

Continued Monitoring of the Constructed Wetland at Diversion Reservoir, Jordan River Watershed, Southern Vancouver Island



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Cover Photograph

Red-legged Frog (*Rana aurora*) in the lower pond of the constructed wetland at Diversion Reservoir, Jordon River Watershed, Vancouver Island, B.C. Photo © Krysia Tuttle, LGL Limited, 2011.

Executive Summary

Constructed wetlands are one example of habitat restoration that can be effectively used to mitigate for the loss of aquatic habitat and to offset the impacts of human activities such as hydroelectric development. The strategic water plan for coastal BC Hydro identified the loss of wetland habitat as having a major impact on wildlife in the Jordan River Watershed on southern Vancouver Island (BC Hydro 2001). In 2009, as part of a habitat restoration strategy developed for BCRP for the Jordan River Watershed, LGL Limited designed and built a two-tiered wetland on the edge of Diversion Reservoir to compensate for habitat that was lost during the impoundment of Jordan River in 1911. This constructed wetland monitoring project builds on amphibian species-at-risk surveys (2005) and work completed under grant 06.W.JOR.01: Jordan River Integrated Wildlife Habitat Restoration Plan and Constructed Wetland Design (2006). The wetland construction was a proof-of-concept build that if successful, can be applied to other watersheds that comprise the Bridge Coastal system.

The implemented constructed wetland design included a lower pond of 3,300 m² and an upper pond of ~4,050 m². The constructed wetland is situated entirely within the drawdown zone of Diversion Reservoir and earthen berms were constructed to retain water with an expectation that the berms would be overtopped by Diversion Reservoir at certain times of the year. Although the wetland was built (2009) and initial re-vegetation was completed (2010), two very important aspects of this wetland project remained: 1) the evaluation of revegetation efforts; and 2) a minimum of two-years of monitoring of the constructed wetland to obtain metrics of success and to determine the utility of the design for potential future wetland construction projects within the Bridge Coastal area.

Monitoring surveys in 2012 revealed that the process of plant succession is occurring naturally three years after the build, mostly with aquatic and terrestrial plants native to the area. A total of 71 plants were documented in the footprint area of the constructed wetlands in 2012: 20 aquatic and 51 terrestrial. Seventeen non-native plants were recorded, some of which are invasive, mainly in the disturbed areas along the northern edge of the wetland. Several of these invasive plants were removed in September.

Results of the wildlife monitoring in 2012 indicated that multiple species are using the constructed wetland habitat. For example, we documented three species of amphibian and one species of garter snake, multiple songbird species (including several breeding occurrences), and mammal tracks and scat, all of which were either using the wetland itself or habitats immediately adjacent to the wetland area (e.g., Diversion Reservoir, upland forest). We also observed two species of butterfly and at least 6 species of dragonfly using the wetland area.

The success of this constructed wetland provides a model that could be applied to other watersheds in BC affected by the impoundment of rivers and creation of reservoirs. To further ensure future success of this wetland, we recommend periodic monitoring surveys of shorter duration to target specific groups over a period of five to ten years, with a decreased monitoring frequency over time. Suggested target monitoring includes spring amphibian surveys (e.g., Red-legged Frog [*Rana aurora*], Western Toad [*Anaxyrus boreas*]), acoustic bat surveys (Townsend's Big-eared Bat [*Corynorhinus townsendii*]), rare plant surveys, and general monitoring of wetland and berm integrity. We also recommend the periodic removal of invasive plant species that were documented at the site to improve the integrity of the wetland, riparian areas and terrestrial surroundings.

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1.0 Introduction

Wetland ecosystems are valuable natural resources that provide habitat for many plant and animal species, as well as contribute to important biological processes (e.g., nutrient cycling; MacKenzie and Shaw 2000). Due to various human activities such as urban, agricultural, and hydroelectric development, wetland ecosystems have been severely impacted throughout North America over the past five decades, changing landscape habitat and ecosystem hydrology, as well as displacing organisms that rely on these sensitive habitat ecosystems (Bishop and Pettit 1992; Nilsson and Berggren 2004). Restoration of wetland areas to pre-disturbance conditions or the creation of new wetland habitat are conservation strategies that help mitigate for the decline in aquatic ecosystems in our natural world (Cairns 1991). Amphibian species are of particular interest to wetland restoration projects, in part because of the diversity of species that occur on Vancouver Island, but also due to their world-wide decline in numbers (Houlahan et al. 2000; Hopkins 2007). Amphibians are animals that rely on moisture during most stages of their lifecycles, thus rely on either wetland/riparian habitat, or moist conditions, such as those found in BC coastal forests.

The strategic plans developed for the 15 watersheds within the BC Hydro's Bridge Coastal system in Western British Columbia include restoration as one method to mitigate for habitat lost during the impoundment of rivers and the creation of reservoirs (BC Hydro 2001). BC Hydro identified the loss of wetland habitat as having a major impact on wildlife in the Jordan River Watershed on southern Vancouver Island. Documented effects of hydroelectric developments in the Jordan River watershed include the near (or complete) extirpation of salmon runs from the lower Jordan River and the loss of wetland habitat for locally breeding amphibian populations (Hawkes 2005), including the provincially and federally-listed Red-legged Frog (*Rana aurora*).

In 2007, BC Hydro's Bridge Coastal Restoration Program (now called the Fish and Wildlife Compensation Program – Coastal [FWCP]) funded a project to construct a wetland within the drawdown zone of Diversion Reservoir on Southern Vancouver Island (Hawkes and Fenneman 2010). The construction of the wetland followed a feasibility study (Hawkes 2007) that ranked and prioritized various restoration options of wildlife and their habitat in the Jordan River Watershed. The wetland construction was also a proof-of-concept design to demonstrate the utility and effectiveness of wetland construction adjacent to the drawdown zones of reservoirs established for the production of electricity in B.C.

In 2009, LGL Limited designed and built a two-tiered wetland on the edge of Diversion Reservoir within the Jordan River Watershed and this report summarizes the results of the second year of post-construction monitoring of the wetland in 2012. This was accomplished by the collection of environmental and ecological conditions (e.g., flora and fauna, biophysical data) at the Diversion Reservoir constructed wetlands and by an assessment of the level of success associated with the proof-of-concept wetland build based on a variety of performance measures that can be compared in future years of monitoring (Tuttle 2012).

1.1 Project Background and Timeline

The seeds for this project were sown in 2005, when a report outlining the status of the Red-legged Frog (a provincial and federal species of conservation concern) in the Jordan River watershed was produced by LGL Limited (Hawkes 2005). This report

suggested that breeding habitat for this species was limited in the watershed, and most of what had originally occurred had been lost during the creation of the Diversion and Bear Creek Reservoirs.

In 2007, LGL Limited developed an Integrated Wildlife Habitat Restoration Plan (IWHRP), which included a proposal to develop a constructed wetland along the shoreline of Diversion Reservoir in the Jordan River watershed (Hawkes 2007). The intent of the proposed design was to create shoreline wetland habitat and thereby help to offset some of the historical wetland habitat losses that occurred with the impoundment of the reservoir. Habitat creation was deemed as the action with the greatest potential to mitigate footprint impacts resulting from impoundment of the Jordan River. This was consistent with the stated wildlife restoration objectives that were presented by BCRP in the Jordan River watershed plan, most notably Objective 2: “Rehabilitate reservoir drawdown zones to enhance productivity and wildlife habitat” (Bridge Coastal Fish and Wildlife Restoration Program 2010).

The wetland was constructed during 2009, revegetated in 2010, and subsequently visited in 2011 to monitor the status of this newly-created habitat (Tuttle 2012). LGL Limited received additional funds from FWCP to conduct a second year of monitoring of the wetlands in 2012.

