

PEPIN MARSH

Construction, Monitoring and Management Planning for a Restored Marsh
Habitat in Aldergrove Lake Regional Park.



Prepared For:

Vancouver Aquarium
Metro Vancouver
Ministry of Forests, Lands and Natural Resource Operations
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SUMMARY

Vancouver Aquarium, Metro Vancouver and the BC Ministry of Forests Lands and Natural Resource Operations are partnering to restore a historic wetland in Aldergrove Lake Regional Park, British Columbia. Pepin Marsh, the proposed wetland, will comprise several shallow ponds adjacent to an ephemeral marsh, and may serve as an introduction site for the endangered Oregon Spotted Frog.

The goals of this project are, through the restoration of a shallow-water marsh wetland habitat on historic agricultural fields, to:

- a) Provide recovery habitat for the endangered Oregon Spotted Frog;
- b) Enhance general wildlife biodiversity, with a particular focus on Species-at-Risk;
- c) Provide outdoor education, stewardship and research opportunities in wetland restoration and species recovery; and
- d) Increase our knowledge of marsh restoration techniques.

Restoration will involve the control of invasive plant species, a re-sculpting of the landscape and the hydrologic restoration of the historic wetland by plugging constructed drainage features, and re-planting with native vegetation. The constructed wetland will include features that promote use by species-at-risk, and features that intend to discourage high-density colonization of the marsh by invasive wildlife.

The constructed habitat will be monitored for hydrologic suitability, vegetative regrowth, wildlife presence and habitat feature development for a minimum of three years post-construction. If the habitat is assessed as suitable, Oregon Spotted Frogs may be introduced to the marsh following approvals by Metro Vancouver and the BC Ministry of Forests, Lands and Natural Resource Operations. Following this introduction, the marsh will be further monitored for the establishment of a self-sustaining population of Oregon spotted frogs, as well as habitat maturation.

In addition to providing habitat for native species, Pepin Marsh will provide stewardship opportunities, research opportunities and education opportunities for the general public, elementary schools, high schools, colleges and universities in the Lower Mainland of British Columbia.

1	BACKGROUND	1
2	SITE SELECTION.....	2
2.1	HYDROLOGY	2
2.2	HISTORIC RANGE.....	3
2.3	LAND JURISDICTION	4
2.4	EDUCATIONAL AND RESEARCH OPPORTUNITIES.....	5
2.5	REPRESENTATIVE OF RESTORABLE WETLANDS IN THE FRASER VALLEY	5
3	GOALS AND OBJECTIVES	6
3.1	GOAL	6
3.2	OBJECTIVES	6
4	WETLAND CONSTRUCTION ACTIONS AND TIMELINE.....	7
4.1	CONTROL OF INVASIVE SPECIES.....	7
4.2	HABITAT COMPLEXING AND FEATURE CONSTRUCTION FOR TARGET SPECIES.....	8
4.3	HYDROLOGIC RESTORATION	9
4.4	REVEGETATION WITH NATIVE PLANT SPECIES	9
4.5	CONSTRUCTION PARTNERS	11
5	ADAPTIVE ECOSYSTEM MANAGEMENT: MONITORING AND MAINTENANCE.....	11
5.1	POTENTIAL MONITORING OUTCOMES AND ASSOCIATED MANAGEMENT ACTIONS.....	14
5.1.1	<i>Hydrologic Outcomes.....</i>	<i>14</i>
5.1.2	<i>Revegetation Outcomes.....</i>	<i>15</i>
5.1.3	<i>Habitat Features.....</i>	<i>15</i>
5.1.4	<i>Wildlife Presence</i>	<i>16</i>
6	OREGON SPOTTED FROG INTRODUCTION AND MONITORING PLAN	16
6.1	INTRODUCTION	17
6.2	MONITORING	17
6.2.1	<i>Oviposition Surveys.....</i>	<i>17</i>
6.2.2	<i>Summer Visual Surveys.....</i>	<i>18</i>
6.2.3	<i>Breeding Season Mark-Recapture Surveys</i>	<i>18</i>
6.2.4	<i>Habitat monitoring.....</i>	<i>18</i>
6.3	LAND MANAGEMENT AFTER THE INTRODUCTION OF OREGON SPOTTED FROGS.....	18
7	STEWARDSHIP, CAPACITY-BUILDING, EDUCATION AND RESEARCH:.....	19
7.1	VOLUNTEER / STEWARDSHIP ACTIVITIES.....	19
7.2	RESEARCH AND MONITORING	19
7.3	YOUTH EDUCATION	20
8	NEXT STEPS	21
	REFERENCES CITED	22

1 Background

The Oregon Spotted Frog (*Rana pretiosa*) is a critically endangered species in Canada (BC red-list, SARA Schedule A, COSEWIC status Endangered). Currently its occupancy is limited to four known and isolated sites in southwestern British Columbia, and one recently extirpated isolated population, totaling under 300 breeding adult females. Reintroduction into historic and introduction into new habitats is essential for the survival and recovery of this species.

Historic wetland loss for agricultural development has eliminated much of the appropriate habitat in the Fraser Valley. As a result, historic habitats have been dramatically altered from their original structure and remnant populations are isolated. Extant and historic populations are additionally threatened by invasive species. The invasive American Bullfrog (*Lithobates catesbianus*) that have become established in the remaining lower mainland wetlands have been proposed as a direct cause of local extinctions. Bullfrogs now exist across approximately 90% of the historic OSF range in BC, and Bullfrog control efforts have been largely ineffective.

As both Oregon Spotted Frog and Bullfrogs prefer shallow warm slow-moving wetland habitats, restoration efforts must improve habitat for Oregon Spotted Frog while reducing suitability for the invasive Bullfrogs. Current research into habitat requirements of both Bullfrogs and Oregon Spotted Frogs indicates that physical separation of the two species may be possible through careful design. By creating shallow-marsh floodplain wetlands, it may be possible to encourage self-selected physical separation between the two species, thus allowing Oregon Spotted Frogs a refuge from the more aggressive Bullfrogs.

Vancouver Aquarium and Ministry of Forests, Lands and Natural Resource Operations will, in partnership with Metro Vancouver Regionals Parks, re-construct a marsh wetland in Aldergrove Lake Regional Park in Aldergrove, BC. The goals of the project are three-fold: Habitat, Research, and Education.

The planned restoration project will incorporate new information on the habitat choices of Oregon Spotted Frogs and Bullfrogs in BC. The techniques and restoration methods proposed are experimental, and are not guaranteed to succeed. Habitat 'success' will lie along a continuum, with a range of potential futures that will affect the management and maintenance of the wetland. A detailed adaptive monitoring program will be developed to track the maturation of the habitat and identify appropriate maintenance and management responses.

Environmental education is a primary goal for both Vancouver Aquarium and Metro Vancouver. The wetland construction process will provide volunteer stewardship opportunities, and the constructed wetland will provide ongoing stewardship and education opportunities.

This documents provides a rationale for site selection, construction goals, timelines and targets, post-construction monitoring and management, post-introduction monitoring and management, and education and stewardship opportunities.

2 Site selection

The wetland restoration project will take place in the south-west corner of Aldergrove Lake Regional Park directly east of the Gordon's Brook (Figure 1). The new wetland constructed through this restoration project will herein be referred to as Pepin Marsh.



Figure 1. Location of the planned Pepin Marsh in Aldergrove Lake Regional Park.

The site was selected as it met five critical components for a suitable project:

- 2.1 Hydrology
- 2.2 Historic Range
- 2.3 Land Jurisdiction
- 2.4 Educational and Research opportunities
- 2.5 Representative of Restorable Wetlands in the Fraser Valley

Sections 2.1 through 2.5 identify the required condition for each of these critical components and details how the Pepin Marsh site met each of these component conditions.

2.1 Hydrology

Wetland restoration is most successful when taking place in a historic wetland. The proposed Pepin Marsh location was historically a floodplain wetland, as evidenced by the topography, soils, and constructed drainage features.

Soil maps of the area are consistent with a depression and seepage site at the base of a glacio-fluvial deposit of gravelly silt. The pocket of soils, named 'Judson muck', is described in a 1966 soil map of Langley Municipality (Luttmerding & Sprout 1966) as developing from an accumulation of organic material consisting mainly of reeds, sedge, wood, and moss from 30 – 150 cm deep. Before 'reclamation' of the land,

vegetation consisted of alder, birch, shore pine, willow, hardhack, sweet gale, Labrador tea, sphagnum moss, orchard grass, hardhack, sedge, Canada thistle, and scattered willow and birch. In 1966, most of the Judson muck land was still unclaimed, as the forage produced was of low feed value due to high content of sedge and other unpalatable plants, and only grasses such as reed canary grass that could withstand the poor drainage produced satisfactory yields (Luttmerding & Sprout 1966).

Constructed drainage features on the site include several drainage ditches as well as drain tile. A seepage collection ditch runs at the base of a south-facing slope, and is connected to several parallel ditches that drain to the south at a slope of approximately 0.4% (1 m over 250 m) towards 0 Avenue. Drainage tiles are present in the south-east field, identified when digging soil test pits in August 2012) and are likely present throughout the site. The drainage ditch along 0 Avenue drains to the east, where it joins with Pepin Brook to exit ALRP under the road through a culvert under the Canada-US border into Washington. These drainage features have resulted in a wet field that is dry in late summer. No surface water was present in watercourses through multiple site visits in August 2012.

