).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

S
ubclass B - Slightly Brackish

Central Deep-marsh Zone:

- Normal Emergent Phase:
  - Dominants:
    - Primary Species:
      - *Typha "glauca"*
      - *Scirpus acutus*
      - *Scirpus fluviatilis*
    - Secondary Species
      - *Typha latifolia*
      - *Scirpus validus*
  - Subdominants:
    - Primary Species:
      - *Drepanocladus* spp.
      - *Ricciocarpus natans*
      - *Lemna trisulca*
      - *Lemna minor*
      - *Utricularia vulgaris*
    - Secondary Species:
      - *Riccia fluitans*
- Open-water Phase:
  - Primary Species
    - *Potamogeton richardsonii*
    - *Potamogeton pusillus*
    - *Ceratophyllum demersum*
    - *Ranunculus trichophyllus*
    - *Myriophyllum exalbescens*
    - *Utricularia vulgaris*
  - Secondary Species:
    - *Chara* spp.
    - *Drepanocladus* spp.
    - *Zannichellia palustris*
    - *Potamogeton pectinatus*
    - *Callitriche hermaphroditica*
- Natural Drawdown Phase:
  - Primary Species:
    - *Eleocharis ACI cularis*
    - *Rumex maritimus*
    - *Chenopodium rubrum*
    - *Kochia scoparis*
    - *Senecio congestus*
  - Secondary Species:
    - *Hordeum jubatum*

Peripheral Shallow-marsh Zone: The species composition is the same as that of the central shallow-marsh zone of slightly brackish seasonal ponds and lakes (Class III-B).

Peripheral Wet-meadow Zone: The species composition is the same as that of the central wet-meadow zone of slightly brackish temporary ponds (Class II-B).

Peripheral Wetlands-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Subclass C - Moderately Brackish:
Central Deep-marsh Zone:

- Normal Emergent Phase:
  - Dominants:
    - Primary Species:
      - *Scirpus acutus*
    - Secondary Species:
      - *Scirpus paludosus*
  - Subdominants:
    - Primary Species:
      - *Lemna minor*
    - Secondary Species:
      - *Drepanocladus* spp.
      - *Lemna trisulca*
      - *Utricularis vulgaris*
- Open-water Phase:
  - Primary Species:
    - *Chara* spp.
    - *Zannichellia palustris*
    - *Potamogeton pectinatus*
  - Secondary Species:
    - *Ranunculus trichophyllus*
    - *Myriophyllum exalbescens*

- Natural Drawdown Phase:
  - Primary Species
    - *Hordeum jubatum*
    - *Rumex maritimus*
    - *Chenopodium rubrum*
    - *Kochia scoparia*
  - Secondary Species:
    - *Panicum capillare*
    - *Eleocharis ACI cularis*
    - *Chenopodium salinum*
    - *Aster brachyactis*

Peripheral Shallow-marsh Zone: The species composition is the same as that of the central shallow-marsh zone of moderately brackish seasonal ponds and lakes (Class III-C).

Peripheral Wet-meadow Zone: The species composition is the same as that of the peripheral wet-meadow zone of moderately brackish seasonal ponds and lakes (Class III-C).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral fen zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Subclass D - Brackish:

Central Deep Marsh Zone:

- Normal Emergent Phase:
    - Dominants:
        - Primary Species:
            - *Scirpus paludosus*
        - Secondary Species:
            - *Scirpus acutus*
    - Subdominants:
        - None.
- Open-water Phase:
    - Primary Species:
        - *Chara* spp.
        - *Zannichellia palustris*
        - *Potamogeton pectinatus*
    - Secondary Species:
        - None.
- Natural Drawdown Phase:
    - Primary Species:
        - *Hordeum jubatum*
        - *Chenopodium salinum*
        - *Kochia scoparia*
        - *Aster brachyactis*
    - Secondary Species:
        - *Panicum capillare*
        - *Rumex maritimus*

Peripheral Shallow-marsh Zone:

- Normal Emergent Phase:
    - Dominants:
        - Primary Species:
            - *Scirpus americanus*
        - Secondary Species:
            - *Puccinellia nuttalliana*
            - *Eleocharis palustris*
            - *Salicornia rubra*
    - Subdominants:
        - None.