The following provides a more detailed timeline for this project:

- **February 2002:** Jordon River Water Use Plan (WUP) was submitted by BC Hydro to Comptroller of Water Rights.
- **November 2003:** Grant application to investigate the distribution of Red-legged Frog habitat in the Jordan River Watershed submitted to BCRP by LGL Limited.
- **May 2005:** LGL Limited submitted the report “Distribution of Red-legged Frog (*Rana aurora*) breeding habitat in the Jordan River Watershed, Vancouver Island, British Columbia” to BCRP, which suggested that a constructed wetland along the shore of Diversion Reservoir would greatly enhance the available habitat for this listed amphibian species.
- **November 2005:** Grant application for the development of an integrated wildlife habitat management plan and development of proof-of-concept wetland design for the Jordan River Watershed submitted to BCRP by LGL Limited.
- **November 2006:** Grant application to build a constructed wetland as a proof-of-concept in the drawdown zone of Diversion Reservoir submitted.
- **August 2007:** LGL submits report entitled “Integrated wildlife habitat restoration plan for the Jordan River watershed, southern Vancouver Island, British Columbia”, which summarized the ecological impacts of hydroelectric developments and provided recommendations for remediation and restoration activities that could help offset these impacts, including the construction of wetland.
- **July 2009:** Site selection for the proof-of-concept wetland build within the drawdown zone of Diversion Reservoir.
- **Sept – Oct 2009:** Construction of berms and creation of wetland habitat by LGL Limited in partnership with Kerr-wood Lidel and TimberWest.

- **April – Aug 2010:** LGL Limited conducted preliminary monitoring site visits to assess the water retention capabilities of the berms, the vegetation regrowth and document wildlife use of the constructed ponds. Three areas around the perimeter of the wetland were planted with willow stakes.
- **November 2010:** Grant application for post-construction of constructed wetland and proof-of-concept assessment at Diversion Reservoir submitted to BCRP by LGL Limited.
- **April – Sept 2011:** One year post-construction monitoring of the wetland, including wetland integrity, flora establishment and wildlife use of the area.
- **November 2011:** Grant application for the continued monitoring of constructed wetland and proof-of-concept assessment at Diversion Reservoir submitted to BCRP by LGL Limited.
- **May – Sept 2012:** Year two of post-construction monitoring of the wetland, including wetland integrity, flora establishment and wildlife use of the area.

2.0 Goals and Objectives

The constructed wetland at Diversion Reservoir was built in 2009, re-vegetated in 2010 (Hawkes and Fenneman 2010), and monitored for one year in 2011 (Tuttle 2012). Two important aspects of this wetland restoration project remained:

1. To evaluate the 2010 revegetation efforts and to continue the revegetation process replanting any areas that did not take using native plants; and
2. To monitor the wetland to obtain metrics of success and to determine the success of the wetland design for potential future wetland construction projects within BC Hydro's Bridge Coastal area.

The primary objective of this project was to conduct a second year post-construction assessment of the ecological conditions (e.g., flora and fauna diversity and richness, wetland integrity and hydrology of the site) of the newly created wetland at Diversion Reservoir. A variety of performance measures were developed in 2011 to indicate success for the wetland; these measures were used in 2012 and can be compared in future years to ensure that the project is meeting its intended goal of the creation of habitat in the Jordan River Watershed.

3.0 Study Area

3.1 Jordan River Watershed

The Jordan River is located within the Capital Regional District, along the southwest coast of Vancouver Island, approximately 72 km by road from Victoria, B.C. The 25 km long river flows southwesterly between the Sooke Hills and the Seymour Mountain range into the Juan De Fuca Strait at the community of Jordan River (Figure 1). The watershed drains an area of approximately 165 km², flowing westward to empty into the Pacific Ocean along the northern coast of the Strait of Juan de Fuca. Jordan River is a steep, incised watercourse with several barriers to fish migration, including a series of boulder obstructions 1.2 km from the mouth of the river (Wright and Guimond 2003). High water inflows from snowmelt occur between May and July, with August and September

generally very dry. Heavy rain also can cause immediate high flows between October and March.

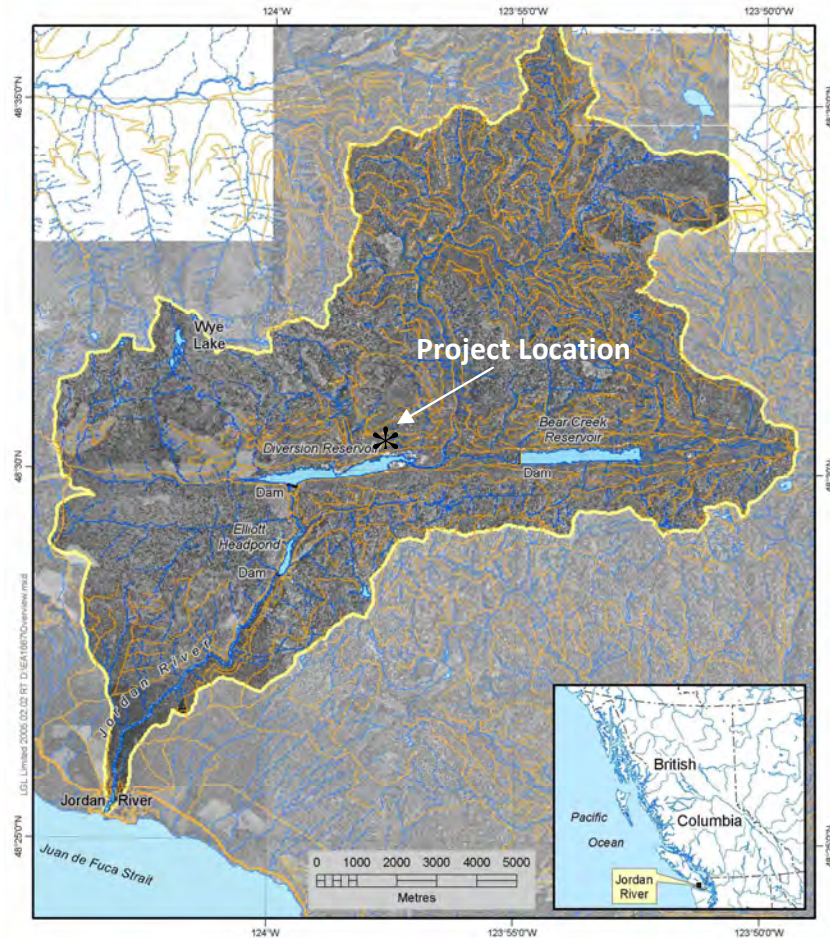


Figure 1: Location of constructed wetlands within the Jordan River Watershed on Southern Vancouver Island.

The Jordan River Watershed is part of the Coast and Mountains Ecoprovince, the Western Vancouver Island Ecoregion, and the Windward Island Mountains Ecosection (Demarchi 1996). Within the Windward Island Mountains Ecosection, the project area is contained within 4 variants of the Coastal Western Hemlock (CWH) biogeoclimatic zone, which covers much of Vancouver Island (Table 1).

Table 1: Biogeoclimatic zones, subzones, and variants occurring within the Jordan River Watershed.

Label	Zone	Subzone	Variant
CWHvm1	Coastal Western hemlock	Very wet maritime	submontane
CWHvm2	Coastal Western hemlock	Very wet maritime	montane
CWHmm1	Coastal Western hemlock	Moist maritime	submontane
CWHmm2	Coastal Western hemlock	Moist maritime	montane

The CWH is characterized by cool summers and mild winters and the highest average rainfall of all biogeoclimatic zones (Pojar et al. 1991). Within the CWH, Western Hemlock (*Tsuga heterophylla*) is the dominant coniferous tree species with Douglas-fir (*Pseudotsuga menziesii* ssp. *menziesii*) being widespread. Western Redcedar (*Thuja*

plicata), Amabilis Fir (*Abies amabilis*) and Yellow-cedar (*Chamaecyparis nootkatensis*) are also common, the latter two species being restricted primarily to higher elevations (especially on southern Vancouver Island). Bigleaf Maple (*Acer macrophyllum*), Red Alder (*Alnus rubra*), and Black Cottonwood (*Populus balsamifera* ssp. *trichocarpa*) are common in riparian zones throughout the CWH (Pojar et al. 1991). Characteristic floristic features of zonal ecosystems in the CWH are:

- a) prominence of western hemlock;
- b) sparse herb layer; and
- c) predominance of several moss species (especially *Hylocomium splendens* [step moss] and *Rhytidiadelphus loreus* [lanky moss]).

