Breeding habitat development for the Western chorus frog

Guide, February 2023

Votre gouvernement

Québec

Coordination and writing
This publication was developed by the Direction de la gestion de la faune de l'Estrie, de Montréal, de la Montérégie et de Laval part of the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP).

It was produced by the MELCCFP's communications branch.

Information

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Recommended citation
Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs. 2023. Breeding Habitat Development for the Western Chorus Frog, Preliminary Version. Direction de la gestion de la faune de l'Estrie, de Montréal, de la Montérégie et de Laval, Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, 18 pages and appendices.

Legal deposit – 2024
Bibliothèque et Archives nationales du Québec
EN translation– ISBN (PDF) : 978-2-550-97200-6
Original Français – ISBN (PDF) : 978-2-550-94199-6
(Modalités d'aménagement d'un habitat de reproduction pour la rainette faux-grillon de l'Ouest (gouv.qc.ca))

Summary

The western chorus frog (*Pseudacris triseriata*) was designated a vulnerable species in 2001 and threatened in 2023, under the *Quebec Act Respecting Threatened or Vulnerable Species* (CQLR, c. E-12.01, r. 2). Population monitoring indicates that the abundance of the species continues to decline despite recovery efforts. Given the high level of concern for the western chorus frog and its habitats, even within conserved habitats, it is becoming necessary to consider the restoration of these habitats and connectivity to ensure the long-term sustainability of the species.

Since 2015, studies in the Montérégie region have focused on different characteristics of the western chorus frog's habitat to determine the parameters to be used to facilitate its restoration and development. The purpose of this document is to make current knowledge and techniques available for the development of western chorus frog habitats. The optimal landscape occupied by the western chorus frog consists of 30% wetlands, mostly open areas, and up to 25% wooded areas. The hydrology of the temporary wetland habitats used by the western chorus frog for breeding has intrinsic variability correlated with the nature of the watershed and the amount of precipitation. A breeding habitat for larval development must reach a hydroperiod of 60 to 100 days and have direct sun exposure from 10:00 a.m. to 2:00 p.m. The choice of location and an assessment of hydrological characteristics are therefore essential. Knowledge of the receiving environment, its geomorphological characteristics and water quality is essential for successful developments.

Lastly, a new approach is needed to reduce the impact of extreme weather events and the warming trend observed in recent years. To ensure an optimal habitat for the species over the long term, it is therefore necessary to provide dense wetlands with varied hydroperiods for breeding and to set up a woody vegetation monitoring and maintenance program. A monitoring protocol is currently being tested.

Note on the genetic identity of the species found in Quebec

The species in Quebec is identified as *Pseudacris triseriata*. Recent genetic analyses have shown that there was a genomic discordance, likely caused by hybridization with the boreal chorus frog (*Pseudacris maculata*). Regardless of this dichotomy between the genetic content of the nucleus and that of the mitochondria, no change in the taxonomic classification is currently proposed; the western chorus frog is a valid wildlife species (Lougheed et al. 2020; COSEPAC 2015; Bogart et al. 2015).

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1. Introduction

The western chorus frog is confined to residual habitats in urban or peri-urban environments subject to high development pressures in the heart of the most densely populated area of Quebec. Picard (2015) mentions a decrease of more than 45% in the number of western chorus frog choruses in the Montérégie region across the area between 2004 and 2014. According to the most recent inventories, the decline is continuing (MELCCFP 2023).

The aim of the 2019-2029 provincial recovery plan for the western chorus frog is to maintain or improve the number and viability of the metapopulations of the species while maintaining its range (ÉRRFGOQ 2019). Of the six main objectives of the plan, two relate specifically to habitat development and restoration:

1. Improved knowledge of the elements likely to contribute to the sustainability of the species;
2. Acquisition of knowledge and development of techniques that enable individuals to be introduced to support or create new populations.

It is certainly preferable to preserve existing breeding habitats rather than develop new ones (Semlitsch, R. 2013). Creating or restoring habitats that meet the specific needs of the western chorus frog is a major challenge. Developments created to compensate for the loss of functional habitat have been criticized because of their limited success and lack of long-term monitoring. Currently, when designing ponds with intermittent hydroperiods, data on soil characteristics and the water cycle in the receiving environment are needed to better predict the resulting hydrology (Bouthillier et Reyes 2016; Kolozsvary et Holgerson 2016; Roy et al. 2014).

Any restoration or development strategy aimed at increasing the support capacity of environments used by the western chorus frog must take into account the environment's hydrological, geomorphological, topographical and vegetation cover characteristics. The development site must be in a landscape with a predominance of open habitats, discontinuous forests and wetlands. The parameters for the restoration and development of western chorus frog habitats must first meet the objective of wetland density with at least one breeding habitat every 100 meters, hydroperiods ranging from 60 to 100 days, and no connection between the breeding habitats and fish habitat. Restoration of sunlight through tree cover management and the control of buckthorn are complementary. Lastly, the development of riparian buffer strips and wildlife crossings structures under roads is aimed at improving connectivity between population cores. The purpose of this document is to make current knowledge and techniques available in view of developing habitats that meet the specific needs of the western chorus frog. Documenting and monitoring these projects will enrich our understanding of these complex systems and improve the development techniques tailored to each environment to support the achievement of the recovery objectives.

2. Parameters to consider

2.1 Characteristics of preferred habitat

The western chorus frog's breeding grounds vary. In the Montérégie region, they are usually located in a relatively flat, poorly drained habitat characterized by roughly 30% wetlands, mainly open habitats, and 15% denser forest habitats (Bouthillier et Reyes 2016). In this patch of wet soil with imperfect drainage, the water cycle is characterized by surface water being stored in the wetlands and depressions that can in turn discharge their overflow into a network of microtopographic flow paths or ditches. Breeding ponds are characterized by shallow water about 30 to 60 centimeters in depth and gently sloping shorelines. The characteristics of the watershed of the western chorus frog's breeding grounds allow temporary wetlands to easily absorb the water inflow from precipitation, with very slow variations in water levels and drying rates. Although these areas lose water through evapotranspiration during the day, they regain much of it from the surrounding environment during the night, which ensures some consistency in water levels despite the shallow depths (Larocque et al. 2020). It is these hydrological characteristics of both the ponds and the watershed that favour their use by the western chorus frog.

In summary, to meet the species' needs, pond capacity is dependent on:

- Hydrological dynamics of the watershed;
- Pond configuration;
- Pond substrate;
- Volume of water in the ponds;
- Bank topography favourable to surface runoff or not;
- Sun exposure;
- Existing vegetation.

Ponds are usually fed or supported by the water table when it is high, as well as by precipitation and snowmelt. For this reason, a prior study of the characteristics of the target area and an assessment of water levels are critical before any type of design is considered for the development of western chorus frog breeding ponds. Since the western chorus frog has a life expectancy of one to two years in Quebec, it is important to ensure that adequate conditions are achieved every year.

2.1.1 Hydroperiod

The hydroperiod of the breeding environment plays a key role in the composition of living communities, for both amphibians and their predators. Western chorus frogs therefore seek the best combination between an early, stable and temporary hydroperiod and a low risk of predation, while the temporality of the flood limits the establishment of predatory species. The western chorus frog is associated with so-called temporary wetlands, in that they dry out during the summer after a flood of 60 to 100 days. This hydroperiod is the result of several environmental and geomorphological factors.