2.2 Historic Range

Historically occupied habitats and habitats within the historic range of Oregon Spotted Frogs are a very high priority for recovery habitat. The Pepin Marsh restoration site is directly within the historic range of the Oregon Spotted Frog in British Columbia. The site is also adjacent to watersheds currently (Salmon River and Bertrand Creek) and historically (floodplain south of the Canada – United States border – Figure 2) occupied by Oregon Spotted Frog. Within this range, Oregon Spotted Frogs occupied shallow water marshes and floodplain habitats as well as low-elevation headwater wetlands in the Lower Fraser and Puget Basins.

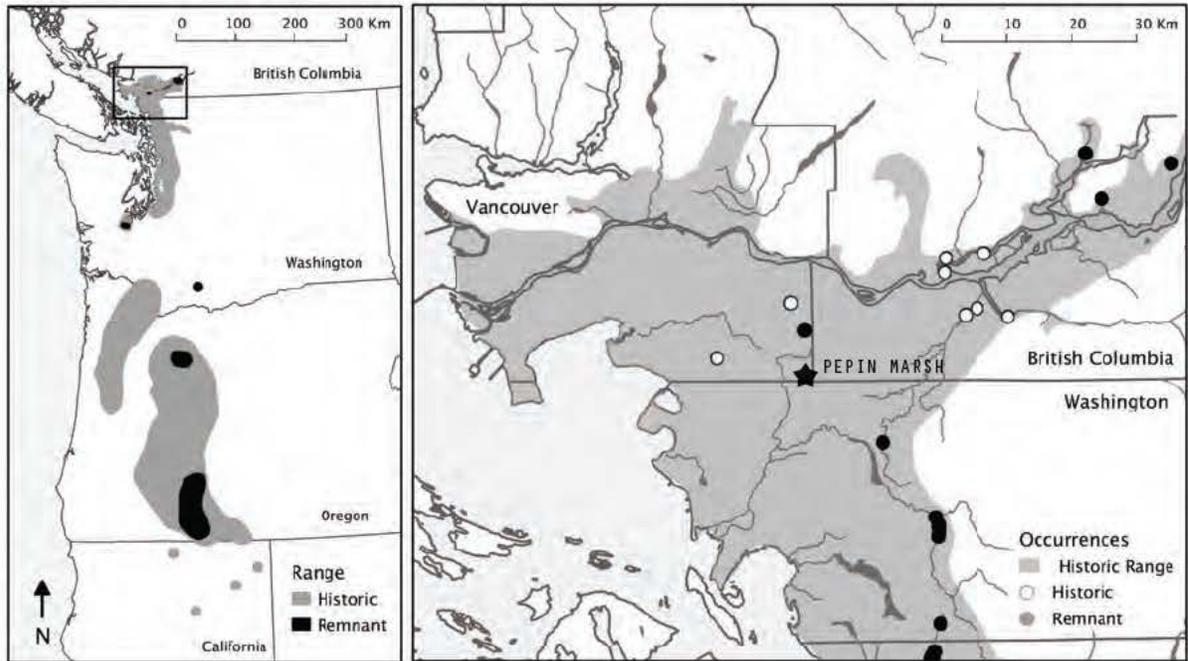


Figure 2. Historic and remnant range of Oregon Spotted Frog in North America. Aldergrove Lake Regional Park and the proposed Pepin Marsh project are directly within the historic range of the species in the Lower Fraser - Puget Sound Basins.

2.3 Land Jurisdiction

Restoration and introduction projects on public (Federal, Provincial, Regional or Municipal) lands are prioritized over potential projects on Private Land. Continued stewardship of all threatened species requires a long-term relationship based in common values. Regarding this particular project, the Vancouver Aquarium was seeking a partner that:

- a. Is currently engaged in managing biodiversity and species-at-risk;
- b. Is amenable, in principle, to introduction of a species listed under the Federal *Species-at-Risk Act* on their land;
- c. Values public outreach, academic research and outdoor education opportunities for youth; and
- d. Is willing to partnering in post-construction maintenance.

Aldergrove Lake Regional Park is managed by the East Area Parks Group of Metro Vancouver.. The Park currently supports a number of Species-at-Risk, including the endangered Nooksack Dace (*Rhinichthys cataractae*), the threatened Salish Sucker (*Catostomus sp.4*), and Oregon Forest Snail (*Allogona townsendiana*). Metro Vancouver Regional Parks are committed to promoting ecological health, human health and wellness, community stewardship, education and partnerships, and promoting opportunities for restoration at disturbed sites.

2.4 Educational and Research opportunities

The Vancouver Aquarium is a non-profit society dedicated to effecting the conservation of aquatic life through display, communication, public programming and education, research and direct action. Opportunities for interactive education were an important component in site selection.

The Aldergrove Lake Regional Park management plan has set aside the south-east corner of the park, the target site, as a conservation / education and research zone. Metro Vancouver has a well-developed interpreter program that is willing and able to partner with Vancouver Aquarium to provide high-quality educational activities to an existing (and growing) audience.

The conservation / education zone is currently used for research by academic partners at the University of British Columbia, and the park has existing facilities and plans additional facilities to accommodate education and research on-site.

2.5 Representative of Restorable Wetlands in the Fraser Valley

Shallow, seasonal freshwater marsh restoration is not a well established practice in the Fraser Valley, however shallow freshwater marshes make up much of the wetland loss that has occurred since settlement in British Columbia. An estimated 85% of wetlands in the Lower Fraser Basin were lost from 1827 – 1990 (Boyle et al. 1997). In an assessment of three different watersheds, each had experienced between 75% and 96% of wetlands loss, most due to dyking, draining and conversion of seasonally flooded natural grass prairies to agricultural and urban uses (Kistritz et al. 1996).

Many parks and ecological reserves in the Fraser Basin contain old field habitats that were historically drained wetlands, and many of these may be available for restoration. This project provides an opportunity to implement and monitor wet field restoration that could be applied to a great number of potential habitats in the historic range of the Oregon Spotted Frog.

3 Goals and Objectives

3.1 Goal

The goals of this project are, through the restoration of a shallow-water marsh wetland habitat on historic agricultural fields, to:

- e) Provide recovery habitat for the endangered Oregon Spotted Frog;
- f) Enhance general wildlife biodiversity, with a particular focus on Species-at-Risk;
- g) Provide outdoor education, stewardship and research opportunities in wetland restoration and species recovery; and
- h) Increase our knowledge of marsh restoration techniques.

3.2 Objectives

1. Wetland construction:
 - a. Invasive species control;
 - b. Habitat feature construction;
 - c. Hydrologic restoration;
 - d. Revegetation with native plant species.
2. Implement an ecological adaptive management plan for potential future scenarios:
 - a. Identify potential ecological outcomes and futures;
 - b. Identify management actions under each potential future scenario;
 - c. Monitor ecological outcomes, apply management actions;
 - d. Continue monitoring, applying and adapting management actions as needed;
 - e. Report on management actions with recommendations.
3. Stewardship, education and research:
 - a. Organize volunteer events for revegetation, monitoring and maintenance activities;
 - b. Partner with academic institutions to engage in research regarding plant and wildlife recovery at the site;
 - c. Partner with Metro Vancouver to develop a field trip curriculum for use by interpretive programs.

4 Wetland Construction Actions and Timeline

Four major phases of construction are required, and will span from June 2013 to April 2014.

Table 1. Construction Timeline for Pepin Marsh at Aldergrove Lake Regional Park.

Construction Timeline			
Section	Construction Stage	Timing	Detail
4.1	Control of Invasive Species		
	Initial Control	June 2013	Field preparation: mowing as soon as field is accessible to tractor
	Initial Control	July 2013	Apply glyphosate using tractor boom in late summer to resprouting grass (approx. 12" height). (requires dry watercourses)
	Seed bank exhaustion	Aug 2013	Tilling / harrowing at least 3 times in summer 2013. Potential for secondary glyphosate application in early August prior to construction
4.2	Habitat Complexing and Feature Construction		
	Habitat complexing	Aug – Sep 2013	Sculpt landscape: channels, pools, benches.
	Feature construction	Sep 2013	Install ponds, weirs, large wood; construct trails.
4.3	Hydrologic restoration		
	Habitat complexing	Sep 2013	Infill ditches, plug drain tile, water flow and water control devices.
	Feature construction	Sep 2013	Connect habitat complex to groundwater; monitor and adjust as necessary.
4.4	Re-vegetation		
	Initial Seeding	Oct 2013	Seed with native wetland seeds.
	Shrub planting	Oct - Nov 2013	Plant riparian / higher elevation berms / islands / trails.
	Herb planting	March - April 2014	Plant plugs in depressions. Spread additional seed.

4.1 Control of Invasive Species: June – August 2013

Reed canary grass is dominant across the proposed restoration site, and in all surrounding fields. Native plants present are limited to stinging nettle and a few planted willows at the east edge of the field. Several cottonwood trees have also been planted at the south end of the main drainage ditch.

Successful reed canary grass control is crucial to the success of this project. Reed canary grass is a hardy, early to leaf plant species that easily outcompetes native vegetation in shallow wetlands. Controlling reed canary grass is a multi-step, multi-season process requiring: 1) killing / removal of existing plants and rhizomes; 2) exhausting the seed bank; 3) active restoration (re-seeding); 4) prevention of re-invasion; and 5) continued monitoring and follow-up treatments. Removal of the root mass is most important to prevent re-infestation of the site. Although reed canary grass is aggressive in aquatic conditions where root matter exists, seeds are drowned in permanent water and are slow to establish in low nutrient sites.

The most effective and efficient means of reed canary grass control is application of a glyphosate-based herbicide. This is recommended on sites with no water present, although in the United States, an aquatic-

approved formulation is being used for marsh restoration in wet meadows. Successful applications require pre-treatment mowing of the existing plants, as well as regular post-application tilling continuing to restoration. Once the root mat has been destroyed, altering hydrology (raising the water table) becomes a useful control technique. Simultaneous to hydrological restoration, dense seeding and plug planting with a variety of native species is necessary to restore the site.