- Open-water Phase:
    - Primary Species:

        - *Zannichellia palustris*
    - Secondary Species:
        - *Chara* spp.

- Natural Drawdown Phase:
    - Primary Species:
        - *Hordeum jubatum*
        - *Aster brachyactis*
    - Secondary Species:
        - *Chenopodium salinum*
        - *Kochia scoparia*

Peripheral Wet-meadow Zone:
- Normal Emergent Phase:
    - Primary Species:
        - *Distichlis stricta*
        - *Hordeum jubatum*
    - Secondary Species:
        - *Triglochin maritima*
        - *Muhlenbergia asperifolia*
        - *Juncus balticus*
        - *Polygonum prolificum*
        - *Atriplex patula*
        - *Potentilla anserina*
        - *Lactuca scariola*

Peripheral Wetland-low-prairie Zone: The species compositions is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Subclass E - Subsaline:
Central Deep-marsh Zone:
- Normal Emergent Phase:
    - Dominants:
        - Primary Species:
            - *Scirpus paludosus*
        - Secondary Species:
            - None.
    - Subdominants:
        - None.
- Open-water Phase:
    - Primary Species:
        - *Ruppia maritima*
    - Secondary Species:
        - *Chara* spp.
        - *Potamogeton pectinatus*

- Natural Drawdown Phase:
  - Primary Species:
    - None.
  - Secondary Species:
    - *Kochia scoparia*

Peripheral Shallow-marsh Zone:

- Normal Emergent Phase:
  - Dominants
    - Primary Species:
      - *Puccinellia nuttalliana*
      - *Salicornia rubra*
    - Secondary Species:
      - *Scirpus nevadensis*
      - *Scirpus americanus*
      - *Suaeda depressa*
  - Subdominants:
    - None.
- Open-water Phase:
  - None.
- Natural Drawdown Phase:
  - None.

Peripheral Wet-meadow Zone:

- Normal Emergent Phase:
  - Primary Species:
    - *Distichlis stricta*
  - Secondary Species:
    - *Triglochin maritima*
    - *Hordeum jubatum*
    - *Muhlenbergia asperifolia*
    - *Spartina grACI lis*
    - *Atriplex patula*

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (Marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Class V - Permanent Ponds and Lakes:
Subclass B - Slightly Brackish:
Central Permanent-open-water Zone:

- Primary Species:
  - *Ruppia occidentalis*
- Secondary Species:
  - None.

Peripheral Deep-marsh Zone: The species composition is the same as that of the central deep-marsh zone of slighlty brackish semipermanent ponds and lakes (Class IV-B).

Peripheral Shallow-marsh Zone: The species composition is the same as that of the central shallow-marsh zone of slightly brackish seasonal ponds and lakes (Class III-B).

Peripheral Wet-meadow Zone: The species composition is the same as that of the central wet-meadow zone of slightly brackish temporary ponds (Class II-B).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Subclass C - Moderately Brackish:
Central Permanent-open-water Zone:

- Primary Species:
    - *Ruppia occidentalis*
- Secondary Species:
    - None.

Peripheral Deep-marsh Zone: The species composition is the same as that of the central deep-marsh zone of moderately brackish semipermanent poonds and lakes (Class IV-C).

Peripheral Shallow-marsh Zone: The species composition is the same as that of the central shallow-marsh zone of moderately brackish seasonal ponds and lakes (Class III-C).

Peripheral Wet-meadow Zone: The species composition is the same as that of the peripheral wet-meadow zone of moderately brackish seasonal ponds and lakes (Class III-C).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Subclass D - Brackish:
Central Permanent-open-water Zone:

- Primary Species:
    - *Ruppia occidentalis*
- Secondary Species:
    - *Potamogeton vaginatus*

Peripheral Deep-marsh Zone: The species composition is the same as that of the central deep-marsh zone of brackish semipermanent ponds and lakes (Class IV-D).