3.2 Diversion Reservoir

Initial impoundment occurred in the Jordan River watershed as early as 1909, and by 1913 two large reservoirs (Bear Creek Reservoir and Diversion [=Jordan] Reservoir) had been created above the townsite of Jordan River. The Elliot Headpond, a small reservoir below Diversion Reservoir, was added in 1971. The construction of these dams resulted in the flooding of almost 200 ha of riparian and wetland habitats in the Jordan River watershed, directly affecting over 20 km of the lower Jordan River. In addition, continued input of copper-contaminated water from the legacy of over 80 years of mining activities that took place in the watershed, as well as over 120 years of logging and the associated ecological impacts, have augmented the negative impacts of the hydroelectric developments and had some serious measurable effects on the health of the Jordan River (Wright and Guimond 2003).

The Jordan Diversion hydroelectric dam impounds the 18 km long Diversion Reservoir with a licensed storage volume of $20.5 \times 10^6 \text{ m}^3$ and a surface area of 179.8 ha (BC Hydro 2006). The normal operating range of the reservoir is between 367.9 m and 386.2 m elevation and monthly reservoir elevations follow a typical pattern with fluctuations based largely upon rainfall driven run-off feeds into the reservoir primarily in December through March. Inflows vary considerably throughout the year (BC Hydro 2003).

3.3 Wetland Design

Prior to wetland construction, the area consisted of a small seeping stream that flowed into Diversion Reservoir, large tree stumps, an abundance of coarse woody debris, and ground cover vegetation that consisted largely of herbaceous and graminoid plants. The constructed wetland is comprised of two wetted areas: a lower pond (~ 3,300 m²) and an upper pond (~ 4,050 m²) for a total wetland area of 7,350 m² (Figure 2). The top elevation of the lower berm was built to 383.2 m ASL, the middle berm to 384.4 m ASL and the upper berm to 384.5 m ASL. Total edge habitat created (i.e., the perimeter of the ponds) was ~551.3 m (lower pond: ~263.2 m; upper pond: 288.1 m). The depth profile of the two ponds differs substantially. The lower pond is deeper with steeper side slopes than the upper pond, with some areas of the lower pond exceeding 2 m in depth. The upper pond is relatively flat-bottomed with depth ranging from 0.5–1.0 m, with the exception of some areas towards the retaining berm that approach 2 m in depth.

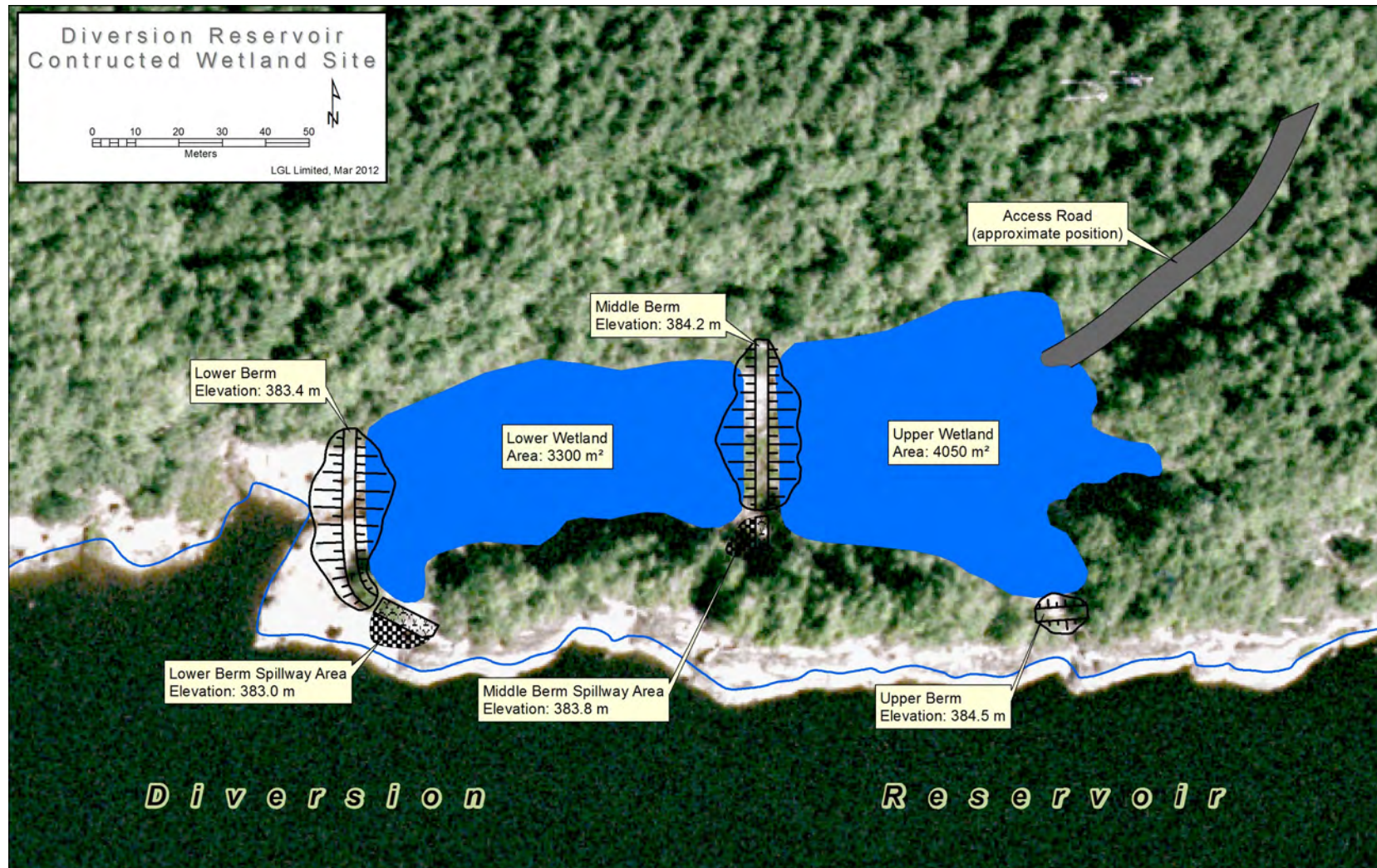


Figure 2: Location of the three berms, spillways and wetted areas (upper and lower) of constructed wetland at Diversion Reservoir. The total area of wetland habitat created is shown in blue and the access road in grey. Image created by Kerr Wood Leidel Consulting Engineers (2009) and was modified by LGL Limited (2012) for this report.

4.0 Methods

4.1 Field Schedule

Four site visits were made by LGL Limited staff members from May to September 2012 to collect wildlife, habitat and hydrological data to give an overall post-restoration assessment of the area. Timing of these surveys was based upon coinciding with the active seasons of the targeted species groups (Table 2). Wildlife monitoring surveys were aimed at documenting the presence of amphibian (e.g., salamanders and frogs), reptile (e.g., lizards, snakes), bird (e.g., songbirds, raptors, marsh birds, etc.), mammal (e.g., mustelids, ungulates), and invertebrate (e.g., terrestrial molluscs, dragonflies) present in the immediate area of the constructed wetlands. Wetland integrity (e.g., berm integrity), composition (e.g., vegetation communities), and bio-physical habitat (e.g., water physicochemistry) data were also collected for the site. All work is based on standardized methodologies (i.e., Resources Inventory Standards Committee standards).