The site currently appears to be nutrient-poor, as demonstrated by a shallow root mat (10 cm) and the relatively low plant height (50 cm) of reed-canary grass. This nutrient-poor status must be maintained for the success of the wetland, and will be improved by disallowing manure or fertilizer spreading on fields upstream of the site within Aldergrove Lake Regional Park.

An integrated pest management approach is needed to control reed canary grass on the site. Initial control through glyphosate application followed by tilling, re-growth, re-application and further tilling is the most effective manner of killing leaf, stem and roots. Ideally, reed canary grass removal would have commenced in Fall 2012, but this was not possible in the project timeline.

4.2 Habitat Complexing and Feature Construction for Target Species: August – September 2013

Oregon Spotted Frogs require permanent shallow water marshes with complex aquatic / terrestrial structure and semi-dense emergent vegetation. The minimum recommended habitat size for a self-sustaining population of Oregon Spotted Frogs is 2 - 4 Ha. Restored habitat must incorporate breeding habitat, overwintering habitat, and summer foraging habitat. In order to ensure both permanent water and appropriate breeding and rearing habitat, the project will incorporate two distinct habitats: permanent pond and seasonal marsh.

In this location, the key to providing appropriate Oregon Spotted Frog habitat that will not be re-invaded by reed-canary grass and Bullfrogs is water depth. Large seasonal water level fluctuations are anticipated and can be accommodated by the species when a variety of surface heights are available to them.

Permanent water pools with a maximum depth of 30 - 40 cm from June – September should be deep enough to deter reed canary grass, shallow enough to deter Bullfrog invasions, and provide summer refuge habitat to Oregon Spotted Frogs. Vegetation islands will be planted at a high density within and around the permanent pools in order to break sight-lines for Bullfrogs (limit their hunting effectiveness) and to provide a high density of refuges for Oregon Spotted Frogs in the drier months.

Winter water levels will be significantly deeper than in the summer, flooding a large ephemeral floodplain marsh adjacent to permanent water ponds. Marsh habitat will dry in the late summer, but provide breeding and rearing habitat for the Oregon Spotted Frogs in the spring. Overwintering structures will be provided in the form of large woody debris in and around the permanent ponds. Aquatic connectivity between the permanent ponds and drainage channels along O Avenue will be maintained as an overflow with water levels controlled through the use of small rock weirs and woody debris dams.

Habitat features will be incorporated for additional at-risk amphibian species (ie. Red-legged Frogs and Western Toads), and marsh-dependent at-risk birds (Great Blue Heron, American Bittern, Black-crowned

Night Heron). The permanent ponds and ephemeral marsh are anticipated to attract fish species including salmonids and juvenile Salish Suckers.

4.3 Hydrologic Restoration: September 2013

After habitat features have been placed and sculpted onto the landscape, hydrologic restoration will require the removal of constructed drainage features (ditches, drain tiles) and reconnection of the site to a permanent water source. Dug ditches will be plugged to restore the water table and can be used for spoil deposit. Drain tiles will be identified through excavation and plugged with a clay barrier.

Water will be accessed from groundwater at the north end of the project site and channeled to the ponds and through the ephemeral marsh towards retained ditches and O Avenue. A connection will be made to Gordon's Brook only if necessary to maintain water in the permanent ponds through the summer. Pepin Creek and Gordon's Brook are high in nutrients from upstream agricultural inputs, and would likely result in the rapid recolonization of the ponds and marsh with reed canary grass.

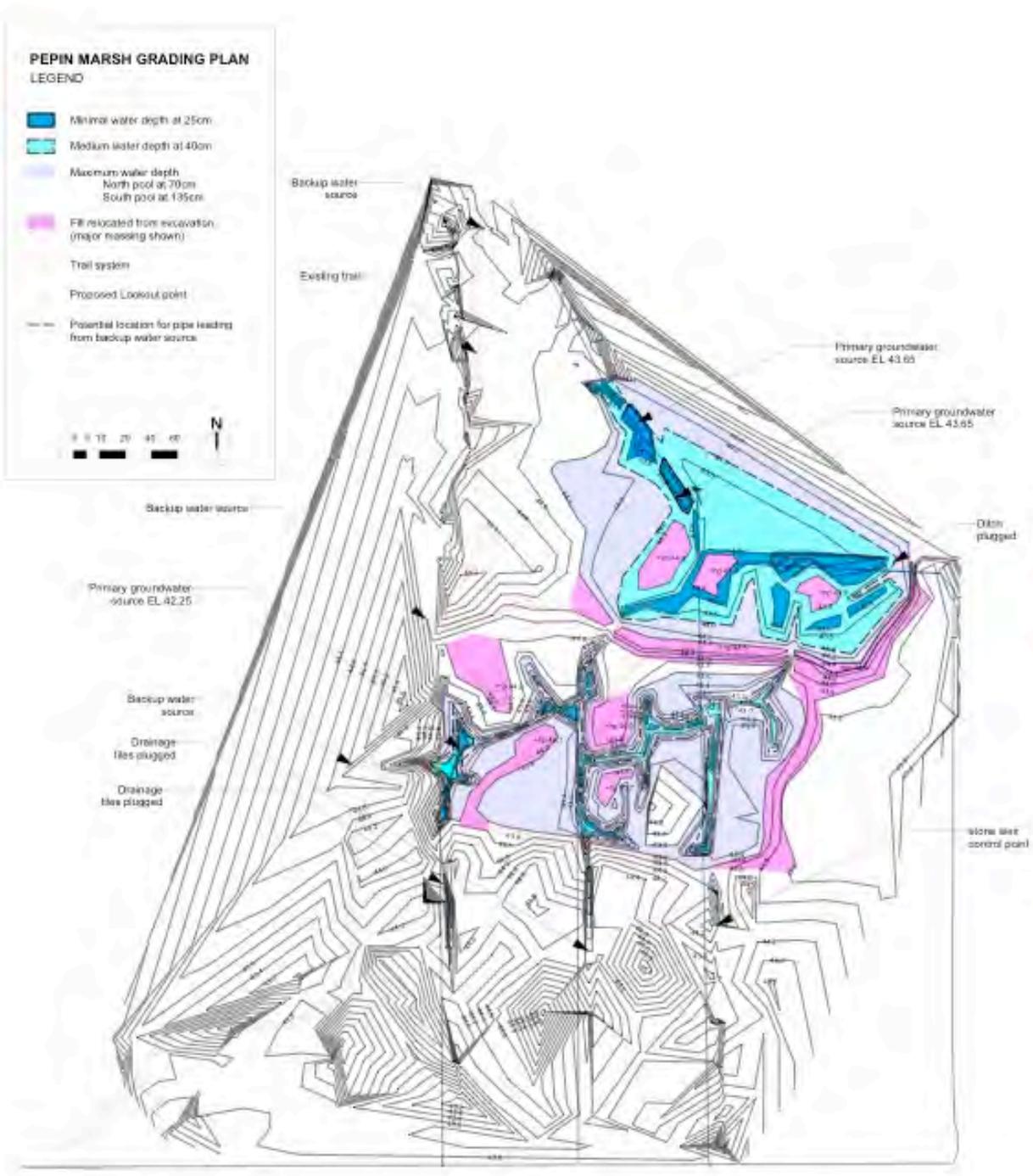
Restoring ditches will require permitting from Fisheries and Oceans Canada, as well as an Instream Works permit from the Ministry of Forests Lands and Natural Resource Operations. Two ditches will be maintained as outflows and modified with natural water control structures (rock dam / woody debris weir) (Figure 3).

4.4 Revegetation with Native Plant species: October 2013 – April 2014

The wetland will be revegetated with native wetland herb, grass, sedge and shrub species known to historically exist in Lower Mainland freshwater marshes. Unfortunately, no reference sites with native arrangements are known to remain in the Lower Mainland that can currently provide information on appropriate vegetation. Plant selection has considered the likelihood of a historic presence in the Lower Mainland, structural suitability for the target species, and availability of materials. A planting plan will be developed after detailed designs have been completed, in consultation with a wetland botanist to ensure no potentially invasive or inappropriate species are selected.

Fast, high-density revegetation across the ephemeral meadow will be crucial to the successful control of reed canary grass on site, requiring a combination of potted shrubs and sedges, plugs of sedges, reeds, rushes, herbs and grasses, as well as seeding. Seeds will need to be imported from native seed distributors in the United States, who provide native seed to nearby restoration projects south of the Canada - United States border.

To create a 'barrier' around the wetland to reduce seed dispersal of reed-canary grass, a thicket of willows, hardhack and dogwood will be planted at the edge of the project footprint and on the slopes of trails. If feasible, the trails will also be treated with a mulch over-layer to reduce the passage of invasive seeds across the 'barrier' line.



SAMPLE SECTION

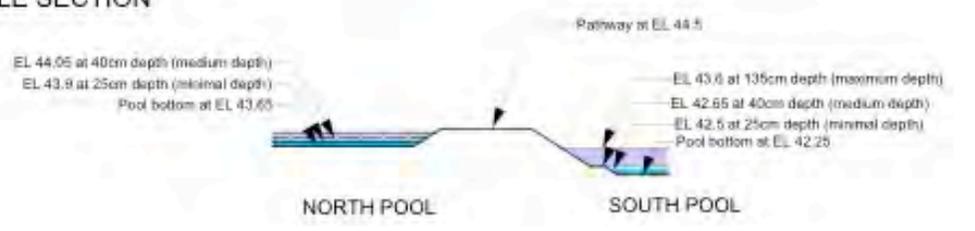


Figure 3. Grading plan and hydrologic modifications for the restoration of Pepin Marsh.