2.1.2 Sunlight

The amount of sunlight in breeding sites is an important factor for the recruitment of the western chorus frog (Werner et al. 2009). The pond's exposure to sun coupled with an adequate hydroperiod is a key combination for a successful development (Roy et Beauvais 2014). Western chorus frog habitats are most often located in open areas with a low forest cover of less than 60% (Bonin et Galois 1996; Bouthillier et al. 2017; Gagné 2011; Ouellet, Martin et Leheurteux 2007; Roy et al. 2014). Picard and Porciuncula (2017) state that there should be sun exposure from about 10 a.m. to 2 p.m. over at least 60% of the pond surface area.

2.1.3 Water temperature

Water temperature influences the onset of breeding activity, tadpole growth, and indirectly the presence of some predators and available food. Typically, breeding songs take place during the day when air and water temperatures are about 9 to 10°C (Whitaker Jr 1971). Dupré and Petranka (1985) found that western chorus frog tadpoles have stronger thermal preferences in the second half of their development, possibly related to the availability of food and their accelerated rate of development. Werner (2009) monitored western chorus frog populations for 11 years and noted rapid larval growth in this second part. A rapid temperature increase in the spring followed by a more constant temperature during the season are most favourable for the species (Bouthillier et al. 2017).

The configuration of the breeding ponds must provide a better gradient of water temperatures to allow larvae to achieve optimal thermoregulation.

2.1.4 Water quality

Anuran larvae are susceptible to a wide variety of pollutants (Bridges et Semlitsch 2000; Hoffman et al. 2002). The water used to feed the ponds must be free of components that may impact larval anurans. For example, a pH that is too low can inhibit the growth of amphibian larvae, and a pH that is too high is known to hinder the development of aquatic wildlife. A field study determined that exposure to low concentrations of road salts decreases the survival capacity of juvenile wood frogs (*Lithobates sylvaticus*) and, as a result, decreased adult abundance (Dananay et al. 2015). Excessive water salinity results in changes to the thyroid gland in amphibians, which alters their hormonal cycle and larval development (Environnement Canada et Santé Canada 2001). Ouellet and his contributors (2009) reported that the boreal chorus frog (*Pseudacris maculata*) does not tolerate a concentration of 10 g/l and above. In that study, concentrations reported in occupied habitats did not exceed 2 g/l. The pH and the salinity index are water quality measurements that are easy to use.

There is no single physicochemical parameter that can account for the toxicity of temporary ponds for amphibian larvae. Sediments can accumulate salts, metals and other pollutants that may affect larval development when remobilized. A project on developed breeding ponds in Switzerland revealed that the physicochemical quality of pond water is dependent on the type of habitat in which it is located (agricultural area, forest, alluvial zone), the source of water supply, as well as the type of subsoil or sealing. The study results showed that pH is mainly negatively correlated with water conductivity and hardness (Morard et Zuberbühler 2006). Conductivity measurement can be interpreted as an indirect measure of the ion charge (mineral or organic) dissolved in water. In another study conducted by Klaver et al. (2013)), higher conductivity was negatively associated with the boreal chorus frog's occurrence in the Greater Yellowstone Ecosystem. Occurrence frequency decreased rapidly as soon as concentrations rose to 150 µS and then dropped to almost zero after 350 µS.

2.1.5 Vegetation

The western chorus frog prefers ponds with an adequate quantity of emergent vegetation that provides it with shelter and where it can attach its egg clusters (Bouthillier et Reyes 2016; Drayer

2011; Montpetit, Tommy et al. 2010; Roy et Beauvais 2014; Shulse et al. 2012a, 2012b). Male reproducers enjoy clumps of emergent plants with drooping leaves such as canary grass where they can take shelter and perform their vocalizations. Areas with submerged plants are also favourable for individuals seeking shelter or laying eggs. Finally, areas of open water can facilitate solar warming, larval foraging, and an adequate temperature for thermoregulation. In general, the layout of favourable vegetation in a breeding pond can be characterized by a low combination of type 1 or 2 and type of cover ranging from type 5 to 8, according to the nomenclature by Golet and Larson (1974).

Diverse plant species have been observed in the habitats. Bouthillier and Reyes (2016) rank the following species among those that appear to be most abundant in western chorus frog habitats:

- Reed canary grass (*Phalaris arundinacea*)
- Sensitive fern (*Onoclea sensibilis*)
- Sedge (*Carex* sp.)
- Dogwood (*Cornus* sp.)
- Spirea (*Spirea* sp.)
- Alder (*Alnus* sp.)
- Willow (*Salix* sp.)
- Ash (*Fraxinus* sp.)
- Red maple (*Acer rubrum*).

These ponds also include vegetation consisting of many obligate and facultative wetland species. Their composition and cover must enable diversified conditions for larval reproduction and development.

2.1.6 Plant species not favourable for the western chorus frog

Some plant species, although present, are not favourable for the western chorus frog and should not be favoured or used:

- The exotic common reed (*Phragmites australis*) is known to dry out ponds and decrease sunlight (Picard 2015; Rittenhouse 2011).
- Buckthorn (*Rhamnus cathartica* and *Rhamnus frangula*) is also a limiting factor to take into account, since the breakdown of the plant’s leaves, fruit, roots and other parts releases a secondary metabolite into the water, known as emodin, which severely affects the larval development of the western chorus frog and other amphibians (Sacerdote et King 2014).
- Cattail (*Typha augustifolia* and *Typha latifolia*), although frequently present, is invasive and produces a large amount of ground vegetation that can delay pond thawing, which is definitely a problem for obtaining a favourable hydroperiod (Lyne Bouthillier, personal observations). Some studies show that cattail may be capable of inhibiting the germination and growth of some native species, since it is thought to release allelopathic substances through its roots (Jarchow et Cook 2009; McNaughton 1968).

Developed open habitats colonized with natural vegetation, consisting of obligate or facultative wetland species, need to be favoured. Placing a vegetation cover over any reworked areas is crucial. The presence of open water early in the season in shallow ponds with a lot of sun exposure enables the growth of a variety of aquatic vegetation. These conditions are conducive to the reproduction and development of western chorus frog larvae. It is important to properly select the plants to be seeded at the site to ensure they are suitable for the conditions.

2.1.7 Predation

The presence of predators is also recognized as a significant limiting factor (Shulse et al. 2012b, 2012a; Skelly 1997; Skelly et al. 1999; Smith 1983; Werner et al. 2009). The western chorus frog's main predators depend on the presence of permanent water. According to Desroches and Rodrigue (2004), Roy et al. (2014) and several other authors, these predators consist of:

- Fish
- Green frogs (*Lithobates clamitans*)
- Bullfrogs (*Lithobates catesbeianus*)
- Odonate larvae
- Beetle larvae
- Water beetles, giant water bugs (*Lethocerus americanus*)
- Red-spotted newts (*Notophthalmus viridescens viridescens*)
- Blue-dotted salamanders (*Ambystoma laterale*)
- Spotted salamanders (*Ambystoma maculatum*)
- Leaches
- Snakes
- Birds.

In addition, it is important that developed ponds do not come into contact with water environments, as they may become colonized by fish. Post-development monitoring is required of both the hydroperiod and the presence of predatory species, two key factors that are essential for the establishment of viable western chorus frog populations.

3. Approach

3.1 Prior studies of the receiving environment

It is essential that a site development or restoration study be conducted. The environment's development potential should be characterized by considering its advantages and weaknesses (e.g., moisture, soil and vegetation quality, presence of wetlands, presence of predators and Invasive alien species (IAS). The recommended approach is to select sites with a high number of already favourable characteristics, with minor weaknesses, that can be improved through specific adjustments. The watershed must be characterized in order to establish the approach to be implemented to meet the western chorus frog's specific needs. The various points to document are described in the following sections.