Table 2: Timing methods for monitoring surveys of constructed wetlands at Diversion Reservoir in 2012. A = amphibian/reptile, B = bird (songbird, waterfowl, incidental), M = mammal (scat, track, browse, bat), V = vegetation (native or invasive), W = wetland characteristic (water levels, water chemistry).

Date	Target Group					Specific Methods	References
	A	B	M	V	W		
May 10 th	X	X		X	X	Amphibian Egg Mass Surveys Songbird Pointcounts Waterfowl Surveys	RIC 1998a RIC 1999b RIC 1999a
June 29 th	X	X	X	X	X	Tadpole Amphibian Surveys Vegetation Surveys	Gosner 1960 Elzinga et al. 1998
August 3 rd	X		X	X	X	Metamorph Amphibian Surveys Incidental Plant Surveys	Elzinga et al. 1998
Sept. 20 th				X	X	Invasive Species Removal	RSBC 1996

4.2 Survey Types

During site visits we recorded general environmental and site conditions, such as weather conditions using a Kestrel[®] 4500 pocket weather tracker, total survey time (i.e., sampling effort), survey area (e.g., upper or lower pond, reservoir and/or habitat type) and notable conditions that may have affected the survey results (e.g., rainfall during egg mass surveys). All field survey data (e.g., species observations) were georeferenced using a handheld Garmin[®] GPSMap 60Csx handheld receiver. During field visits to the constructed wetland we identified all flora and fauna to species (see Appendix A and B).

The following sections describe the specific methods used to survey for vegetation, amphibians, and waterfowl and birds (Figure 3). All other plant and wildlife observations were recorded as incidental. We also documented wetland characteristics, including berm conditions, assessing water levels, and water physicochemistry.

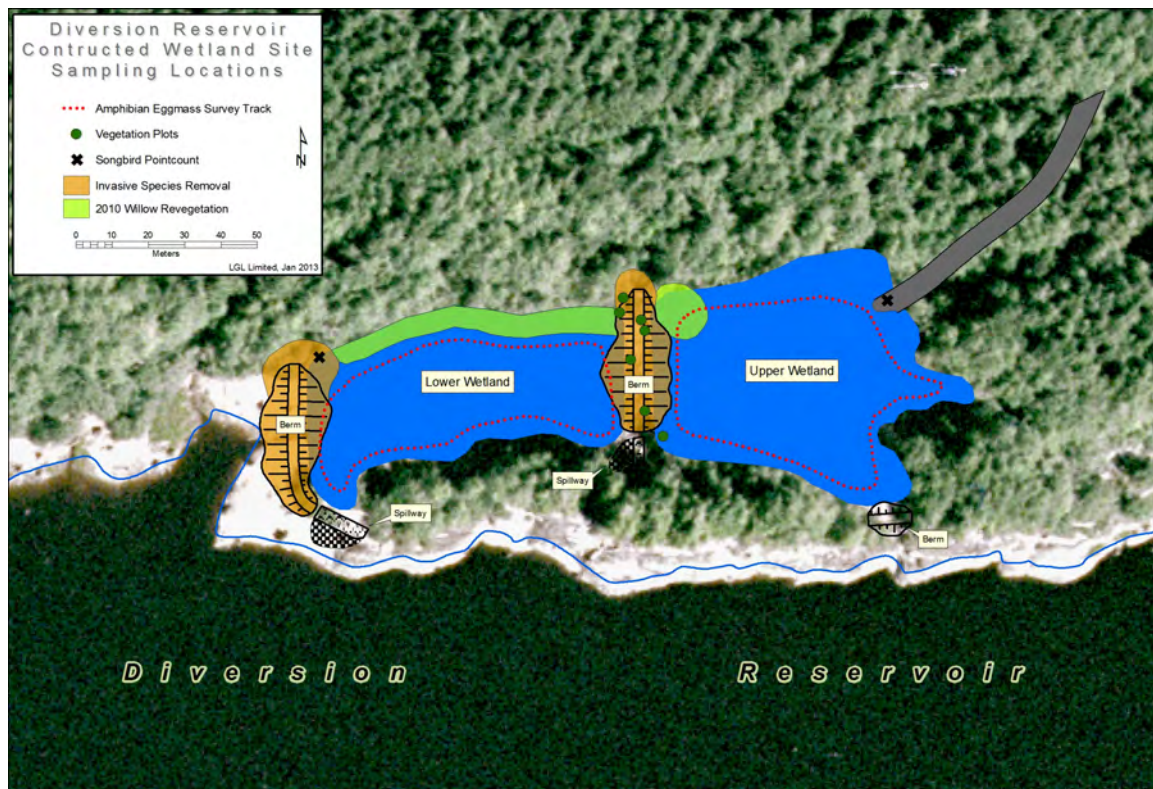


Figure 3: Sampling locations at constructed wetlands, Diversion Reservoir in 2012. Water chemistry sampling locations and incidental wildlife and plant survey tracks are not plotted on map, but cover the full extent of the wetlands and surrounding riparian areas.

4.2.1 Wetland Characteristics

Each wetland (labelled hereafter as upper and lower pond) was photographed from several angles to document wetland seasonal progression and water levels relative to the constructed berms and riparian vegetation. Constructed berms were photographed to document general condition over time (e.g., integrity, soil deposition). Daily reservoir elevations were obtained from BC Hydro to determine the period length of inundation to the wetlands from Diversion Reservoir. Water conditions such as dissolved oxygen (mg/L), pH, conductivity ($\mu\text{S}/\text{cm}$), and temperature ($^{\circ}\text{C}$) were documented with a YSI 85 water metre during each visit in the upper and lower ponds of the wetland and for Diversion Reservoir.

4.2.2 Vegetation

Surveys for plants included general incidental observations and quadrat plots documenting all aquatic and terrestrial native plants at the constructed wetland, as well as monitoring the success of the willow stakes planted during 2010.

General plant surveys: General plant surveys were completed in 2012. All plants were identified to species, photographed, and referenced by pond. These surveys also enabled an assessment of the relative diversity of exotic plants to native species at the site, which will provide an opportunity for managers to intervene in future seasons if the establishment of exotic species is considered to be at unacceptably high levels.

Quadrat plant surveys: A total of four vegetation plot surveys were completed in August 2012. These quadrats consisted of a 0.75 x 0.75 m (0.5 m²) square within which the percent cover of all species of plants was estimated. In addition, the overall cover of vegetation and other habitat variables (rock, soil, woody debris) were recorded within each quadrat to better describe the overall habitat conditions that are present. Quadrat surveys were completed both on the berms (which now support some vegetation) as well as in terrestrial environments around the perimeter of the wetlands. Quadrats were not completed in aquatic habitats as these are not suited to this particular methodology.

Survivorship of planted willow stakes: In 2010, the initial steps of revegetation included the establishment of shrub habitat around the perimeter of the wetland, particularly those areas covered with the layer of organic material, as well as on the access road on the north side of the wetland. Approximately 376 willow stakes (Sitka Willow and Pacific Willow) were collected from the fringes of the newly-formed wetland and planted in bare, disturbed areas along the northern edge of the wetland. Planted willow stakes were examined for both bud growth and overall condition, including mortality. The total number of planted stakes was recorded, with each stake classified as either live or dead based on its appearance during the survey period (some individuals that appeared dead may in fact begin to produce new growth in the future once their root system has become better established).