4.5 Construction Partners

Funding for habitat construction is provided by:

- Vancouver Aquarium
- Ministry of Forests, Lands and Natural Resource Operations
- Government of Canada's Habitat Stewardship Program
- BC Habitat Conservation Trust Fund

Additional support for volunteer plantings and recovery will be provided by:

- Fraser Valley Watershed Coalition
- Lower Mainland Green Team
- Government of Canada's Science Horizons program.
- Government of Canada's Aboriginal Fund for Species at Risk

5 Adaptive Ecosystem Management: Monitoring and Maintenance

The constructed wetland will require monitoring and maintenance, however as the final outcomes are uncertain, an adaptive management approach that accepts several potential futures and management plans must be considered. Adaptive management planning will involve:

- i. Identifying potential future scenarios for the post-construction marsh;
- ii. Identifying management actions under each potential future scenario;
- iii. Monitoring ecological outcomes;
- iv. Applying appropriate management actions;
- v. Continuing to monitor, apply and adapt management actions as needed; and
- vi. Reporting on management actions with recommendations.

Post-construction habitat monitoring will begin in Fall 2013 and continue until for at 4 years following construction. The plan indicated in Table 2 below provides a monitoring framework. Figure 4 indicates management recommendations dependent on hydrological and revegetation outcomes. The final decision on whether or not the habitat is suitable for introduction of Oregon Spotted Frogs in the future will depend on the information gathered.

Monitoring of the constructed habitat and subsequent monitoring of an introduced population will be dependent on available funding and labour resources. At this time, funding has only been secured for the construction of the marsh, as well as the development of a detailed monitoring plan post-construction. Monitoring will be considered a high priority by the Oregon Spotted Frog Recovery Team, and will be arranged by Balance Ecological in concert with academic institutions and environmental non-government and stewardship organizations.

All monitoring programs will be permitted through Metro Vancouver Regional Parks, Ministry of Environment General Wildlife Sundry Permits, and will follow established protocols coordinated and supervised by the Oregon Spotted Frog Recovery Team.

Table 2. Post-construction monitoring program for Pepin Marsh.

Monitoring Program						
PEPIN MARSH	Hydrological Regime		Re-vegetation		Habitat Features	Wildlife Presence
	Permanent ponds	Wet Meadow	Permanent ponds	Wet Meadow		
Methods	Water gauges in ponds	Water depth at transect points and in groundwater wells	Visual surveys & vegetation plots	Visual surveys & permanent vegetation plots along transects	Habitat plots at designed feature sites	Wildlife surveys: visual, auditory and trapping
Targets	Max 40 cm in June - July; Min 25 cm in Aug / Sept.	Fields flooded during winter & OSF breeding season.	Native: invasive plant species ratios	Native: invasive plant species ratios	Substrate and vegetation structure; water depth etc.	Native and invasive amphibians; native birds; native and invasive fish.
Potential outcomes:	1. As per design 2. Wetter than design 3. Drier than design See. Figure 4: Potential futures and Adaptive Management Plan		A. Preferred outcome B. Acceptable outcome C. Undesirable outcome See. Figure 4: Potential futures and Adaptive Management Plan		i. Confidence in breeding / over-wintering habitat suitability. ii. Non-confidence in habitat suitability for OSF.	a. Low density of bullfrog adults and invasive fish. b. High density of bullfrog adults and breeding on-site; invasive fish species.
Mgmt questions addressed	Hydrologic changes needed: increase / decrease input or outflow See. Figure 4		Invasive species management methods: chemical or manual / patch-treatment or landscape-level. See. Figure 4		Likelihood of success for Oregon spotted frog introduction.	Likelihood of success for Oregon spotted frog introduction.

PEPIN MARSH

Potential Futures & Adaptive Management Plan

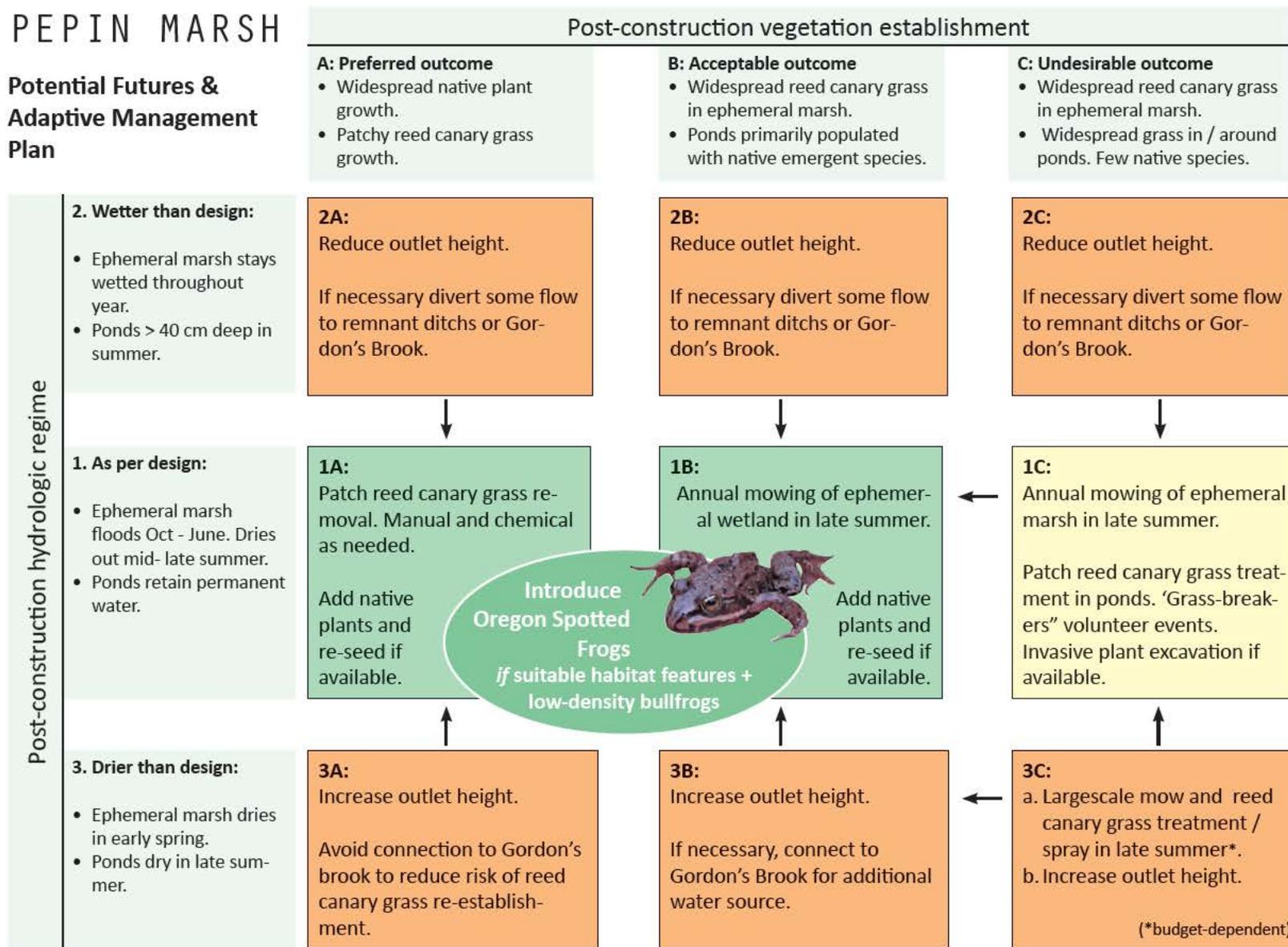


Figure 4. Potential futures and recommended management actions for post-construction Pepin Marsh.

5.1 Potential Monitoring Outcomes and Associated Management Actions

Revegetation and hydrologic outcomes are linked and must be managed in unison. Figure 4 identifies the management actions recommended in each scenario.

5.1.1 Hydrologic Outcomes

Monitoring of the hydrologic and revegetation outcomes will be undertaken in the four years following construction in order to assess the success of the project. The combined results of hydrologic and revegetation outcomes will guide the most appropriate management steps to maintain the wetland for Oregon Spotted Frogs and general biodiversity.

Two distinct zones are required to provide appropriate habitat for Oregon Spotted Frogs:

4. Permanent ponds:
 - a. Maximum depth of 40 cm in the early summer (June – July) to discourage reed canary grass growth from seed and adult Bullfrog breeding / presence; and
 - b. Minimum depth of 25 cm in the late summer (August – September) to ensure permanent water for Oregon Spotted Frogs through the dry season.
5. Ephemeral marsh:
 - a. Broad flooding in winter and spring (Oct – June) to provide open, warm breeding and rearing habitat for Oregon spotted frogs; and
 - b. Summer season shallow marsh or dry land that can be mowed in the fall to ensure open habitat for breeding during the spring floods.

Three potential outcomes are anticipated:

1. As per design: North ponds retain permanent water. South marsh floods fall – early summer. Dries out mid- late summer.
2. Drier than design: North ponds dry in late summer; south marsh dries in early spring.
3. Wetter than design: North ponds too deep: developing dense floating vegetation and Bullfrogs. South marsh stays wetted throughout year: floods deep (> 30cm) in summer.

If necessary, hydrology will be adjusted by increasing or decreasing either inflows or outflows. Outlets will be constructed to be easily controlled with human power (eg. rock weirs & woody debris dams), and will be the first control structures to be manipulated. If additional hydrological adjustment is required, inflow adjustments will be made by constructing a connection to Gordon's brook. This is less desirable, as Gordon's Brook contains high nutrients from upstream agricultural impacts and is likely to accelerate reed canary grass growth in the ponds and marsh. If necessary, water from Gordon's Brook could be pre-treated for nutrients by passing flow through a high-density cattail wetland.