Analysis of landscape features

Prior analysis of known data using geomatic data on the watershed and its water dynamics is essential. Control points will then be validated on site. Specifically, the topography, the presence and type of wetlands, flow channels and drainage ditches, vegetation cover, presence of habitats of species at risk, and stormwater use and management are important parameters to consider. At this stage, it must be determined whether there is a minimum number of favourable characteristics within 300 meters of the site to be restored. The following criteria are used to assess the qualities of the existing habitat:

- A minimum of 20% wetlands ideally composed of a significant proportion of temporary wetlands;
- A predominant herbaceous vegetation cover with at least 15% tree or shrub environments, without exceeding 50%:
    - A heterogeneous layout of plant communities is highly favourable;
- A network of shallow and low-flow channels that favour dispersal.

The following characteristics are assets:

- No surface water drainage and catchment that influences the environment's water system;
- Limited presence of anthropogenic environments and annual intensive crops;
- Limited presence of sources of water contamination;
- Few to none invasive alien species, such as reed grass and buckthorn;
- Limited presence of dispersal barriers (e.g., roads, major watercourses, anthropogenic surfaces, dry environments).

It is also recommended that the restoration project aim to ensure a sustainable conservation environment with a size that accommodates multiple breeding habitats in a natural environment matrix permeable to western chorus frog dispersal and with a consolidated perimeter so as to minimize the edge effect with areas of anthropogenic use.

3.1.1 Assessment of restoration approaches

Characteristic thresholds were selected for three main preferred habitat elements of a western chorus frog habitat with a radius or diameter of 300 meters, derived from the study by Bouthillier and Reyes (2016), namely, wetland density, vegetation opening and connectivity, in order to guide restoration strategies to enhance existing habitat or develop potential habitat for the western chorus frog. Improvements are suggested for each element when thresholds are not met in a given environment. In addition, the terrestrial habitat conserved around these wetlands should be 300 meters or more, with some exceptions.

Threshold 1: Where the percentage of wetlands is less than 30%

- Establish temporary wetlands suitable for western chorus frog breeding (point 4.1);
- Increase habitat water storage capacity through various techniques such as:
    - Increase the hydroperiod of ephemeral wetlands through deepening;
    - Widen sections of ditches with lack of drainage to favour water accumulation or flow in a low-slope area or natural depression;
    - Install clay dykes (clay plugs) in flow channels draining wetlands at appropriate locations;
    - Raise the water level of the wetland through a mound created on the downstream bank;
- Favour water retention from precipitation by limiting surface runoff:
    - Block drainage ditch flow with earthen dikes that route excess runoff to a potential accumulation zone or developed area;
    - Use submersible filtering dikes to slow water flow and increase retention time in ditches (Bentrup 2008);
    - Install water level control structures or dikes in major flow paths;
    - Raise rainwater manhole levels.

Threshold 2: Where the representativeness of open environments is less than 40-50%

- Reduce the land canopy cover to aim for a habitat made up of 75% open habitat and sparse forest;
- Make openings in the canopy by targeting pioneer or exotic species or individuals in poor condition;
- Maintain existing fallow environments with mowing in late fall every 3 to 4 years;
- Control invasive alien plants species (IAPS) using proven methods and by limiting the impact on habitats and the western chorus frog, as well as by reseeding with native herbaceous species (Appendix 2);
- During the winter, remove debris from wetlands and safely dispose of IAPS debris;
- To diversify the tall grass cover of overly homogeneous meadows, mow one or more 1-ha sections each year late in the season and rotate the treated plots every 4 to 5 years, while keeping at least 30% untreated areas.

Threshold 3: Where there is habitat fragmentation not conducive to western chorus frog dispersal

- Improve connectivity and water quality along watercourses with riparian strips widened by 10 to 30 meters;
- Provide connectivity corridors between population cores;
- Restore discontinuities in existing corridors;
- Favour the creation of multi-species wildlife crossings under roads.

3.1.2 Detailed characterization of the target development environment

Once the objectives have been determined, a more accurate characterization of the receiving environment will allow the developments to be properly sited and designed. This characterization should lead to an assessment of the existing strengths that the development project can build on along with the deficient aspects that need to be addressed by the development (see sections 4 and 5 for the proposed development strategies). A characterization of the receiving environment should lead to the following actions:

- Delineate the contours of permanent and temporary wetlands at their highest flooding levels;
- Document the hydroperiod of potential wetland habitats for the development;
- Document the temporal dynamics of the interstitial runoff from spring to late summer as well as the flows involved for the potential sites;
- Identify the flow paths, peak flows and flow direction;
- Assess the water quality in the area along with activities in the watershed that may affect the water quality of the development;
- Qualify the substrate found in the potential wetlands for the development;
- Identify the presence of predatory species;
- Determine the development of the tree canopy;
- Map the presence of invasive species.

4. Design concept

4.1 Development of breeding sites

4.1.1 Selection of breeding pond implementation site

The selection of a development pond site implies that an analysis of the water accumulation areas, surface runoff, and environmental characterization data has been completed and that the selected site has favourable characteristics. The site must then meet surface water retention requirements through the presence of clay soil and not be hydrologically connected to fish habitat. Ideally, sites with spring water accumulation should be studied first. Conversely, areas where invasive species are present should be avoided. For the target site(s), other prior data are required in greater detail, such as the existing topography and degree of sunlight.

4.1.2 Characterization of hydrology

It is recommended to visit the target site immediately after the snowmelt and then in mid-June to map the wetlands, runoff and flows It is suggested that a piezometer be installed at the pond site prior to development to collect surface hydrological data on pre-existing conditions for at least one season. The quantity of water accumulated on the surface and in the first centimeters of water accumulation in the soil will be determined by piezometric monitoring (See 5.1 below). With this data, the drying rate and hydroperiod of the chosen site will be validated according to the precipitation received, based on data collected by a nearby meteorological station. The development concept that will be realized will apply specifically to preexisting conditions in the receiving environment. The complete methodology is described in the western chorus frog breeding habitat hydrological monitoring protocol (Bouthillier et Reyes 2017).

4.1.3 Water quality

In the restoration strategy, vegetated buffer strips can be installed to reduce the impact of contamination sources. The use of native species that are a combination of herbaceous and shrub species achieves several objectives, including sediment trapping, improved infiltration, and improved wildlife habitat quality:

- Set up buffer strips as close to pollution sources as possible and follow contour lines so that preferential surface flow paths are directed towards the buffer zone (Bentrup 2008);
- Install a vegetated buffer strip at least 30 to 60 meters wide between the contamination sources and the developments (Ouellet, M. et Leheurteux 2006; Semlitsch, R. D. et Jensen 2001);
- A mix of herbaceous and woody species may be the best overall combination of plants for a permanent vegetation cover (see list in Appendix 2);
- Plant debris contributes to pesticide denitrification and degradation, while large woody debris favour sediment deposition;
- Select plants that tolerate deicing salts if these products are involved;
- Periodically remove trees and shrubs as needed to maintain heavily grassed buffer zones or to maintain the desired mix of woody species (Bentrup 2008).

4.1.4 Soil quality for the development

The selected site must have a substrate that enables surface water retention. It is important to check for the presence of clay soils by drilling with an auger to determine the particle size in the first metre. A ribbon test can be performed on the site during the visit. The proposed methodological details are described in the technical data sheet in Appendix 1. It should be noted that if the soil does not have a sufficient surface water retention capacity due to its coarse particle size, corrections will require adding clay, using bentonite clay, or installing a waterproofing membrane at the bottom of the pond. In all cases, this will considerably increase the cost and complexity of the project and for post-development piezometric monitoring.