4.2.3 Amphibians and Reptiles

Amphibian surveys occurred via several techniques: 1) diurnal call surveys; 2) egg mass and larval surveys; and 3) visual encounter surveys (Donnelly et al. 1994). Amphibian call surveys are typically nocturnal based when frogs are most likely to be calling; however, Pacific Chorus Frogs (*Pseudacris regilla*) can also be heard calling during the day time during breeding season. Upon first arrival to the site we listened for five minutes at the edge of the wetland for amphibian activity. Aquatic searches for egg masses were conducted by visually scanning the surface and pond-bottom substrate within the wetland footprint. Egg masses were identified to species, photographed and georeferenced. Tadpoles were counted and staged using the Gosner Index (Gosner 1960). Visual encounter surveys (VES) were used for the detection of conspicuous (e.g. Red-legged Frog) species of amphibian. Searches occurred in riparian habitats, within wetlands or under vegetative cover (e.g., CWD, leaf litter, sword fern). Reptiles, such as garter snakes, were recorded on an incidental basis and morphometric data was collected (e.g., snout-vent length, weight, sex).

4.2.4 Birds

Bird observations were made via songbird pointcounts (May survey only) and on an incidental basis (remainder of survey times). Birds were identified to species, and further documented by number (where possible), activity (e.g., calling, nesting, flyover, etc.), and macrohabitat (e.g., wetland, riparian, forest, reservoir, etc.).

Water birds: An inventory of waterfowl and allied species occurred during site visits; methods followed RIC standards (1999a) but were primarily of an incidental nature. The wetland was systematically slowly scanned in a semicircle radius, with the scanning direction matching the direction of travel in order to minimize double counting. Scans were made using the naked eye or binoculars to detect, identify and count species. Observers spent sufficient time scanning to ensure that diving birds had resurfaced and

were not missed. Flyovers (i.e., birds seen or heard flying overhead but not directly associated with the terrestrial environment at the wetland site) were recorded as such.

Songbird Pointcounts: Songbird pointcount surveys were conducted on May 10th 2012. The standard methodology for variable radius point-counts followed RIC (1999b) and Breeding Bird Atlas procedures (BCBBA 2009). The pointcount stations were established at either end of the wetland separated by ~200 m to avoid counting birds twice. Surveys occurred at approximately 30 minutes prior to daybreak and were five minutes in duration. Surveyors first scanned each pond for bird activity with binoculars upon first arriving at the site and then observations began approximately 1 minute after.

4.3 Richness, Diversity and Productivity Measures

Species richness, productivity (amphibians only), and diversity measures were determined from data collected during wildlife and vegetation surveys in 2012. The number of species documented at the constructed wetland site was used as a measure of species richness. Productivity is related to the fecundity of the population being sampled. To determine productivity of amphibian populations, we reported on the number of egg masses observed for each species, and the estimated number of tadpoles and metamorphs observed in each pond of the wetland, as well as in the pitted ponds (created during materials extraction for the constructed berms).

We used an information statistic, Shannon's Diversity Index (H_s), to analyze the diversity of the plant and wildlife communities in the constructed wetlands. Shannon's diversity index is the probability that two randomly selected individuals will be members of the same species taking rare species into account. A community is considered more diverse when the probability of randomly selecting different species is low (Krebs 1999). A higher H_s indicates a higher community diversity; natural communities typically have values between 1.5 to 3.5.

4.4 Performance Measures

Post-construction monitoring of the Diversion Reservoir constructed wetland involved monitoring the characteristics (e.g., integrity, biophysical conditions) of the wetland itself and the effectiveness of the wetland in meeting the ecological objectives of the project (e.g., providing aquatic and riparian habitat for wildlife in the Jordon River watershed).

We collected data associated with the following performance measures (Tuttle 2012) to assess the success of the constructed wetland at Diversion Reservoir:

1. Continued existence of ~ 7,500 ha of created wetland habitat.
2. Water retention into early summer in at least one pond of the wetland. Water retention is also related to the depth profile of the wetland, whereby a water depth of greater than 1 m in some areas of both the upper and lower pond is maintained.
3. Water physicochemistry conditions (e.g., pH, DO, conductivity) within the acceptable range for aquatic life.
4. Little to no erosion or deterioration of the berms as determined by incidental visual post-construction monitoring and potentially formal integrity checks by a qualified engineer (on an as needed basis as part of future monitoring).

5. Less than > 50% accumulation of coarse woody debris (CWD) in the upper and lower wetland ponds throughout the summer (estimated as a percentage of surface cover: 0%; 1 to 25%, 26 to 50%, 51 to 75%, 76 to 100%).
6. Plant and wildlife species richness and diversity at the wetland.
 - a. Successful natural establishment of native plant (i.e., macrophytes) into newly created wetlands within five years. "Successful establishment" is defined here as continuous species presence for at least two years. Includes a ratio of native to invasive plant species.
 - b. Successful natural establishment of native wildlife species into newly created wetlands within 5 years. "Successful establishment" is defined here as continuous species presence for at least two years. This will be determined by assessing overall species richness and diversity, through the documentation of use by pond-breeding amphibians (e.g., Red-legged Frogs), riparian songbirds, waterfowl and other water-associated birds (e.g., Great Blue Heron), mammals, and insects (e.g., dragonflies).
7. Evidence of breeding at the wetland by amphibians (e.g., egg mass counts), riparian songbirds, waterfowl and other water-associated birds (e.g., nesting activity, presence of fledglings).
8. A measureable increase in productivity within five years of the implementation of the wetland construction. A measureable change will be assumed to be a change of 25 percent or greater.
 - a. A measurable increase in native aquatic plant (i.e., macrophyte) cover and diversity (species richness and evenness) within five years. This will include the cover of all layers of aquatic macrophytes including submerged, rooted and floating, floating, and emergent macrophytes.
 - b. Measurable increases from baseline conditions in productivity of amphibian egg masses (specifically Red-legged Frogs) within five years (baseline from 2011).
9. The extent and survivorship of re-colonized vegetative cover, includes survivorship of planted willow stakes from 2010. No measurable increases greater than 25 percent from baseline conditions of diversity (species richness and evenness) of key undesirable plant species over 10 years. Key undesirable species include Scotch Broom (*Cytisus scoparius*), Himalayan Blackberry (*Rubus armeniacus*), and thistle species (*Cirsium* spp.).

5.0 Results

5.1 Wetland Characteristics

5.1.1 Wetland Retention and Integrity

Water retention in each pond of the constructed wetland was documented during all site visits in 2012; both upper and lower ponds maintained water levels (i.e., depth profiles) of greater than 1 m in a portion of the wetland from May to September. In particular, the southern edges of each pond are notably deep (e.g., > 2 m in some areas). Daily reservoir elevations were obtained from BC Hydro to compare the period of inundation throughout the year. Based on the wetland design, the lower of the two ponds was

inundated more frequently and for longer periods than the upper pond, throughout the year (Figure 4; Figure 5). The upper wetland was completely inundated three times during the active season: early March; late June; and mid-October.