5.1.2 Revegetation Outcomes

Revegetation with native plants is the desired outcome, however it is possible that reed canary grass will reclaim much of the landscape if pre-construction control efforts are not successful. In particular, the ephemeral marsh is at risk of being reclaimed by reed canary grass if native seeding and planting is not able to out-compete reed canary grass seedling growth.

Three potential outcomes are anticipated:

- A. Preferred outcome: Widespread reduction of reed canary grass growth in ponds and marsh. Dense growth of planted, seeded and historic species. Patches of reed canary grass re-grow in distinct areas.
- B. Acceptable outcome: Widespread regrowth of reed canary grass across ephemeral marsh.
- C. Undesirable outcome: Widespread regrowth of reed canary grass across ephemeral marsh and around ponds.

Widespread growth of reed canary grass across the ephemeral marsh is an acceptable outcome, provided the marsh dries enough in the summer to be mowed in the fall. If reed canary grass revegetates the marsh, annual mowing will be required to retain open breeding ponds for the Oregon spotted frog.

5.1.3 Habitat Features

Oviposition and overwintering habitat features are essential for the successful colonization of the marsh by Oregon spotted frogs. Habitat features will be monitored with thermal and light loggers installed in identified habitat features and assessed annually.

Appropriate thermal conditions throughout the breeding period are crucial for successful OSF breeding. Oregon spotted frogs lay eggs in the shallow edges of wetlands where water heats significantly throughout the day. Eggs will develop normally when held at constant temperatures from 7 - 28°C, and are tolerant of fluctuating temperatures as low as 1°C for 8 hours (Licht 1971). In known breeding locations in BC, water temperatures fluctuate between 3 and 21°C during breeding season.

Overwintering habitats selected by Oregon Spotted Frogs in radio-telemetry studies include islands of dark vegetation with thick root structures, beaver dams, and large woody debris. Large woody debris, wood piles and hardhack 'islands' will be installed as a part of the construction and monitored for thermal suitability.

Two potential outcomes are anticipated:

- 1. Oviposition and overwintering features suitable for Oregon Spotted Frog.
- 2. Oviposition or overwintering features unsuitable for Oregon Spotted Frog.

If these features are not assessed as appropriate for the Oregon Spotted Frog, frogs will not be introduced to the habitat. However, these habitat features may be modified and created post-construction using manual labour, and re-assessed in following years.

5.1.4 Wildlife Presence

Wildlife presence will be monitored at the newly constructed marsh. In addition to inventories of target native species, inventories for invasive American Bullfrogs and invasive fish species will be conducted. The habitat design attempts to deter high-density colonization by adult Bullfrogs, but may provide suitable habitat in unexpected ways.

Two potential outcomes are anticipated:

1. Low density of Bullfrog density. Few invasive fish.
2. High density of Bullfrog adults and breeding on-site in marsh OR high density of invasive fish species.

If Bullfrogs are found in the ponds and marsh in high density after three years of surveys, Oregon Spotted Frogs will not be introduced to the habitat.

6 Oregon Spotted Frog Introduction and Monitoring Plan

In the event that the restored habitat is considered suitable for Oregon Spotted Frogs and that Oregon Spotted Frogs are introduced to Pepin Marsh, the Oregon Spotted Frog Recovery Team will be the lead on introducing and monitoring the species in the park. Following a minimum of 3 years of post-construction habitat monitoring, a ‘Habitat Assessment, Constraints, Opportunities and Management Plan’ document will be developed and will advise the Recovery Team as to the suitability of the habitat for Oregon Spotted Frog introduction.

The Introduction and Monitoring plan below is a draft approach based on the current best available information. Ongoing research into the most efficient and cost-effective methods, habitat suitability, thermal thresholds, light exposure thresholds, and invasive species impacts will be incorporated into recovery planning as it becomes available. The approach is one of adaptive management, with an emphasis on monitoring breeding success in relation to measurable habitat variables. A preliminary timeline and approach is projected in Table 3 and detailed in the sections below.

Table 3. Proposed Introduction and Monitoring Program Timing, using 2017 as baseline year indicating earliest possible introduction of the Oregon Spotted Frog.

Action	Introduction Monitoring Program							Continue until:	Annual Cost	Timing
	Year 1 (2017)	Year 2 (2018)	Year 3 (2019)	Year 4 (2020)	Year 5 (2021)	...				
Egg mass / tadpole release	+	+	+	+	+	+	Self-sustaining population	NA	April	
Visual surveys	+	+	+	+	...		Egg masses found (Anticipate year 3 or 4)	\$ 2,500	August	
Oviposition surveys			+	+	+	+	Indefinitely (Highest priority action)	\$2,500	March - April	
Mark-recapture				+	+	+	Indefinitely (dependent on funding)	\$10,000	Feb - March	

6.1 Introduction

Oregon Spotted Frogs will be introduced to the wetland as eggs, tadpoles, and potentially as head-started juveniles, in habitats identified as suitable for breeding and rearing. The number of animals released will be dependent on the production of captive breeding populations by Oregon Spotted Frog Recovery Team partners. Releases will continue until the population is considered self-sustaining, which will be determined through annual oviposition monitoring. It is anticipated that this may take as few as 10 years and as many as 30 years.

A literature review of recent strategies to create recovery populations employed in Canada and the United States suggests that eggs should be the primary life stage for introductions. This cost-effective method addresses potential limitations of adult / juvenile introductions by allowing frogs to develop homing mechanisms in their new environment and predator acclimation (Hawkes 2009). Introduction protocols are currently in progress, and are the subject of an ongoing Masters thesis at Simon Fraser University under the supervision of Dr. Wendy Palen.

6.2 Monitoring

Monitoring of the introduced population will be dependent on available funding and labour resources. The Oregon Spotted Frog Recovery Team has been successful in securing funding for Oregon Spotted Frog breeding surveys annually since 2000, and anticipates a continuation of this success. As one of the first examples of species-at-risk introductions to new habitats in Canada, this project is anticipated to attract high priority funding from both the Federal and Provincial governments, and will continue to attract applied research projects from graduate researchers at the University of British Columbia and Simon Fraser University.

All monitoring programs will be permitted through Ministry of Environment General Wildlife Sundry Permits, and will follow established protocols coordinated and supervised by the Oregon Spotted Frog Recovery Team.

6.2.1 Oviposition Surveys

Oviposition surveys are the highest priority monitoring action for Oregon Spotted Frog remnant and recovery populations. Annual breeding / egg mass surveys will begin in the 3rd year after introduction, and will continue indefinitely to monitor the success of the introduction. Oregon Spotted Frogs in the wild are anticipated to breed for the first time in their 3rd or 4th year following the initial population introduction; therefore oviposition will not be anticipated until several years worth of releases have occurred.

Oviposition surveys are the least invasive and most efficient technique for population monitoring. These surveys consist of searching wetlands and the shallow water, shore and shoreline along the perimeter of breeding ponds during breeding season, generally in late February - March. All adults, juveniles, larvae and egg masses encountered will be recorded. Waders and boats (kayak / canoe) will be used to move through the habitat. Habitat will not be affected by this project, as this is solely a presence / absence inventory.

6.2.2 Summer Visual Surveys

Summer visual surveys can be effective at determining whether or not eggs and tadpoles introduced to the wetland have successfully metamorphosed into juvenile frogs. These surveys are particularly important in the years prior to breeding surveys (Years 1, 2 and 3 post first release). Visual surveys will be performed in late August in a 50-m vicinity of the initial release.

6.2.3 Breeding Season Mark-Recapture Surveys

Once breeding areas have been established by the frog and identified by researchers, the most accurate and effective manner of population monitoring is through mark-recapture surveys. Surveys are performed prior to and during the frog's breeding season in February and March. Frogs captured are individually tagged and released. Recapture of marked frogs over several years provide a detailed indication of the population size, structure and likelihood of the success of the species introduction.

6.2.4 Habitat monitoring

Habitat monitoring will involve a minimum of four site visits per year to assess: invasive plant and amphibian species status; water quality; thermal and light exposure conditions; and identify any significant habitat changes or potential threats.

6.3 Land Management after the Introduction of Oregon Spotted Frogs

In the event that Oregon spotted frogs are introduced to Pepin Marsh in Aldergrove Lake Regional Park, the Oregon Spotted Frog Recovery Strategy (2012) identifies activities that may be harmful to the species, as well as management implications regarding those threats. Table 4 summarizes the activities, implications and potential impacts on Aldergrove Lake Regional Park management.

Table 4. Activities identified as potentially harmful to Oregon Spotted Frogs in the Oregon Spotted Frog Recovery Strategy (2012), management implications and potential impacts to Aldergrove Lake Regional Park management.

Harmful Activities	Post-Introduction Habitat Management Impacts	
	Management Implications	ALRP Impact
Hydrological Modifications	Avoid alteration of watercourses that lead to changes in water quantity and/or in the flow rate and pattern.	Minimal impact - Hydrologic suitability will be ascertained in pre-introduction assessment. Any changes to flow in Gordon's Brook and Pepin Creek for research purposes will be coordinated with the OSFRT.
Fertilizers and Chemicals	No run-off or spray of pesticides, herbicides, fertilizers, sewage, manure into occupied / supporting habitat.	Landscaping and trail maintenance limited to mechanical means.
Sediment Input	Avoid activities that will increase sediment input into occupied / supporting habitat. Eg. Forest harvest.	No impact.
Exotic Predators	Increased vigilance for invasive species; partner with OSFRT for exotics management.	Annual bullfrog monitoring by OSFRT / MFLNRO staff. Indication of high bullfrog densities would result in habitat alteration to reduce habitat suitability.
Riparian Alterations	No development of new facilities requiring riparian removal within survival habitat	Develop and maintain trails in and around habitat as low-traffic, low-impact trails. Use boardwalk where necessary. Install viewing platforms with interpretive signage around OSF introduction. Avoid trampling and reduce trail degradation.