4.1.5 Topography

Western chorus frog breeding environments are typically less than 50 centimeters in depth. Precise topographical measurements must be taken at the location chosen to carry out the breeding pond development plan. The survey should be conducted without the presence of any leaves to facilitate data measurement. The measurements must enable the site microtopography and surface flows to be properly sited. These data are required to determine:

- The ideal location;
- The depth at which the bottom of the projected pond must be located in relation to the surrounding land;
- Configuration of contour lines;
- Spillover axis.

Topographical surveys with referencing using a survey marker are not always required, although it is preferable to have such referencing in relation to the actual elevation of the area in the watershed. The elevation can be used to position the development and validate the local watershed that feeds it.

4.1.6 Amount of sunlight

After leafing out, sunlight can be assessed by direct observation, or using a densitometer, to better delineate the shade at the installation site. For instance, the sun angle at this time of year is 45° below our latitudes, so the shade created by a 20-metre tree extends over 20 meters. If sunlight conditions between 10:00 a.m. and 2:00 p.m. are not optimal, either the location of the development will need to be changed or the site will need to be prepared by selective felling in the pond's exposure quadrant, preferably in winter, between the 130º and 230º azimuths:

- Cut down trees that create shade over the pond between 10:00 a.m. and 2:00 p.m. and dispose of the cutting debris outside of the wetlands and the area to be developed;
- If there is buckthorn to be cut down, dispose of debris outside of the habitat or compost it away from wetlands and surface runoff;
- If necessary, replace the cut stems with indigenous compact shrub species or herbaceous species typical of wetlands (see Appendix 2).

Planting small shrubs and herbaceous seeding does not affect sun exposure and reduces the need for subsequent woody stem control.

4.2 Guidelines for the development of a breeding habitat

The complexity of a breeding habitat development that meets the specific requirements of the western chorus frog lies in the capacity of the developed environment to maintain an adequate hydroperiod for complete larval development while maintaining relatively stable water levels and temperature after the initial warming. This last aspect is an indirect consequence of the ability of the watershed to compensate for precipitation within its many wetlands as well as a direct consequence of pond configuration. These environments are dependent on precipitation to maintain themselves. Due to climatic variability, a restoration project must aim for the development of several ponds with a heterogeneous layout and location, so that there are ponds that meet the needs of the species itself in extreme hydrological conditions. The configuration of the development contributes to this through:

- Low slopes with ratios ranging from 1V:3H to 1V:5H;
- A slightly irregular contour;
- An overflow zone along the periphery that serves as a retention basin during overflows from snowmelt, for example.

These ponds should be of different sizes, with each surface area assessed according to environmental characteristics, in order to produce separate hydroperiods from 60 to 100 days, or even longer, to maximize recruitment success year after year, despite the spring droughts.

- The development should aim for a depth of 0.4 to 0.6 meters;
- The deep portion of the development that is at the maximum depth must be at least 30% of the total surface area;
- We suggest not less then a minimum surface area of 200 m^2.

The size of each pond should be appropriate to the potential evapotranspiration rates. Variations in the volume of water to compensate for evapotranspiration during excessive heat or drought events can be proposed in the design. A pond with a hydroperiod of 90 to 100 days and the presence of a permanent wetland in the surrounding area can be a sound choice to counter periods of drought caused by climate change. Several combinations of surface areas associated with a maximum depth may be proposed, such as:

- An area of 200 m^2 to 300 m^2 with a depth of 0.6 m;
- An area of 500 m^2 to 600 m^2 with a maximum depth of 0.5 m;
- An area of 700 m^2 to 1000 m^2 with a maximum depth of 0.4 m.

A technical data sheet listing the recommended guidelines is found in Appendix 1. The approximate costs of a breeding site development can be found in Appendix 3.

4.2.1 Restoration of vegetation cover

The following actions are recommended when an herbaceous vegetation cover has to be restored in formerly cultivated or reworked areas:

- Loosen the soil;
- Seed with an herbaceous mix typical of wetlands or adapted to soil conditions:
    - Boivin and Brisson (2014) recommend more than 50% small annual plants, 25% interstitial plants, and 25% tall clonal plants;
    - Native plant mixes are commercially available. Some species to be prioritized are listed in Appendix 2;
    - Unless otherwise stated, a rate of 3000 seeds/m^2 should be used (Boivin and Brisson, 2014; Byun et al., 2013);
    - Planting/seeding should be done as early in the year as possible, between May and July; otherwise, in the fall, in September and October;
    - The possibility of covering seeded areas with straw mulch should be assessed;
    - After two months of growth, the measure of seeding success must be 75% of ground cover in a terrestrial environment;
    - Recommended plants are listed in Appendix 2.

4.3 Concept for restoring connectivity

Preference should be given to the development of dispersal corridors along flow paths and migration corridors where the landscape is favourable. It is suggested that multiple travel routes be built and discontinuities in existing routes restored to increase interconnectivity. It is preferable to develop and protect large areas of connectivity in order to reduce the effect of negative external pressures, commonly referred to as an “edge effect.” The preferred guidelines are shown below.

4.3.1 Guidelines for the development of a connectivity corridor

- Improve the permeability of the watercourses and flow paths of interest through the following actions:
    - Create gentle slopes of 1V:3H to 1V:5H;
    - Limit erosion and maintenance with the creation of expanded riparian strips with an herbaceous and shrub cover consisting of indigenous species (Appendix 2);
    - Create areas for overflowing water along the flow paths;
- Provide connectivity corridors with a minimum width of 60 meters for distances of less than 100 meters;
- Increase the width of the corridors in proportion to their length:

    - Create plots 100 to 300 meters in width with breeding developments every 100 meters along these dispersal corridors;
- Favour the creation of wildlife crossings under roads using structures to be used by multiple wildlife species and that are at least one metre in diameter:
    - For the characteristics of the recommended structures, see the Ontario Ministry of Natural Resources and Forestry guide at https://files.ontario.ca/bmp_herp_2016_final_final_resized.pdf;
    - The crossing design should favour a moist substrate in the structure as well as little water or a light flow by avoiding floods and high velocity flows as well as the penetration of natural light;
    - An optimal habitat must be created for dispersal near the openings to facilitate the permeability of the structure; a breeding pond within 100 meters is recommended;
- Vegetate roadside ditches near the corridor and design them to reduce the flow velocity to form valleys without creating a pond:
    - Smooth out ditch slopes with slopes of 1V:3H;
    - Slow the flow caused by a longitudinal slope made more pronounced by:
        - Construction of a drain or grassed waterway;
        - Creation of retention sills through a succession of small rocky sills;
        - Development of the ditch with two flow levels;
- Assess on a case by case basis the use of mechanisms to discourage use of the road, such as exclusion fencing or the retaining wall riprap;
- Minimize the use of deicing salts in habitat and connectivity areas or replace them with materials that are environmentally and technically viable, such as sand or wood chips.

5. Development monitoring

Due to the complexity of the implementation environments and the expected results as well as developments to meet the needs of the western chorus frog, the projects require a period of adjustment and experimentation. To that end, the production of an as-built plan is strongly suggested as a reference. A post-development monitoring period of a few years will help document changes in the habitats and their use by wildlife during several spring seasons with varying climatic conditions. Standardized monitoring of pond parameters should include the elements presented in the following sections.

5.1 Hydroperiod monitoring

In practice, the pond hydroperiod is calculated from the spring thaw to the first complete drying out. The theoretical start of the hydroperiod is calculated as soon as average temperatures remain above the freezing point combined with the first occurrence of a maximum temperature above 5ºC. Piezometric monitoring should be done five years long once the development has been completed to verify the progression of the hydroperiod under different climatic conditions.