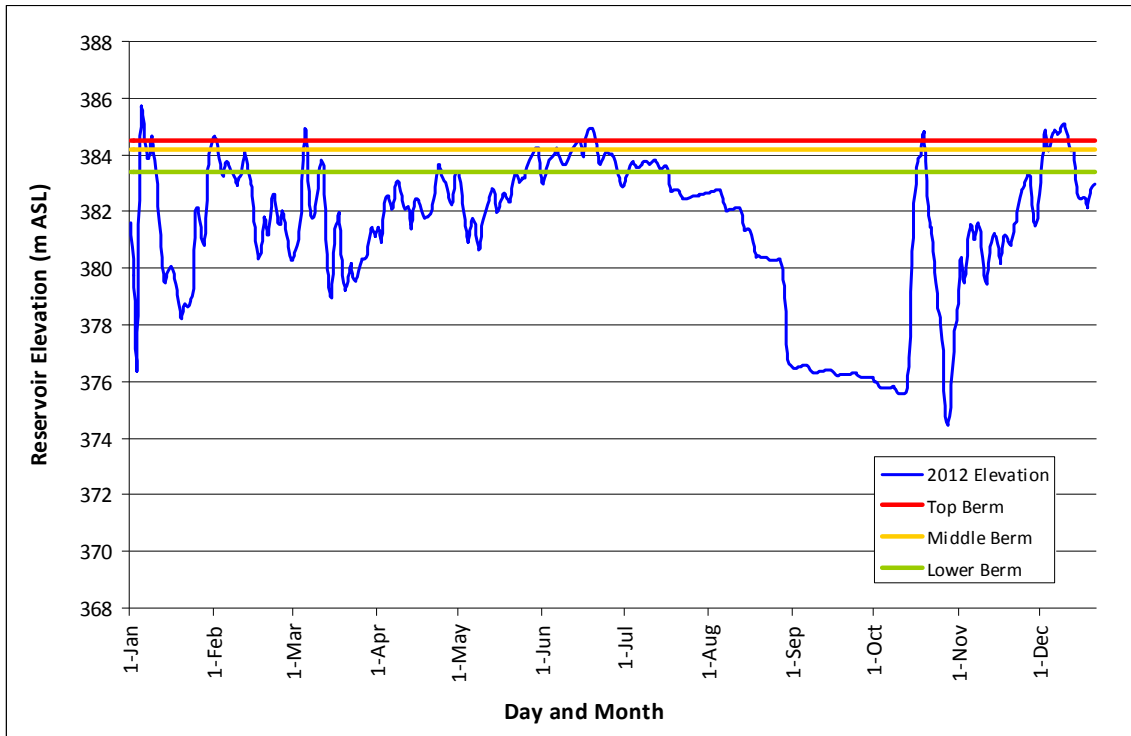


Figure 4: Daily reservoir elevations for Diversion Reservoir (blue line) and berm heights for the constructed wetlands showing the period of reservoir inundation for 2012.

The western reaches of the upper pond (including the upper berm) received some deposits of coarse woody debris (CWD) in 2012, presumably left behind as the reservoir levels dropped. The floating CWD (estimated at < 25%) remained in the wetland for the remainder of the summer months, and with the exception of a couple of large logs, was much less than in 2011.



Figure 5: Photographs of upper wetland (left) and lower wetland (right) at Diversion Reservoir constructed wetland 2012.

5.1.2 Water Physicochemistry

We collected point data for water physicochemistry (water temperature, dissolved oxygen, pH and conductivity) from four sampling locations at the constructed wetlands in Diversion Reservoir (Table 3). The ponds all exhibited water characteristics similar to those of other wetlands of similar types (Hawkes and Tuttle 2010) and measured variables fell within the acceptable range of values that will support aquatic life (e.g., aquatic macroinvertebrates, fish and amphibians).

Table 3: Mean water characteristics for the constructed wetland (upper and lower ponds) and Diversion Reservoir for the period May through September 2012.

Location / Month	Dissolved Oxygen (mg/L)	Conductivity ($\mu\text{S}/\text{cm}$)	pH	Water Temperature ($^{\circ}\text{C}$)
Lower Wetland	7.80	28.33	7.56	19.25
Upper Wetland	7.89	35.70	8.19	16.37
Reservoir	7.96	19.23	7.37	18.63
May	9.67	21.87	7.97	10.40
June	11.30	12.63	7.47	17.80
August	6.51	32.47	8.24	21.07
September*	8.12	31.45	7.16	22.85
Overall Average	8.10	28.24	7.76	17.59

The constructed wetlands appeared to provide suitable habitat for wildlife based on some of the physicochemistry data collected. Water temperature varied greatly across the seasons from 10.4 $^{\circ}\text{C}$ in the spring to over 22 $^{\circ}\text{C}$ in the summer. pH levels remained fairly consistent across the sampling period. Dissolved oxygen levels were higher in the spring and decreased as the summer progressed (likely due to increased algal growth and plant decomposition). In general, developing amphibians that rely on oxygen in the water column tend to be found in ponds with higher dissolved oxygen levels (Dale et al. 1985; Duellman and Trueb 1986); the dissolved oxygen levels for these wetlands in the spring fall within those ranges (9.7 and 11.3 mg/L). Conductivity is likely to be affected by a number of factors, including time of day, season and air temperature; thus, the biological significance of any variability is difficult to assess.

5.2 Plants and Wildlife

A total of 120 species (i.e., species richness) were located or observed during the monitoring surveys: 71 plants species and 49 wildlife species (plus at least five species of dragonflies). Only two provincial or federally-listed plants and animals were documented in 2012, but an additional 27 could occur at this site (see Section 5.2.2.4 below). Diversity of the plant and wildlife communities at the wetland varied by group; wildlife diversity ($H_s = 1.25$) was lower overall compared to plant diversity ($H_s = 1.66$), both of which were lower than in 2011. The following sections describe each group in detail and see Table 10 and Table 11 in the Appendix for a complete list of plants and wildlife documented by habitat at the constructed wetlands in 2012.

5.2.1 Vegetation

5.2.1.1 Vegetation Community

Diversion Reservoir is situated within the CWHmm1 (Moist Maritime Coastal Western Hemlock zone, submontane variant) biogeoclimatic zone. The year-round availability of spring-fed water from the adjacent northern forested slope, as well as from Diversion

Reservoir, maintains high moisture content in the soil and allows for the continued existence of a wetland community. Prior to the creation of the wetland, the vegetation was characterized by species that were widespread within the drawdown zone of the reservoir. Dominant herbaceous plants at the site included Wool-grass (*Scirpus cyperinus*) and Kellogg's Sedge (*Carex lenticularis* var. *lipocarpa*), with willows (Sitka Willow [*Salix sitchensis*] and Pacific Willow [*S. lucida* ssp. *lasiandra*]) forming the dominant riparian vegetation around the fringes of the bay. Upland habitats around the site are composed of mid-seral second-growth coniferous forests that are dominated by Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*), Western Hemlock (*Tsuga heterophylla*), and Western Redcedar (*Thuja plicata*), with Red Alder (*Alnus rubra*) and Black Cottonwood (*Populus trichocarpa*) occurring primarily on wetter microsites. Understory vegetation of upland habitats includes species such as Sword Fern (*Polystichum munitum*), Salmonberry (*Rubus spectabilis*), Red Huckleberry (*Vaccinium parvifolium*), and Vanilla-leaf (*Achlys triphylla*), all of which are common and characteristic plant species throughout much of the CWH biogeoclimatic zone.

A total of 71 species of vascular plant were documented at the constructed wetland from April to September 2012 (see Table 10 in Appendix A for a complete plant list for the area), including 54 native and 17 introduced species. No species at risk were documented at the site during the 2012 surveys. Most of the plants that occurred within the footprint of the wetland area were herbaceous or forb species (n = 44), although graminoid (n = 12), shrub (n = 9) and tree (n = 6) species were also common around the periphery of the wetland and in the surrounding riparian forest. Due to the high elevation of the area, the majority of the plant growth occurred from May to July (later than at sea level), and as a result vegetation surveys were conducted in June to coincide with the peak growing season.

Common aquatic plant species (n = 20) that had colonized the wetland included American Brooklime (*Veronica beccabunga*), Marsh Speedwell (*V. scutellata*), Pacific Water-parsley (*Oenanthe sarmentosa*), Spring Water-starwort (*Callitriche palustris*), and Small-flowered Forget-me-not (*Myosotis laxa*). Immediately around the edges of the wetland, rush and grass species such as Common Rush (*Juncus effusus*), Spreading Rush (*Juncus supiniformis*), Wool-grass (*Scirpus cyperinus*), and Kellogg's Sedge (*Carex lenticularis* var. *lipocarpa*) grew in areas with increased sun exposure and high soil moisture. Other common herbaceous species at the site include Giant Horsetail (*Equisetum telmateia*), Broad-leaved Dock (*Rumex obtusifolius*), and Purple-leaved Willowherb (*Epilobium ciliatum*). The most commonly occurring riparian tree and shrub species around the wetland were Red Alder (*Alnus rubra*), Salmonberry (*Rubus spectabilis*), and both willow species (Pacific Willow [*Salix lucida* ssp. *lasiandra*] and Sitka Willow [*S. sitchensis*]).