Restrictions on activities within the Recovery Habitat zone will consider existing land uses, potential conflicts and concerns of land managers. The introduction of the species does not intend to impose additional restrictions on any existing structures or land management, and it is anticipated that the introduction is in line with the existing management practices of the park. The Recovery Team is committed to working with land managers and staff to identify and resolve and all potential conflicts prior to introduction as well as any challenges that arise. Aldergrove Lake Regional Park has been prioritized for recovery habitat precisely because few conflicts are anticipated, and the area is currently managed and protected for existing Species-At-Risk. Management of the area will differentiate between occupied habitat and supporting habitats, although all are considered recovery habitat.

7 Stewardship, capacity-building, education and research:

7.1 Volunteer / Stewardship Activities

Volunteer events to plant shrubs, remove invasive species, and conduct regular monitoring and maintenance activities provide opportunities to connect the public with nature and involve them direct in habitat and species recovery. Volunteer events also significantly reduce the labour costs involved in habitat restoration projects, and provide the most effect venue for connecting local residents with nature. Partnerships with existing non-government organizations that organize stewardship events increase the reach of the project. Open House events during the Management Planning process for ALRP revealed a large community of local residents who have vested interest in the Park and may also be interested in building an ALRP Volunteer Program.

Additional support for volunteer plantings and recovery will be provided by:

- Fraser Valley Watershed Coalition
- Lower Mainland Green Team
- Pepin Brook Streamkeepers
- Government of Canada's Science Horizons program.
- Government of Canada's Aboriginal Fund for Species at Risk

7.2 Research and Monitoring

The Pepin Marsh project is the first attempt to restore a floodplain marsh specifically for Oregon Spotted Frogs in the Fraser Valley. Marsh restoration is anticipated to be one of the most effective methods to recover the Oregon Spotted Frog, and continued monitoring and learning from this project is a key goal for the Oregon Spotted Frog Recovery Team. Design concepts proposed are untested, and may not succeed. Prior to introduction of the species, certain biological and physical requirements must be met, and these requirements must first be monitored and examined. Additional research opportunities will come from monitoring invasive Bullfrog colonization of the wetland as it matures, as will the eventual introduction of endangered Oregon Spotted Frogs.

A list of potential projects regarding the monitoring of the wetland will be provided to local educational institutions, and circulated towards particular study groups. In particular, the project will provide project opportunities to:

- Simon Fraser University
 - o Center for Wildlife Ecology
 - o Earth2Ocean Sciences.
 - o Biology
- University of British Columbia
 - o Conservation Biology
 - o Landscape Architecture
 - o Zoology
 - o Botany
- BC Institute of Technology
 - o Ecological Restoration
 - o Fish, Wildlife and Recreation
- University of the Fraser Valley
 - o Biology
 - o Geography

7.3 Youth Education

Excavated materials will be used to construct trails on elevated berms that act as water control structures and provide viewing platforms. Public engagement is an important goal of the project. Low-impact trails will be developed through the site, however final trail placement will likely be determined at the time of construction and excavation, as the variable nature of subsoils is certain to alter the design in unexpected ways.

Educational programming is yet to be determined but may include school field trips, a self-guided tour, information panels, viewing platforms, etc. Both the Vancouver Aquarium and Metro Vancouver run school outreach programs that will be able to take advantage of the new wetland as an educational space and site access will be designed with this programming in mind.

8 Next Steps

Construction of the project is ready to begin in the summer of 2013. The marsh will be constructed by Balance Ecological, and financed through Vancouver Aquarium and BC Ministry of Forests, Lands and Natural Resource Operations. A detailed construction plan and permit applications will be prepared by February 28, 2013, and submitted to the relevant authorities.

Following construction, Balance Ecological will also prepare a detailed construction report and monitoring plan for the wetland, and is committed to seeking volunteers and funds to implement monitoring plans.

Vancouver Aquarium will provide funds towards the construction of the wetland, provide captive-bred eggs and tadpoles for the introduction of the Oregon Spotted Frog to the wetland (if approved), and will work with Metro Vancouver to develop and deliver educational programming regarding the marsh restoration, threatened and endangered species, and Oregon spotted frog recovery actions.

Metro Vancouver, in addition to working with Vancouver Aquarium to develop and deliver educational programming, will coordinate with Balance Ecological and the Ministry of Forests, Lands and Natural Resource Operations to maintain trails, manage access, and manage invasive plant species in the restored wetland as needed in accordance with the management plan.

Vancouver Aquarium, Metro Vancouver and the BC Ministry of Forests Lands and Natural Resource Operations should develop a formal agreement to carry out the activities detailed in this document, and assign lead roles for monitoring and management actions.

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PEPIN MARSH WORK PLAN

An addendum to:

‘CONSTRUCTION AND MAINTENANCE FOR A RESTORED MARSH HABITAT IN ALDERGROVE REGIONAL PARK’

Submitted to: Metro Vancouver Regional Park

By: Balance Ecological on Behalf of the Vancouver Aquarium

June 21, 2013

TABLE OF CONTENTS

1	WETLAND CONSTRUCTION ACTIONS AND TIMELINE.....	1
1.1	CONTRACTORS AND PERSONNEL	1
1.2	CONSTRUCTION TIMELINE.....	1
1.3	MACHINE ACCESS	5
1.4	SITE PREPARATION – INVASIVE SPECIES CONTROL.....	5
1.5	WATER QUALITY AND SEDIMENT CONTROL	5
1.6	HABITAT COMPLEXING AND FEATURE CONSTRUCTION FOR TARGET SPECIES: AUGUST – SEPTEMBER 2013	6
1.7	TRAIL CONSTRUCTION – SEPTEMBER 2013.....	7
1.8	REVEGETATION WITH NATIVE PLANT SPECIES: OCTOBER 2013 – APRIL 2014	7
1.9	POST-CONSTRUCTION REPORTING.....	7
1.10	HYDROLOGIC MONITORING AND OUTLET MODIFICATION	7
1.11	INVASIVE SPECIES MONITORING AND CONTROL.....	7
2	COMMUNICATIONS.....	8
3	EMERGENCY RESPONSE AND CONTAINMENT PLAN	8

1 Wetland Construction Actions and Timeline

Four major phases of construction are required, and will span from June 2013 to April 2014.

Work will be directed by Balance Ecological, contracted to the Vancouver Aquarium, BC Ministry of Forests, Lands and Natural Resource Operations, and BC Conservation Foundation.

Work will be performed by contractors acting on behalf of Balance Ecological, Vancouver Aquarium, and BC Conservation Foundation.

1.1 Contractors and Personnel

Task	Company	Personnel	Phone #
Project Manager	Balance Ecological	Monica M Pearson, R.P.Bio	[REDACTED]
Administration	BC Conservation Foundation	Joanne Neilson, Administrator Aleesha Switzer, Field Technician	[REDACTED]
Site Preparation	Precision Land Prep	Prit Gill	[REDACTED]
Equipment Operator	George Flath Construction	George Flath Marvin Wheeler	[REDACTED]
Planting	Fraser Valley Watershed Coalition	Natashia Cox Rachel Drennan	[REDACTED]
Planting	Lower Mainland Green Team	Leda Salakyan	[REDACTED]
Planting	Matsqui AFSAR crew	Via Robin Clark	[REDACTED]

1.2 Construction Timeline

Tasks are weather dependent, and this schedule will be adjusted as necessary in response to weather conditions. Site preparation activities cannot be conducted in rain or near-rain conditions, or heavy winds. Habitat complexing may be delayed by heavy rains.

Site-specific conditions may require changes to the construction plan. Any major changes will be communicated to Metro Vancouver as soon as possible.

Table 1. Timeline of activities related to wetland restoration at Pepin Marsh in 2014 - 2014.

	Dates	Task	Location	Equipment	Personnel
Control of Invasive Species					
June	23 – 29	Site Preparation - Mowing	Site Prep + Mow Only zones	John Deere 5525 + MX6 brush cutter	Prit Gill
	30 – 6	Site Preparation – Fence removal / Mark site prep zones	Site Prep Zone		Balance Ecological
July	7 – 13	Site preparation – Herbicide application	Site Prep Zone	John Deere 5525 + spray boom	Prit Gill
	14 – 20	Site preparation – Till / Disc	Site Prep Zone	John Deere 5525 + domries disc, 3-shank ripper	Prit Gill