- Conduct hydrology monitoring with a water level data collection device;
- Follow the methodology in the western chorus frog breeding habitat hydrological monitoring protocol (Bouthillier et Reyes 2017):
    - Parallel monitoring of precipitation and air temperature data at the nearest weather station must also be conduct;
    - The temperature can be documented directly from the water level probe (hydrological monitoring guide);

- The date of the first drying out must be assessed and a comparison done of the hydroperiod against local precipitation conditions.

Corrective actions can also be planned based on the efficiency results obtained in the first years.

5.2 Water quality monitoring

The water pH levels in wetlands where the western chorus frog is found is expected to be close to the concentration of rainwater. In addition, the salinity of the water in the breeding environments should not exceed a concentration of 2 g/l. The electrical conductivity of the water is proportional to its electrically conductive salt ion concentration and enables salinity to be determined. For monitoring water quality in the developments, we suggest, in addition to direct observation of colour and deposits, pH and conductivity measurements as general indices of water quality. Collect a representative sample as close to the bottom as possible. Dissolved sodium chloride levels can always be measured more accurately with a calibrated refractometer or salinometer. At 25º Celsius, a measurement ranging from 0 to 500 is considered to be in the non-saline water category, according to the scale by J.H. Durand (1958).

- Water pH levels should be close to the neutral value (7.0 ±1.0);
- Water conductivity should ideally be under 100 µS, without exceeding 350 µS:

5.3 Vegetation monitoring

- Monitor seeded plant regrowth and the survival of plantings during the first two growing seasons:
    - Cover rate of native herbaceous flora acceptable at 85% of ground cover;
    - Survival rate of plantings acceptable at 85%;
- Verify vegetation succession in the riparian strip of breeding the grounds and sun exposure every five years;
- Check the habitat tree cover every 20 years.

5.4 Monitoring of use by wildlife species

- April to July: listening to anuran songs and direct observation of adults and metamorphs for the first five years, and then at regular intervals (five-year increments are suggested);
- Conduct an inventory using a handle aquatic net and bait trap to detect the presence of predators in May and June for the first five years, and then at regular intervals (five-year increments are suggested):
    - A permit for the capture of wildlife for scientific, educational or wildlife management purposes is required in Quebec (MELCCFP SEG permit);
- Assess western chorus frog reproductive success in developed ponds if songs were heard in the spring:
    - It is suggested, at a minimum, to qualitatively detect the emergence of metamorphs through direct observation in mid-June along the edge of the pond coupled with an aquatic net and bait trap inventory;
    - In Quebec, a MELCCFP SEG permit is required for capture.

Note: Techniques for quantifying the number of metamorphs with eDNA are being studied, which could lead to changes for a quantitative assessment.

6. Conclusion

Habitat development and restoration can be used to address population demise and ensure better recovery: 1) by improving the support capacity of occupied habitats, 2) by creating habitats to expand the current range, or 3) by addressing habitat fragmentation by restoring connectivity through the development of dispersal corridors.

To successfully recreate conditions that favour the life cycle of the western chorus frog, the focus must therefore be on implementation areas that already have favourable landscape characteristics. The living environment of the species is associated with a particular wetland habitat type and a complex water regime. It is difficult to preserve characteristics favourable to the maintenance of western chorus frog populations in a developed habitat, since such a habitat is dependent on the hydrological conditions of the watershed, climate variations, as well as the species that will colonize it. For this reason, habitats with characteristics that are too far removed from the specific features of the preferred habitat should not be used for a western chorus frog development.

The specific features of the species' preferred habitat are difficult to recreate. Several development attempts in Quebec have either failed or had very limited success. However, several parameters are known to date, based on recent studies and experimentation. However, care must be exercised, and knowledge acquisition is still paramount at this stage of our knowledge. Based on all the factors that may affect the hydroperiod, sunlight, plant composition and the presence of predators, a non-invasive approach should be chosen based on the environmental predispositions.

With the aim of achieving recovery, the natural environments occupied by the western chorus frog must be a conservation priority in an urban, peri-urban or agricultural setting. In the absence of proven effectiveness, natural habitats must be conserved and protected.

7. Bibliographic References

Bentrup, G. 2008. Zones tampons de conservation : lignes directrices pour l’aménagement de zones tampons, de corridors boisés et de trames vertes. . U.S. Department of Agriculture, Forest Service, Southern Research Station., Asheville, NC:, 115p.

Biebighauser, T. R. 2011. Wetland restoration and construction: a technical guide. Tom Biebighauser.

Bogart, J. P., E. B. Taylor et R. Boles. 2015. Rainette faux-grillon de l’ouest (Pseudacris triseriata) et rainette faux-grillon boréale (Pseudacris maculata): clarification concernant les espèces sauvages inscrites en vertu de la LEP à la lumière d’interprétations taxinomiques récentes 7.

Bonin, J. et P. Galois. 1996. Rapport sur la situation de la rainette faux-grillon de l’Ouest (Pseudacris triseriata) au Québec. Ministère de l’Environnement et de la Faune, Direction de la faune et des habitats, 39p.

Bouthillier, L. et L. Reyes. 2016. Étude des habitats potentiels au mont Saint-Bruno pour l’aménagement d’habitats pour la rainette faux-grillon. Rapport pour l’année 2015. Ministère des Forêts, de la Faune et des Parcs, Direction de la gestion de la faune de l’Estrie, de Montréal, de la Montérégie et de Laval, Secteur des opérations régionales, Longueuil, 73p.

Bouthillier, L. et L. Reyes. 2017. Protocole de suivi hydrologique des habitats de reproduction de la rainette faux grillon. Ministère des Forêts, de la Faune et des Parcs, Direction de la gestion de la faune de l’Estrie, de Montréal, de la Montérégie et de Laval., 14p.

Bouthillier, L., L. Reyes et I. Picard. 2017. Étude pour l’aménagement d’habitats pour la rainette faux-grillon au mont Saint-Bruno. Rapport final pour 2016. Ministère des Forêts, de la Faune et des Parcs, Direction de la gestion de la faune de l’Estrie, de Montréal, de la Montérégie et de Laval, Secteur des opérations régionales., Longueuil, 127p.

Bridges, C. M. et R. D. Semlitsch. 2000. Variation in pesticide tolerance of tadpoles among and within species of Ranidae and patterns of amphibian decline. Conservation Biology 14(5): 1490-1499.

COSEPAC. 2015, novembre 26. Énoncé de clarification sur les questions taxinomiques pertinentes pour la situation des rainettes faux-grillons au Canada.

Dananay, K. L., K. L. Krynak, T. J. Krynak et M. F. Benard. 2015. Legacy of road salt: Apparent positive larval effects counteracted by negative postmetamorphic effects in wood frogs. Environmental Toxicology and Chemistry 34(10): 2417-2424.

Desroches, J.-F. et D. Rodrigue. 2004. Amphibiens et reptiles du Québec et des Maritimes. 2004. Éditions M. Quintin.

Drayer, A. N. 2011. Efficacy of constructed wetlands of various depths for natural amphibian community conservation.

Dupré, R. K. et J. W. Petranka. 1985. Ontogeny of temperature selection in larval amphibians. Copeia (2): 462-467.

Durand, J. H. 1958. Les sols irrigables; étude pédologique.

Environnement Canada et Santé Canada. 2001. Liste des substances d'intérêt prioritaire rapport d'évaluation : Sels de voirie. Environnement Canada, 188 pagesp.