5.2.1.2 Introduced Plant Species

Several non-native plant species were noted at the study site, some of which are considered invasive in that they often outcompete or displace native vegetation. Scotch Broom (*Cytisus scoparius*), Canada Thistle (*Cirsium arvense*), and Bull Thistle (*Cirsium vulgare*) were the most abundant invasive species, particularly on the slightly drier microsites that were typically associated with small areas of disturbance; all three of these species are considered invasive in British Columbia. Most of the introduced species at the site occurred in the disturbed areas (e.g., road access points, constructed berms), often as single plants or small groups. These species were not generally present

in the natural forested habitats at the site or within the aquatic habitats of the constructed wetland, at least not in densities that would be cause for concern.

5.2.1.3 Survivorship of Willow Stakes

Site visits to the wetland in 2012, included an evaluation of the willow stakes planted in 2010 (Figure 6). Approximately 376 willow stakes were planted in 2010, of which 322 were alive in 2011, and ~300 were alive in 2012. Survivorship of the living stakes was estimated to be > 75%. Virtually all living stakes were putting out new green vegetative shoots, and most individuals had developed reproductive structures. Red Alder seedlings had also naturally revegetated the inner face of the middle berm, creating a band of seedlings above the lower band of herbaceous vegetation. Due to the rapid establishment of native aquatic and terrestrial plants at the constructed wetlands, no additional planting of willows or transplanting of other native plants to the wetland was carried out in 2012.



Figure 6: Photographs of willow stake revegetation along the northern shoreline of the constructed wetland at Diversion Reservoir in 2011 (left) and 2012 (right).

5.2.2 Wildlife

5.2.2.1 Amphibians and Reptiles

Three species of pond breeding amphibian were documented using the ponds and riparian edges at the constructed wetlands in 2012: Red-legged Frog; Northwestern Salamander (*Ambystoma gracile*); and Pacific Chorus Frog (*Pseudacris regilla*). Overall, the number of pond-breeding amphibian species was high for this site compared to the number of species that occur on Vancouver Island (n = 3 and 6, respectively) (Figure 7). Most notably, numerous egg masses, tadpoles, and two metamorph Red-legged Frogs were observed in and around the periphery of the wetland. No adults were seen in 2012, although egg masses lend evidence to their presence outside of survey periods.



Figure 7: Species of pond breeding amphibians documented at the constructed wetlands at Diversion Reservoir in 2012. From left to right: Pacific Chorus Frog, Northwestern Salamander, and Red-legged Frog (tadpole).

We documented a total of 86 amphibian egg masses within the constructed wetland ponds, and no egg masses were observed in the reservoir in 2012 (Table 4). The observed egg masses were from three species of pond-breeding amphibian including Pacific Chorus Frog (n = 22), Red-legged Frog (n = 58), and Northwestern Salamander (n = 6). In most cases, amphibian egg masses were located in shallow to moderate depths of water (10 to 90 cm) and attached to vegetation (e.g., willow branches or underwater sedges) near the edges of the pond. Pacific Chorus Frogs were heard calling in both riparian and forested habitat, and bred in both the upper and lower ponds of the constructed wetlands (egg masses and tadpoles observed). Tadpoles observed included Red-legged Frogs(n = 6) in both ponds and Pacific Chorus Frog tadpoles (n = 4) located in the upper pond.

Table 4: Number of pond-breeding amphibians by species and life stage identified at the constructed wetlands, Diversion Reservoir in 2012.

Species	Scientific Name	Life Stage	# Per Pond		Total # Egg Masses
			Lower	Upper	
Red-legged Frog	<i>Rana aurora</i>	Egg Mass	34	24	58
		Tadpole	1	5	
		Metamorph	1	1	
Northwestern Salamander	<i>Ambystoma gracile</i>	Egg Mass	6	0	6
		Adult	0	1	
Pacific Chorus Frog	<i>Pseudacris regilla</i>	Egg Mass	12	10	22
		Tadpole	0	4	
		Metamorph	3	15	

One Common Garter Snake (*Thamnophis sirtalis*) was documented on the middle berm between the upper and lower ponds foraging on Pacific Chorus Frog tadpoles. Western Terrestrial Garter Snakes (*Thamnophis elegans*) have previously been observed at the wetland and it is likely that Northwestern Garter Snakes (*Thamnophis ordinoides*) could also occur at the site.

5.2.2.2 Birds

Forty species of bird were documented during visits to the constructed wetlands in 2012; these numbers being a drastic increase from the numbers recorded in 2009 (pre-construction) and 2010 (1st year post-construction). Of these species, only two (Great Blue Heron [*Ardea Herodias*; blue-listed and special of special concern] and Barn Swallow [*Hirundo rustica*; blue-listed]) are assessed as a species at risk. In addition to the species detected during the site visits, other species at risk that could be expected at

the site include Green Heron (*Butorides virescens*), Olive-sided Flycatcher (*Contopus cooperi*), and Band-tailed Pigeon (*Patagioenas fasciata*).

The constructed wetland site is important both for nesting, migrating, and wintering songbirds (n =31), as well as water birds and shorebirds (n = 7) that are associated with wetland and lake habitats. Thirteen species of bird were recorded at songbird pointcounts and 39 incidental observations of bird species were made both within the wetland footprint and in the surrounding forested area (Table 5). Nesting activity was noted on several occasions near the wetlands, and fledgling American Robins (*Turdus migratorius*) and Cedar Waxwings (*Bombycilla cedrorum*) were documented feeding in the area during the summer. Wilson's Warbler (*Wilsonia pusilla*) and Warbling Vireos (*Vireo gilvus*) were the most frequently observed species, with 15 and 12 individuals (respectively) detected from the wetland and riparian areas.

Table 5: Species of bird observed at the constructed wetlands, Diversion Reservoir during 2012. PC = pointcount observation, I = incidental observation.

Common Name	Species Name	No. of Individuals		Activity	Habitat Type
		PC	I		
Hérons, Bitterns (Ardeidae)					
Great Blue Heron	<i>Ardea herodias</i>		2	Visual	Upper Wetland
Waterfowl (Anatidae)					
Hooded Merganser	<i>Lophodytes cucullatus</i>		2	Visual	Lower Wetland
Canada Goose	<i>Branta canadensis</i>		3	Swimming	Wetland, Res
Barrow's Goldeneye	<i>Bucephala islandica</i>		2	Swimming	Upper Wetland
Shorebirds (Scolopacidae)					
Spotted Sandpiper	<i>Actitis macularius</i>		2	Visual	Wetland
Kingfishers (Cerylidae)					
Belted Kingfisher	<i>Megaceryle alcyon</i>		1	Feeding	Wetland
Raptors (Accipitridae)					
Osprey	<i>Pandion haliaetus</i>		1	Flyover	Reservoir
Bald Eagle	<i>Haliaeetus leucocephalus</i>	1		Flyover	Reservoir
Grouse (Parsianidae)					
Ruffed Grouse	<i>Bonasa umbellus</i>	2	2	Drumming	Forest
Woodpeckers (Picidae)					
Hairy Woodpecker	<i>Picoides villosus</i>		1	Calling	Forest
Flycatchers (Tyrannidae)					
Pacific-slope Flycatcher	<i>Empidonax difficilis</i>		2	Calling	Forest
Vireos (Vireonidae)					
Warbling Vireo	<i>Vireo gilvus</i>	6	6	Calling	Riparian
Jays & Crows (Corvidae)					
Common Raven	<i>Corvus corax</i>		1	Flyover	Reservoir
Stellar's Jay	<i>Cyanocitta stelleri</i>		1	Calling	Forest
Swallows (Hirundinidae)					
Barn Swallow	<i>Hirundo rustica</i>		1	Feeding	Upper Wetland
Chickadees (Paridae)					
Chestnut-backed Chickadee	<i>Poecile rufescens</i>	1	5	Calling	Forest
Trecreepers (Certhiidae)					
Brown Creeper	<i>Certhia americana</i>		2	Calling	Forest
Wrens (Troglodytidae)					
Pacific Wren	<i>Troglodytes pacificus</i>	1	3	Calling	Forest
Kinglets (Regulidae)					
Ruby-crowned Kinglet	<i>Regulus calendula</i>		1	Calling	Forest
Golden-crowned Kinglet	<i>Regulus satrapa</i>		2	Calling	Forest
Hummingbirds (Trochilidae)					
Rufous Hummingbird	<i>Selasphorus rufus</i>		1	Calling	Riparian
Thrushes (Turdidae)					
American Robin	<i>Turdus migratorius</i>	3	4	Calling	Wetland, Rip