Peripheral Shallow-marsh Zone: The species composition is the same as that of the peripheral shallow-marsh zone of brackish semipermanent ponds and lakes (Class IV-D).

Peripheral Wet-meadow Zone: The species composition is the same as that of the peripheral wet-meadow zone of brackish semipermanent ponds and lakes (Class IV-D).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Subclass E - Subsaline

Central Permanent-open-water Zone:

- Primary Species
    - None.
- Secondary Species:
    - None.

Peripheral Deep-marsh Zone: This zone is often poorly represented; when present, the characteristic species are the same as those of the central deep-marsh zone of subsaline semipermanent ponds and lakes (Class IV-E).

Peripheral Shallow-marsh Zone: The species composition is the same as that of the peripheral shallow-marsh zone of subsaline semipermanent ponds and lakes (Class IV-E).

Peripheral Wet-meadow Zone: The species composition is the same as that of the peripheral wet-meadow zone of subsaline semipermanent ponds and lakes (Class IV-E).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Class VI - Alkali Ponds and Lakes

Central Intermittent-alkali Zone:

- Primary Species:
    - *Ruppia maritima*
- Secondary Species:
    - None.

Peripheral Shallow-marsh Zone: The species composition is the same as that of the peripheral shallow-marsh zone of subsaline semipermanent ponds and lakes (Class IV-E).

Peripheral Wet-meadow Zone: The species composition is the same as that of the peripheral wet-meadow zone of subsaline semipermanent ponds and lakes (Class IV-E).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

Peripheral Fen Zone (marginal pockets): The species composition is the same as that of the central fen zone of fen ponds (Class VII).

Class VII - Fen Ponds

Central Fen Zone:

- Normal Emergent Phase:
    - Dominants:
        - Primary Species:
            - *Typha latifolia*
            - *Glyceria striata*
            - *Phragmites communis*
            - *Scirpus validus*
            - *Carex aquatilis*
            - *Salix interior*
            - *Salix candida*
            - *Cicuta maculata*
            - *Aster junciformis*
        - Secondary Species:
            - *Triglochin maritima*
            - *Deschampsia caespitosa*
            - *Calamagrostis inexpansa*
            - *Muhlenbergia glomerata*
            - *Eleocharis calva*
            - *Eriophorum angustifolium*
            - *Scirpus atrovirens*
            - *Carex sartwellii*
            - *Carex interior*
            - *Carex aurea*
            - *Carex lanuginosa*
            - *Carex rostrata*
            - *Juncus torreyi*
            - *Hypoxis hirsuta*
            - *Ranunculus septentrionalis*
            - *Epilobium leptophyllum*
            - *Lysimachia thrysiflora*
            - *Gentiana procera*
            - *Asclepias incarnata*
            - *Scutellaria epilobiifolia*
            - *Lobelia kalmii*
            - *Eupatorium maculatum*
            - *Solidago graminifolia*
            - *Helianthus rydbergii*

- Subdominants:
  - Primary Species:
    - *Drepanocladus* spp.
  - Secondary Species:
    - *Lemna minor*
    - *Parnassia palustris*
    - *Viola nephrophylla*
- Open-water Phase:
  - Primary Species:
    - *Chara* spp.
    - *Drepanocladus* spp.
  - Secondary Species:
    - *Zannichellia palustris*
    - *Ceratophyllum demersum*
    - *Ranunculus gmelini*
    - *Hippuris vulgaris*
    - *Utricularia vulgaris*

Peripheral Wet-meadow Zone: The species composition is the same as that of the central wet-meadow zone of slightly brackish temporary ponds (Class II-B).

Peripheral Wetland-low-prairie Zone: The species composition is the same as that of the central wetland-low-prairie zone of ephemeral ponds (Class I).

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