ÉRRFGOQ. 2019. Plan de rétablissement de la rainette faux-grillon de l'Ouest (Pseudacris triseriata) — 2019-2029, produit pour le ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Équipe de rétablissement de la rainette faux-grillon de l'Ouest du Québec., 65 p.p.

Gagné, C. 2011. Analyse des caractéristiques du paysage en lien avec la présence de la rainette faux-grillon de l'Ouest en milieu agricole en Outaouais, incluant le parc de la Gatineau. Rapport présenté à la Commission de la capitale nationale. Conservation de la Nature Canada CNC, 54p.

Golet, F. C. et J. S. Larson. 1974. Classification of Freshwater Wetlands in the Glaciated Northeast.

Hoffman, D. J., B. A. Rattner, G. A. Burton Jr et J. Cairns Jr. 2002. Handbook of ecotoxicology. CRC press.

Jarchow, M. E. et B. J. Cook. 2009. Allelopathy as a mechanism for the invasion of Typha angustifolia. Plant Ecology 204(1): 113-124.

Klaver, R. W., C. R. Peterson et D. A. Patla. 2013. Influence of water conductivity on amphibian occupancy in the Greater Yellowstone Ecosystem. Western North American Naturalist 73(2): 184-197.

Kolozsvary, M. B. et M. A. Holgerson. 2016. Creating temporary pools as wetland mitigation: how well do they function? Wetlands 36(2): 335-345.

Larocque, M., M. Roux, S. Gagné et O. Cousineau. 2020. Acquisition de connaissance sur la dynamique hydrique de la rainette faux-grillon de l'ouest - Rapport final. Université du Québec à Montréal, Rapport déposé au Ministère des Forêts, de la Faune et des Parcs, Montréal, Québec, 86p.

Lougheed, S. C., P. Li, R. Clemente-Carvalho, Y. Chen, M. K. Hickox et N. A. Cairns. 2020. Using Next Generation Sequencing Data to Test for Distinctiveness of Disjunct Regional Populations of Western and Boreal Chorus Frogs in Canada. Department of Biology, Queen's University.

McNaughton, S. J. 1968. Autotoxic feedback in relatin to germination and seedling growth in Typha latifolia. Ecology 49(2): 367-369.

MELCCFP. 2023. Analyse des menaces et évaluation de la viabilité des occurrences de la rainette faux-grillon de l'Ouest (Pseudacris triseriata) au Québec — Rapport d'analyse réalisé dans le cadre de l'approche intégrée de rétablissement (AIR). Gouvernement du Québec, Québec, 25 p.

Montpetit, T., L. Tanguay et N. Roy. 2010. Protocole et principes d'aménagement et de suivi de nouveau habitats pour la rainette faux-grillon. Centre d'information sur l'environnement de Longueuil, 23p.

Morard, É. et N. Zuberbühler. 2006. Qualité de l'eau et succès de la reproduction des amphibiens, Grenouilles rousses (Rana temporaria) et Rainettes vertes (Hyla arborea) dans des étangs créés à leur intention dans les cantons de Bâle et d'Argovie. Centre de coordination pour la protection des amphibiens et des reptiles de Suisse, Karch. 28 p.

Ouellet, M. et C. Leheurteux. 2006. PPrincipes de conservation et d'aménagement des habitats de la rainette faux-grillon de l'Ouest (Pseudacris triseriata): revue de littérature et recommandations. Amphibia Nature et le ministère des Ressources naturelles, de la Faune et des Parcs, Québec, 53p.

Ouellet, Martin, C. Fortin et M.-J. Grimard. 2009. Distribution and habitat use of the boreal chorus frog (Pseudacris maculata) at its extreme northeastern range limit. Herpetological Conservation and Biology 4(2): 277-284.

Ouellet, Martin et C. Leheurteux. 2007. Principes de conservation et d'aménagement des habitats des amphibiens: revue de littérature et recommandations suggérées pour la rainette faux-grillon de l'Ouest (Pseudacris triseriata). Le Ministère, Direction du développement de la faune.

Picard, I. 2015. Portrait de la rainette faux-grillon en Montérégie en 2014: 10 ans plus tard. Ciel et Terre, Longueuil, Québec, 92 pages + 8 annexesp.

Picard, I. et A. Porciuncula. 2017. Projet « Restaurer et améliorer les écosystèmes humides protégés de la rive-sud de Montréal 2016-2019 ». Portrait initial du site, évaluation des secteurs et des types d'intervention et cahier de charge. Ciel et Terre, Longueuil, 106 pages et annexes.p.

Rittenhouse, T. A. 2011. Anuran larval habitat quality when reed canary grass is present in wetlands. Journal of Herpetology 45(4): 491-496.

Roy, É. et M.-P. Beauvais. 2014. Revue de littérature sur les caractéristiques des étangs de reproduction aménagés pour la rainette faux-grillon de l'Ouest. Nature-Action, Québec, 40 pages + annexesp.

Roy, É., N. Tessier, L. Veilleux, M.-P. Beauvais, L. Bouthiller et K. Lehoux. 2014. Acquisition de connaissances et validation des protocoles d'aménagements pour la rainette faux-grillon. Rapport rédigé par Nature Action Québec et MDDEFP pour la Fondation de la faune du Québec, 67 p.p.

Sacerdote, A. B. et R. B. King. 2014. Direct Effects of an Invasive European Buckthorn Metabolite on Embryo Survival and Development in Xenopus laevis and Pseudacris triseriata. Journal of Herpetology 48(1): 51-58.

Semlitsch, R. 2013, décembre 18. Demande d'avis sur les paramètres importants pour le suivi des étangs de rainette faux-grillon de l'Ouest.

Semlitsch, R. D. et J. B. Jensen. 2001. Core habitat, not buffer zone. National wetlands newsletter 23(4): 5-6.

Shulse, C. D., R. D. Semlitsch, K. M. Trauth et J. E. Gardner. 2012a. Amphibian Reproductive Success in Wetlands. The Bulletin of the Ecological Society of America 93(3): 236-237.

Shulse, C. D., R. D. Semlitsch, K. M. Trauth et J. E. Gardner. 2012b. Testing wetland features to increase amphibian reproductive success and species richness for mitigation and restoration. Ecological Applications 22(5): 1675-1688.

Skelly, D. K. 1997. Tadpole communities: pond permanence and predation are powerful forces shaping the structure of tadpole communities. American Scientist 85(1): 36-45.

Skelly, D. K., E. E. Werner et S. A. Cortwright. 1999. Long-term distributional dynamics of a Michigan amphibian assemblage. Ecology 80(7): 2326-2337.

Smith, D. C. 1983. Factors controlling tadpole populations of the chorus frog (Pseudacris triseriata) on Isle Royale, Michigan. Ecology 64(3): 501-510.