	Dates	Task	Location	Equipment	Personnel
	21 – 27				
	28 – 3	Site preparation – Herbicide application / Disc	Site Prep Zone	John Deere 5525 + spray boom / domries disc	Prit Gill
August	4 – 10				
	11 – 17	Site preparation – Herbicide application (if needed) / Disc	Site Prep Zone	John Deere 5525 + spray boom / domries disc	Prit Gill
	Habitat Complexing and Feature Construction				
	18 – 24	Water control / Set levels at strategic locations Feature Construction	Zone 3, 4 Zones 1 / 2 / 3	Hitachi 150 / 200 0 Long Reach	BE / George Flath Construction
	25 – 31	Feature Construction Habitat Complexing	Zone 1 / 2 / 3 Zone 1 / 2 / 3	Hitachi 150 with thumb / Hitachi 200 Long Reach	BE / George Flath Construction
September	1 – 7	Habitat complexing and feature construction	Zone 4	Hitachi 150 with thumb / Hitachi 200 Long Reach	BE / George Flath Construction
	Hydrologic restoration				
	8 – 14	Water Control refinement	Zone 3 / 4	Hitachi 150 with thumb / Hitachi 200 Long Reach	BE / George Flath Construction
	Trail Construction				
	15 – 21	Trail Construction	Trail network	As needed	Metro Vancouver
	22 – 28	Trail construction	Trail network	As needed	Metro Vancouver
Revegetation					
October	29 – 5	Seeding (weather dependent)	Zone 1 / 2 / 3 / 4		Balance Ecological
	6 – 12	Seeding (weather dependent)	Zone 1 / 2 / 3 / 4		
	13 – 19	Planting	Zone 1 / 2 / 3 / 4		Balance Ecological
	20 – 26	Planting	Zone 1 / 2 / 3 / 4		FVWC Crews
	27 – 2	Planting	Zone 1 / 2 / 3 / 4		Balance Ecological
Novem	3 – 9	Planting	Zone 1 / 2 / 3 / 4		Matsqui Crew
	10 – 16	Planting	Zone 1 / 2 / 3 / 4		Matsqui Crew
	17 – 23				
	24 – 30				
Spring 2014	Plant plugs	Zone 1 / 2 / 3 / 4		Balance Ecological	
Summer 2014	Outlet modification	Zone 3		Balance Ecological	

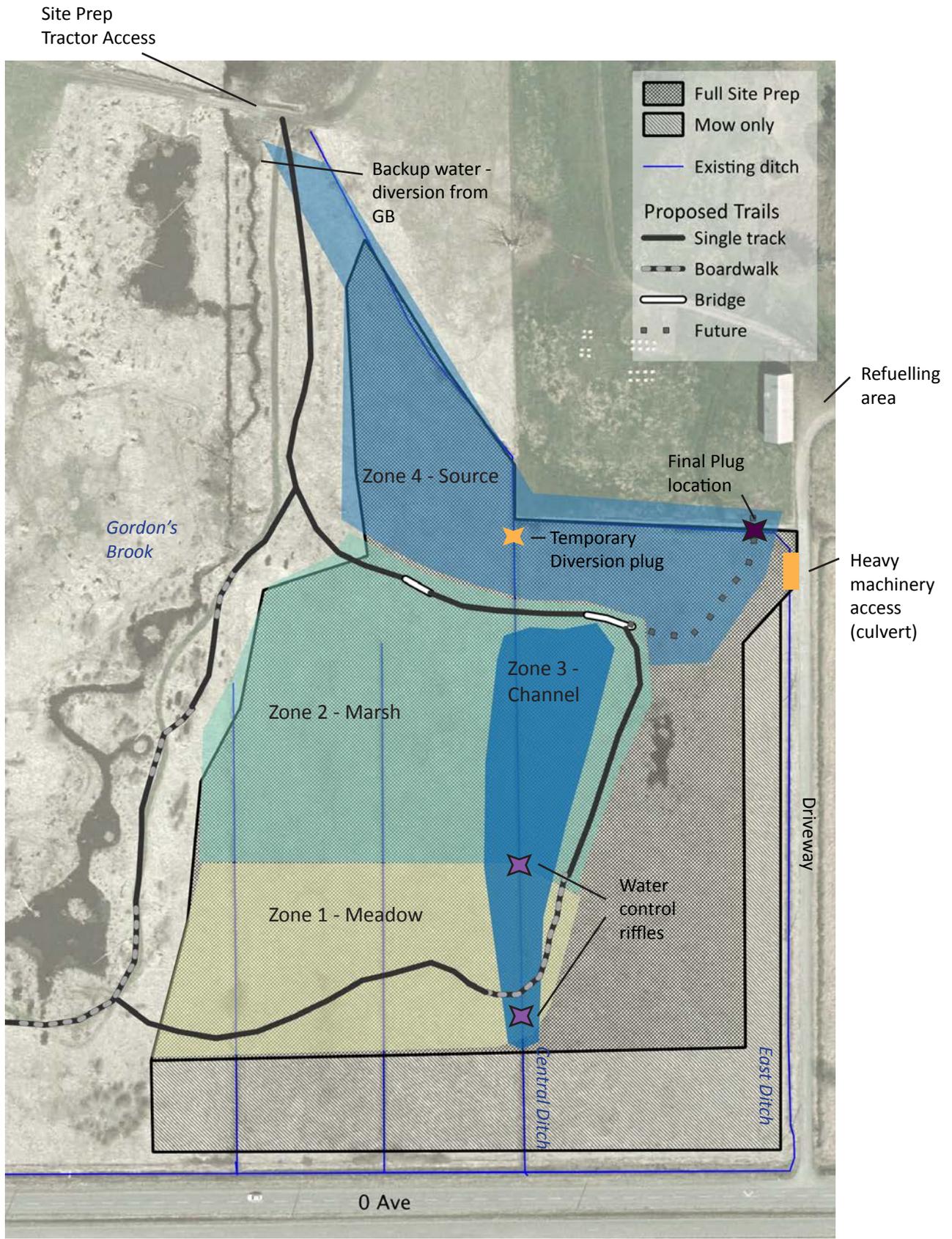
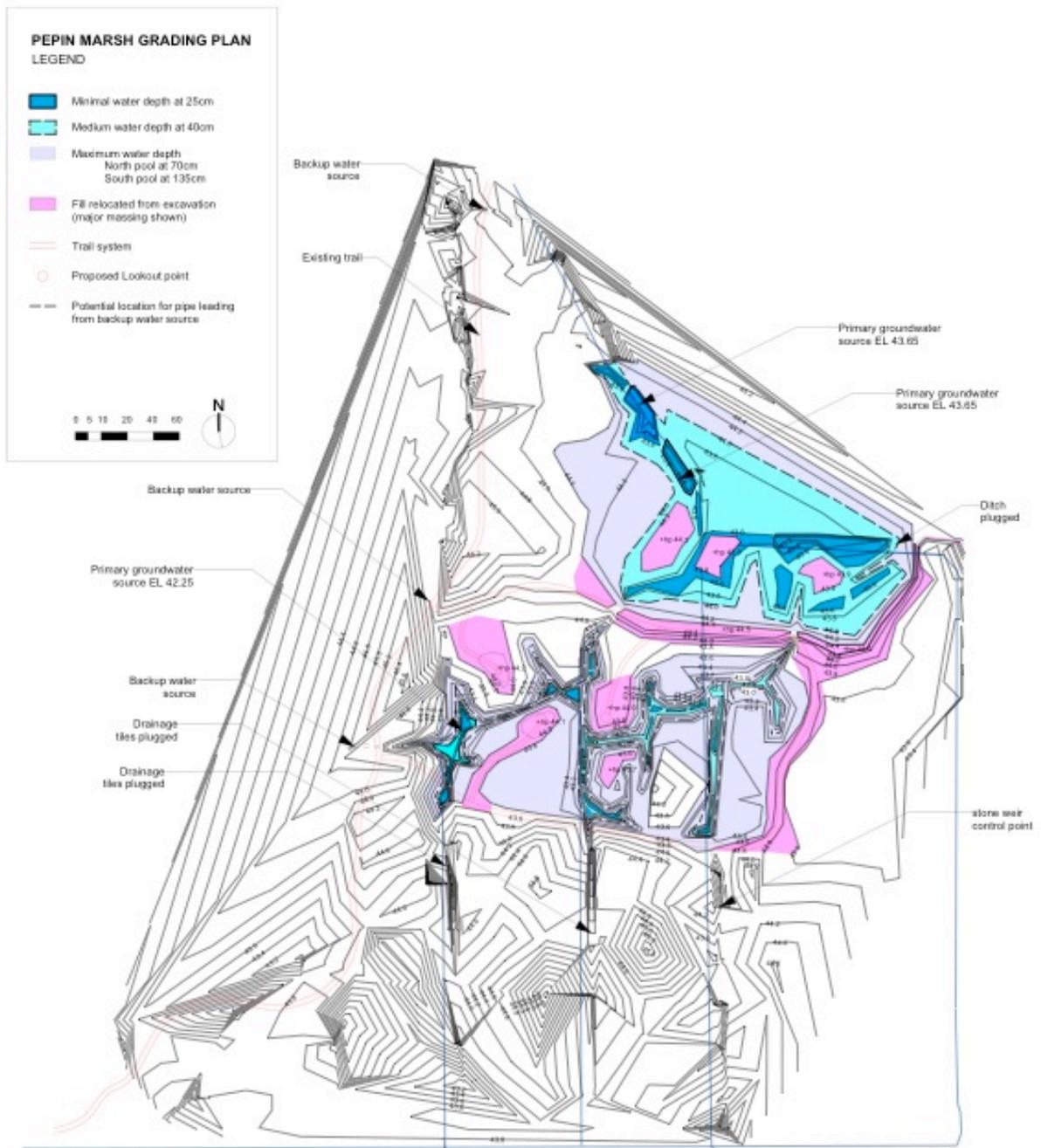


Figure 1. Work Zones for Pepin Marsh Construction



SAMPLE SECTION

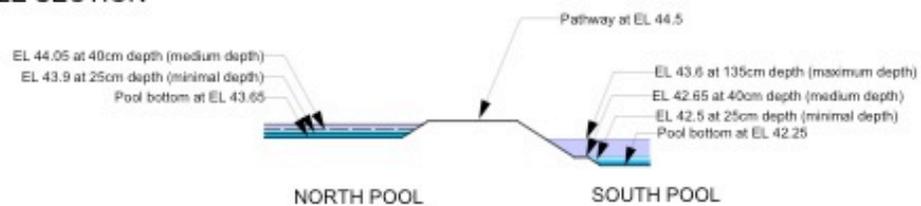


Figure 2. Grading plan and hydrologic modifications for the restoration of Pepin Marsh.