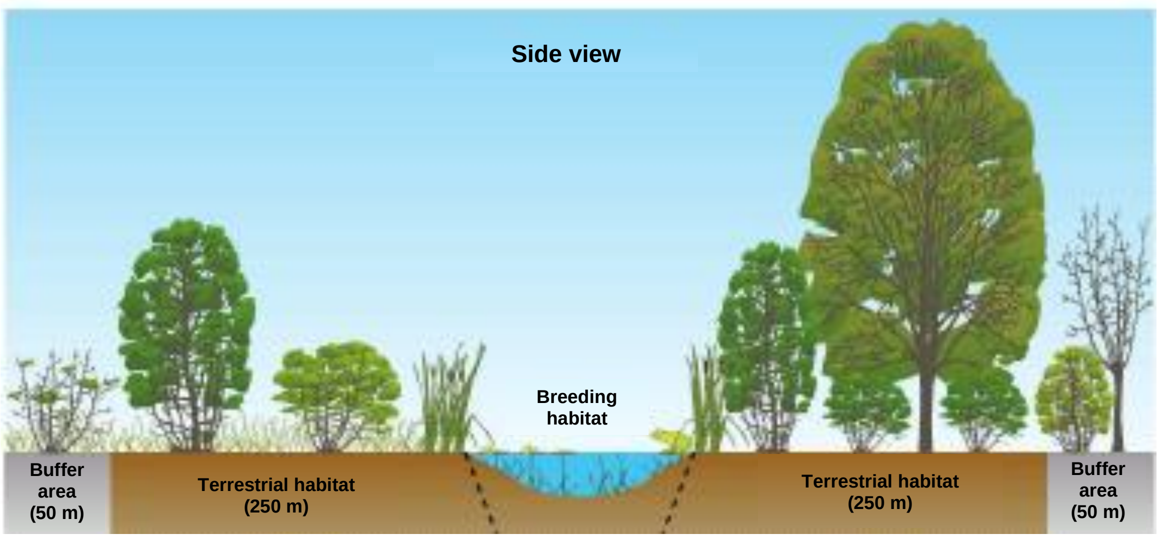
Werner, E. E., R. A. Relyea, K. L. Yurewicz, D. K. Skelly et C. J. Davis. 2009. Comparative landscape dynamics of two anuran species: climate-driven interaction of local and regional processes. Ecological Monographs 79(3): 503-521.

Whitaker Jr, J. O. 1971. A study of the western chorus frog, Pseudacris triseriata, in Vigo County, Indiana. Journal of Herpetology 127-150.

Appendix 1: Technical Data Sheet – Western Chorus Frog Breeding Pond Development

Description of a typical habitat

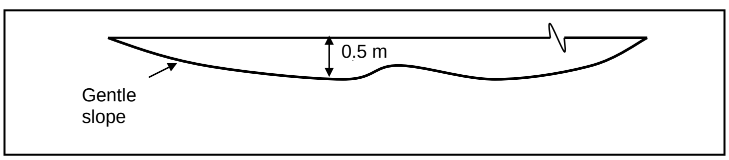
- The breeding pond varies in size and is surrounded by a terrestrial habitat with a surface area of 250 m and a 50-m buffer strip, as shown in the following figure.



Sectional diagram of western chorus frog habitat (adapted from Montpetit, T. et al. 2010)

Description of a typical breeding environment

- Breeding ponds are typically 30 to 45 up to 60 centimeters deep and consist of still, stagnant water fed by rain, snowmelt or groundwater;



Sectional diagram of western chorus frog breeding habitat

- The pond banks have gentle slopes, ideally 1:3 or 1:5, meaning that 1 metre of height difference is associated with a length of 3 to 5 meters of bank:

Unfavourable slope if ≥ 0.30%,
Very steep slope of 1:2.5

Favourable slope if ≤ 25% in relation to 1:5;

Sectional diagram of very steep slope and favourable slope

- Water is supplied to the breeding environment through snowmelt and precipitation;
- The minimum hydroperiod (when surface water is present) is 60 to 100 days.

Recommendations

- The breeding development must completely dry out each year after July 1, otherwise every two years;
- Hydroperiod monitoring with a surface piezometer is preferred;
- Avoid any hydrological contact with a watercourse or ditch where fish are present;
- The water feeding into the ponds must not be connected to the municipal or industrial storm drainage system, since this water may contain contaminants;
- The vegetation belts from the centre of the pond outwards totalling 100 to 200 meters in radius consist of:
  - A first belt that includes the breeding environment with a 30-metre riparian strip:
    - Must consist of a portion of open water and a portion with low herbaceous vegetation (e.g., sedge, rushes, grasses);
    - A few scattered trees are acceptable along the northern edge since they do not impact the wetland's sun exposure.
  - A second belt considered as a terrestrial feeding and hibernating habitat:
    - May consist of a patchwork of grasses, shrubs (e.g., willows, spirea, dogwood), scattered trees, or with forest plots covering 10 to 50% of the area.

Site selection

- The aim is a terrestrial habitat over a 200-m radius (30% or more grassland, 20% or more wetlands, 50% or less sparse forests);
- Loamy, clayey or silty clay soil must be chosen with water retention characteristics and/or lack of drainage;
- The site should have few or no invasive species such as alder buckthorn (*Frangula alnus)* and European buckthorn (*Rhamnus cathartica*), and especially common water reed (*Phragmites australis*);
- Exclusion zones should be observed, such as:
  - Transmission tower anchoring under electrical power lines (27 m);
  - Gas pipeline rights-of-way (variable);
  - Proximity to road ditches, fish habitat and drainage ditches maintained as much as possible.

Selection of development period

- The development should ideally be carried out when the ground is frozen, during the winter, otherwise when the land dries out in late summer or near the hibernation period in October and November, to ensure the ground bearing of motorized equipment and avoid wildlife fatalities;
- It is recommended that planting/seeding be done as soon as possible after the work has been completed:
  - Between April and late May or as soon as the water dries up so that the new plant species can become established before the exotic common reed begins to grow;
  - In the fall if the method used ensures seed or plant growth in the following year;
  - Avoid the dry period for seeding and planting.

Description of a developed breeding environment

- The ideal shape of the ponds being developed is circular, but it can be modified according to the purpose of the site and its size: oval, rectangular or widened ditch, but natural-looking shapes are recommended;
- The minimum pond size is ideally more than 200 m² and can be up to 1000 m², depending on the humidity conditions of the receiving environment and sunlight;
- A development of 2 or 3 ponds of various capacities and hydroperiods is preferable rather than a single pond;
- The depth should not exceed 0.6 m, and ideally 30 to 45 cm.
- Slopes are less than 25%;
- Ensure a coverage ratio of wetlands and favorable terrestrial environments of 1:1 up to 2:1;
- The environment of the chosen location is such that the site warms up quickly during the thaw and there is sunlight between 10:00 a.m. and 2:00 p.m., from the thaw to July 1;
- To ensure the sustainability of the work, it is important to promptly revegetate the treated sites with species suited to the site drainage conditions. Rapid seeding of the disturbed surfaces with a mix of native grasses is required.

Plant seeding

Preference should be given to mixes of native herbaceous species for wet meadows with a diverse composition rather than ryegrass seed. It is important to favour species suited to the type of soil and that are quickly established. Suppliers can provide the representative percentages by species and the seeding rate, and Appendix 2 can also serve as a reference.

- The recommended seed mix should contain more than 50% annual plants, 25% interstitial plants and 25% tall clonal plants to ensure effective vegetation restoration using a rate of 3000 seeds/m^2.
- The mix consists of:
  - 50% small, fast-growing annual plants (e.g., *Bidens connata*, *Bidens cernua*, *Eleocharis obtusa* and *Lolium multiflorum*);
  - 25% medium-sized plants (e.g., *Mimulus ringens*, *Carex hystericina*);
  - 25% tall clonal plants (e.g., *Leersia oryzoides*, *Schoenoplectus tabernaemontani*).
- Use of the mix for bank regeneration, diking and waterfowl may be suitable. The mix is composed of sweet-clover, timothy, reed canary grass, Tribute fescue, marsh bent grass and/or streambank wheatgrass, hybrid and/or white clover, and Tatjana fescue.

* Avoid planting cattail. The plant’s significant production of aboveground biomass often results in a large amount of ground litter, which reduces the warming capacity of the breeding sites.

Development procedure

- Soil permeability test – check the soil's capacity to effectively retain surface water to determine if a membrane will be required. Collect a soil core sample and check for coarse or permeable substrate and the presence of clay and impervious material.
- Other techniques:
    - Ribbon test: take a soil sample and form a ball about 2.5 centimeters in diameter, wet it with a little water and try to form a short ribbon with your fingers that is 5 centimeters (2 inches) long. If it can be held at one end without breaking indicates that the soil has good water retention capacity ((Biebighauser 2011);
    - Auger coring up to 3 feet deep and measurement of water table height using a graduated ruler;
    - Another option during a dry period is to check for grey soil colour, conduct a 24-hour water retention test, cover the coring hole, and come back 24 hours later to check if water has seeped in.

A few conditions that can be included in the work method to ensure that impacts on the existing environment are minimized:

- Schedule work during periods where there is the least impact on frozen ground or after October 15th; otherwise, avoid the period between the thaw and August First.
- Avoid machinery movement and any debris resulting from work in the conservation hub wetlands. Avoid breeding wetlands and the associated 30-metre protective strip.
- Clearly position the boundaries of habitats of at-risk species and wetlands to be avoided within the area involved. If possible, avoid the first 100 meters around breeding wetlands.
- Select construction equipment based on terrain type, favour the lowest ground contact pressure, and equip heavy machinery with crawler tracks and biodegradable fluids.
- Install covered surface culverts in transversal ruts when stabilizing access roads.
- Minimize access roads used by machinery. For example, use existing trails to avoid disturbing the environment, especially since the area is a conservation area. Indicate the permitted access roads on a map.
- Systematically fill ruts that exceed 20 centimeters.
- During excavation, keep the topsoil in windrows (at least 25 centimeters thick) so that it can be reused for the restoration of the disturbed sites, if it does not contain any IAS.
    - Healthy soil should be separated from contaminated soil, which will be disposed of off-site or buried, in accordance with best practices.
- Limit to strictly as necessary the clearing of vegetation, scouring, stripping, earthworks and the levelling of work areas.
- Favour zones for disposing cuts outside the conservation area. Indicate the storage areas on a map for the contractor.
- Immediately after the restoration work, take the necessary steps to protect exposed surfaces to keep seeds in place and prevent soil erosion caused by runoff. Install mulch without the use of protective polypropylene netting.
- Close access roads at the end of construction to avoid illegal trails being created for motor vehicles.

Development monitoring

- Hydrological monitoring by piezometer (maximum depth, variations in hourly water levels and first drying out):
  - Ideally on an annual basis; otherwise, priority is given to the period between the thaw and September 1.
- Water temperature monitoring (associated with the previous element).
- Monitoring of use by wildlife (amphibian species and predators).
- Monitoring of western chorus frog recruitment.
- Monitoring of vegetation and invasive species regrowth.

A standardized protocol for monitoring western chorus frog developments is being tested and will be available in 2024. Contact your regional wildlife management branch part of the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs.

Appendix 2
List of Plant Species Favourable for the Development of Western Chorus Frog Habitats

Environment	Latin name	Height (m)	Soil type
Wet meadow	*Andropogon gerardii* (persistent foliage in winter)	2.0	Various soils
	Beckmannia syzigachne	0.4 to 1.0	Cool to moist soil
	Bromus ciliatus	0.6 to 1.2	Cool soil, moist soil, wet soil
	Desmodium canadense	0.45 to 1.25	Cool to moist soil
	Elymus canadensis (shelter plant)	1 to 1.5	Dry to moist soil
	Elymus trachycaulus	0.9	Cool to moist soil
	Eupatorium perfoliatum	1.0 to 1.5	Cool soil, moist soil, wet soil
	Festuca rubra	0.1 to 0.6	Dry to cool soil
	Geum rivale	0.25 to 0.6	Cool soil, moist soil, wet soil
	Impatiens capensis	0.5 to 1.0	Cool soil, moist soil, wet soil
	Lolium multiflorum (shelter plant)	0.6 to 1.2	Dry to cool soil
	Panicum virgatum	1.0 to 1.5	Cool soil
	Poa palustris	0.5 to 1.0	Cool soil, moist soil, wet soil
	Solidago canadensis	0.6 to 1.5	Dry to cool soil
	Spartina pectinata (stabilization)	0.8 to 1.5	Cool to moist soil
Shrubs	*Cornus stolonifera*	1.0 to 3.0	Dry to cool soil
	Ilex mucronata	2.0 to 5.0	Cool soil, moist soil, wet soil
	Physocarpus opulifolius	2.5 to 3.5	Various soils
	Salix eriocephala	1.25 to 1.5	Cool soil, moist soil, wet soil
	Salix interior	1.0 to 2.0	Moist to wet soil
	Spiraea latifolia	0.6 to 1.5	Various soils
	Spiraea tomentosa	0.6 to 1.5	Various soils
	Spirea alba	0.6 to 1.5	Dry to cool soil
Wetland	*Bidens cernua*	0.4 to 1.0	Cool soil, moist soil, wet soil
	Bidens connata	0.25 to 1.2	Moist to wet soil
	Bidens frondosa	0.6 to 1.0	Moist to wet soil
	Bromus ciliatus	0.6 to 1.2	Cool soil, moist soil, wet soil
	Caltha palustris	0.3 to 0.6	Moist to wet soil
	Hypericum virginicum	0.3 to 0.4	Moist to wet soil
	Iris versicolor	0.45 to 0.65	Cool soil, moist soil, wet soil
	Juncus effusus	0.45 to 0.65	Moist to wet soil
	Lycopus americanus	0.3 to 0.6	Moist to wet soil
	Poa palustris	0.5 to 1.0	Cool soil, moist soil, wet soil
	Scirpus atrovirens	0.8 to 1.2	Moist soil, wet soil

Source: https://www.aiglonindigo.com/catalogue

Appendix 3
Required Equipment and Costs for the Development of a Western Chorus Frog Breeding Pond

Appropriate equipment for excavation, pond preparation, and site revegetation is required, in addition to the equipment needed to install a membrane, if applicable. The costs are highly variable depending on the size of the pond. An assessment is provided below for a pond approximately 230 m² in size.

Approximate costs

The minimum total cost for a 230 m² pond is approximately $5,000, excluding labour costs (excluding the excavator operator).

Pond excavation machinery, materials and tools

Machinery	Type	Price/unit	Minimum cost
Power shovel (excavator)	Minimum 90 horsepower with a 42-inch-wide shovel	$180/hr x 10 hours	$1800
Or bulldozer	At least 100 horsepower		
Return transportation		$300/ one direction	$600
Hand tools	Shovels, rakes, spades		
Hand auger	Soil sampling		$100
Surveying level	Delineation		$100

Required and optional materials

Optional materials	Details	Price/unit	Costs
Soil	To raise a dike	$35/yard x 50 yards	$1750
45-mm EPDM or 30-cm PVC synthetic waterproof membrane	For covering the bottom of the pond (available from nurseries, pool suppliers and specialized companies)	$10/m² X 230 m²	$2300
Membrane lining, 8 oz min., for aquatic use and presenting no danger to fish	Sold in 50-foot widths. Double thickness required	$10/m² X (230 m² X 2)	$2300
Galvanized steel posts 12” in length with washers	For attaching the geotextile; sold in hardware stores	$1 X 100	$100
Shrubs			Variable
Trees			Variable
Required materials	**Details**	**Price/unit**	**Minimum costs**
“Biosecure” straw mulch	Straw without any invasive plant seeds	$10/bale X15	$150
Seeds for sowing, native wetland herbaceous species	Seeds for fast-growing annuals and perennials	$75/125 grams	Based on the surface area

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Québec