1.3 Machine Access

Tractor access for site preparation will be through Pepindale Farm on 272nd St.

Machine access will be from the driveway off of 0 Ave. A culvert will be installed on the north end of the easternmost north-south ditch along the road to ease access to the site.

1.4 Site Preparation – Invasive Species Control

Invasive species control will begin in June 2013, by mowing the existing grass in the 'Site Prep' and 'Mow Only' zones. When the grass has regrown to over 12 inches in height, we will apply a glyphosate-based herbicide using a boom sprayer across the 'Site Prep' zone. Several days after application, we will disc and till the 'Site prep' zone to fold organic matter into the soil and expose roots. Grass will be allowed to grow up again to 12' before a second application of herbicide and subsequent discing. A third treatment may be necessary before construction begins.

Existing fences along the central channel will be removed. Barbed wire will be recycled, and fenceposts salvaged as possible. Fence will be replaced where required by Metro Vancouver.

1.5 Water Quality and Sediment Control

Water level monitoring has indicated that we can anticipate dry drainage ditches and little groundwater, thanks to the existing drainage features. No in-channel work will take place if channels are wet and connected to permanent water. The central channel will be plugged directly south of the intersection between the the location of the north loop to direct surface water from the northern hillside through the east ditch, along the driveway and away from the work site during construction.

The work site will be isolated from permanent water by plugging drainage ditches and erosion from surface flows will be controlled by retaining a buffer of grass to the south and east of the work site. Silt fencing will be installed as needed if heavy rainfall is forecast. If groundwater is encountered during construction at unexpected locations, it will be directed to flow out of the worksite and into the nearest adjacent grassy field. If necessary, we will dig a temporary sump pit and pump water into the nearest adjacent grassy field. During the last stage of construction, the temporary blockage will be removed and a permanent blockage will be installed in the north-east ditch in order to direct flows towards the main wetland.

Sediment control effectiveness will be monitored regularly during precipitation events. Sand bags, silt fence, and pumps and hoses will be located onsite to ensure quick response to sediment control issues in a timely manner. Sediment controls will be maintained and repaired as necessary. An adaptive management approach will be implemented in that sediment controls will be modified or enhanced in response to identified deficiencies, for example deteriorating water quality.

Water quality will be monitored during and post works to determine compliance with the turbidity requirements of the BC Water Quality Guidelines. The BC Water Quality Guidelines allows for a maximum turbidity of 8 NTU above background in 24 hours when the background turbidity is less

than 80 NTU and 10% of background when background is greater than or equal to 80 NTU. If the turbidity is not within the guidelines, corrective sediment and erosion control measures will be implemented.

1.6 Habitat Complexing and Feature Construction for Target Species: August – September 2013

Zone 1 - Meadow

Work in Zone 1 will involve excavating a trench across the field to expose drain tile, and the subsequent infilling of that trench to plug drain tile and drainage channels. Construction of a low berm over the dug trench will serve as both a berm and as the base of the south loop trail. Material will be sourced on-site. All spoil will remain on site and within the work zone during and after works.

The final configuration of Zone 1 will be a trail bordering a meadow that floods occasionally during high rainfall events, yet even enough to mow with a large mower.

Zone 2 - Marsh

Work in Zone 2 will involve the excavation of ponds and small channels, as well as the installation of large woody debris and complex microtopography. Spoil from pond excavation will be used in trail construction and spread aesthetically across the land after major pond construction is complete. All spoil will remain on site and within the work zone during and after works.

The final configuration of Zone 2 will include shallow ponds connected by channels and surrounded by diverse microtopography.

Zone 3 - Channel

The central drainage ditch will be modified by widening, incorporation of small floodplain benches and meanders reintroduced to the straight channel. A naturalized water control structure (riffle) will be installed using wood and rock imported onto the site.

The channel is expected to be dry during the work, and any water from rainfall events that may flow in from the North will be diverted through the north-east channel during construction. The channel will be connected to water in the final stage of construction.

Zone 4 - Source

Zone 4 contains the groundwater source that will flood the wetland. Work in this zone will be the last to be completed, once habitat feature construction and complexing has been completed in Zones 1, 2 and 3.

Work in Zone 4 will involve the excavation of ponds and small channels, the installation of large woody debris, and exposing the groundwater source to the wetland. It may also include the installation of a backup water diversion pipe from Gordon's Brook to the wetland. The focus of this work is to ensure adequate water supplies for permanent ponds and addition supply to Zones 1, 2

and 3. We will work from South to North, connecting the ponds to groundwater at the end of the project. Our final task will be to install a permanent block on the eastern ditch.

1.7 Trail Construction – September 2013

Trail sections within the wetland will be outlined during construction, and the core material of raised trails installed as berms. Metro Vancouver will be responsible for additional trail construction activities. Balance Ecological and George Flath Construction will work with Metro Vancouver to install trails if requested.

1.8 Revegetation with Native Plant Species: October 2013 – April 2014

The wetland will be revegetated with native wetland herb, grass, sedge and shrub species known to historically exist in Lower Mainland freshwater marshes. Revegetation will include planting of potted plants, planting of wetland plugs, as well as high-density seeding of native wetland species. A pasture mix will be applied to areas within the 'Site Prep' zone outside of the construction area.

To create a 'barrier' around the wetland to reduce seed dispersal of reed-canary grass, a thicket of willows, hardhack and dogwood will be planted at the edge of the project footprint and on the slopes of trails. If feasible, the trails will also be treated with a mulch over-layer to reduce the passage of invasive seeds across the 'barrier' line.

Willows will be sourced on-site, cut from existing willow groves planted around the Gordon's Brook project site.

1.9 Post-construction Reporting

A post-construction report will be prepared, detailing the as-built structure, monitoring program and likely management outcomes. Monitoring and management will focus on hydrologic conditions and invasive species regrowth.

1.10 Hydrologic Monitoring and Outlet Modification

Water levels will be monitored following the work, and water outlets and inlets may be modified as necessary to increase or decrease water levels as per design. Minor adjustments will be made by hand, with addition or removal of riffle rocks at water level control points. If major adjustments are necessary, we will submit an additional work plan for the necessary activities.

1.11 Invasive Species Monitoring and Control

Invasive species control will also be monitored, and additional control method may be applied as necessary. Minor regrowth of reed canary grass will be spot-treated with herbicides in Summer 2014. Major regrowth of reed canary grass will require annual mowing in accessible portions of Zones 1 and 2.

2 Communications

Metro Vancouver will be informed when machinery will be on-site with as much notice as possible. Once on-site work has begun Balance Ecological will provide weekly brief communications and photographs that can be provided to the public as deemed necessary by Metro Vancouver and Vancouver Aquarium.

3 Emergency Response and Containment Plan

Storage of hazardous materials will be limited to only the necessary quantities to conduct the works. No fuels or other hazardous materials will be brought onto the work site. All re-fuelling will take place a minimum of 30 m from the nearest watercourse, at the refueling location. All heavy equipment will have spill kits with them and daily machinery inspections are conducted prior to each work shift.

Initial response to any spill during the works will be as follows:

- Ensure safety in the spill area;
- Stop the flow of the hazardous material if it is safe to do so;
- Secure and isolate the spill area;
- Assess the situation (identify product, equipment involved, affected area, spill status, time of spill); and,
- Begin containing and recovering the spill with onsite emergency spill equipment if it is safe to do so.

Personnel and equipment (spill kit with excavators and one large spill kit for the work area) will be available to respond to the occurrence of a minor spills (within 100 litres) and able to restore the location to pre-spill conditions. Response to spills including containment and clean-up will occur to completion and appropriate personnel will be notified of the spill following the clean-up.

In the event of a spill greater than 100 litres or triggering the reportable quantities outlined in the *Spill Reporting Regulation*, the Ministry of Environment (Provincial Emergency Program - PEP) immediately will be notified immediately and we will coordinate with the agency while the response is underway. Balance Ecological will use its own resources for minor spills (i.e. generally under 100 litres in volume) and will request assistance from relevant government agencies and professional incident response companies in the event of a major spill as well as additional equipment.

Spill reporting regulations will be in compliance with the Provincial *Environmental Management Act* Spill Reporting Regulation. Specifically, reporting to the Provincial Emergency Program will occur when the volume of spilled substance exceeds the volumes in Schedule 1 of the Spill Reporting Regulation entitled Reportable Levels for Certain Substances. Generally, and with respect to flammable liquids such as diesel and other oils, the Spill Reporting Regulation requires spills be reported to the Provincial Emergency Program if the spilled substance is conveyed to any watercourse regardless of volume or if the spill is greater than 100 litres and has spilled to ground.

Spills, which do not trigger the Spill Reporting Regulation, will be documented internally and reported to MV regardless of where the spill occurs.

Following the cleanup of any significant spill (i.e. abnormal in volume or substance) is complete; Balance Ecological will hold a debriefing with all involved personnel. This debriefing will include review of the following:

- Root cause of the spill;
- Measures to prevent the spill from occurring again;
- Review with associated crew members; and,
- How could the response have been improved

EXTERNAL CONTACTS FOR SPILL RESPONSE

- Provincial Emergency Program (PEP) 1-800-663-3456
- Fisheries and Oceans Canada, Fisheries Officer 604-892-3230
- MoE, Conservation Officer 604-898-2175
- DFO Radio Room 1-800-465-4336
- Fire Emergency 911
- Police Emergency 911
- Ambulance 911