Varied Thrush	<i>Ixoreus naevius</i>	1	Calling	Forest	
Swainson's Thrush	<i>Cyanocitta stelleri</i>	1	Visual	Riparian	
Hermit Thrush	<i>Catharus guttatus</i>	1	Visual	Lower Wetland	
Pipits (Motacillidae)					
American Pipit	<i>Anthus rubescens</i>	1	Flyover	Wetland	
Waxwings (Bombycillidae)					
Cedar Waxwing	<i>Bombycilla cedrorum</i>	5	Feeding	Wetland, Rip	
Warblers (Parulidae)					
Common Yellowthroat	<i>Geothlypis trichas</i>	1	2	Calling	Wetland
Yellow-rumped Warbler	<i>Dendroica coronata</i>	4	4	Calling	Riparian
Yellow Warbler	<i>Dendroica petechia</i>		1	Calling	Riparian
Wilson's Warbler	<i>Wilsonia pusilla</i>	7	8	Song	Wetland, Rip
Townsend's Warbler	<i>Dendroica townsendi</i>		1	Song	Forest
Orange-crowned Warbler	<i>Vermivora celata</i>	2	3	Calling	Forest
Sparrows (Emberizidae)					
Lincoln's Sparrow	<i>Melospiza lincolnii</i>		1	Calling	Riparian
Song Sparrow	<i>Melospiza melodia</i>	3	5	Calling	Wetland, Rip
Dark-eyed Junco	<i>Junco hyemalis</i>	1	2	Feeding	Wetland, Forest
Chipping Sparrow	<i>Spizella passerina</i>		2	Feeding	Riparian
Fox Sparrow	<i>Passerella iliaca</i>		1	Calling	Wetland
Finches (Fringillidae)					
Pine Siskin	<i>Carduelis pinus</i>	1	1	Flyover	Wetland
Red Crossbill	<i>Empidonax difficilis</i>		5	Flyover	Wetland

5.2.2.3 Mammals

Mammal use of the constructed wetland site was determined via the documentation of tracks, scat, and browse sign. Five mammal species were documented at the constructed wetlands during the 2012 site visits, including Black Bear (*Ursus americanus*), Red Squirrel (*Tamiasciurus hudsonicus*), Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*), and one species of mustelid (American Mink [*Neovison vison*]). Columbian Black-tailed Deer likely used the area frequently as pellets were noted and tracks were observed making their way across the middle berm between the upper and lower wetland ponds. Black bear scat was found at the edge of the upper wetland, and marten, mink and squirrel tracks were observed at the edge of the upper pond. Grey Wolf (*Canis lupus*) scat and tracks were observed on the logging road, immediately north of the constructed wetlands (~50 m away from wetland).

Diversion Reservoir is within the distributional range of other species of mammals, such as several species of bat (Tuttle 2011), Cougar (*Felis concolor*), Roosevelt Elk (*Cervus canadensis roosevelti*; tracks were documented nearby in 2010), Deer Mouse (*Peromyscus maniculatus*), shrews (*Sorex* spp.), Townsend's Vole (*Microtus townsendii*), Short-tailed Weasel (*Mustela erminea*), etc.

5.2.2.4 Species at Risk

The CDF biogeoclimatic zone supports a disproportionate abundance of both provincial and federal species of concern, and supports some of the most threatened ecosystems in Canada. For example, the British Columbia Conservation Data Centre (BC CDC) lists a total of 318 species of flora and fauna in the Southern Island Forest District that have provincial status as species of risk, including both red-listed (Endangered, Threatened) and blue-listed (Special Concern) species and ecological communities. Similarly, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which assesses the status of species at the federal level, has classified 92 species in the southern Vancouver Island region (which includes Diversion Reservoir) as species at risk (species that are considered Extinct, Extirpated, Endangered, Threatened, or

Special Concern in Canada). Extensive human development within this region contributes additional ecological pressures, significantly affecting these populations of these species at risk.

Wetland communities such as the constructed ones at Diversion Reservoir typically support a unique assemblage of species (some of which could be species at risk). Immediately adjacent to the wetland, a second-growth coniferous forest stand (dominated by Douglas-fir and Western Redcedar) exists, which also has the potential to house additional species at risk, including Red-legged Frogs. Four other species have been recorded in the past (Great Blue Heron [2012], Vancouver Island Beggarticks [2010], Great Blue Heron [2010], Western Toad [2009]). To emphasize the importance of the site Table 6 lists the species at risk that may potentially be present, including species that have been confirmed at the site.

Table 6: Species at risk that could occur in or near the constructed wetland at Diversion Reservoir based on known distribution and habitat preferences. Species that have been confirmed for the wetland area are bolded and marked with an asterisk (*). Note that not all species have been assessed at the federal level, and thus do not receive a conservation status from COSEWIC. COSEWIC codes: E (Endangered); T (Threatened); SC (Special Concern); NAR (Not at Risk); and DD (Data Deficient).

Scientific Name	Common Name	Provincial Status (BC CDC)	Federal Status (COSEWIC)
Vascular Plants			
<i>Hydrophyllum tenuipes</i>	Pacific Waterleaf	Red	
<i>Bidens amplissima</i>*	Vancouver Island Beggarticks	Blue	SC
<i>Claytonia washingtoniana</i>	Washington Spring-beauty	Red	
Invertebrates (Dragonflies and Terrestrial Molluscs)			
<i>Pachydiplax longipennis</i>	Blue Dasher	Blue	
<i>Erythemis collocata</i>	Western Pondhawk	Blue	
<i>Sympetrum vicinum</i>	Autumn Meadowhawk	Blue	
<i>Carychium occidentale</i>	Western Thorn	Blue	
<i>Monadenia fidelis</i>	Pacific Sideband	Blue	
<i>Nearctula sp.</i>	Threaded Vertigo	Blue	SC
<i>Pristiloma johnsoni</i>	Broad-whorl Tightcoil	Blue	
<i>Vertigo andrusiana</i>	Pacific Vertigo	Red	
Reptiles and Amphibians			
<i>Anaryxus boreas</i>	Western Toad	Blue	SC
<i>Rana aurora</i>*	Red-legged Frog	Blue	SC
<i>Aneides vagrans</i>	Wandering Salamander	Blue	
Birds			
<i>Ardea herodias fannini</i>*	Great Blue Heron	Blue	SC
<i>Chordeiles minor</i>	Common Nighthawk	Yellow	T
<i>Contopus cooperi</i>	Olive-sided Flycatcher	Blue	T
<i>Dendragapus fuliginosus</i>	Sooty Grouse	Blue	
<i>Falco peregrinus anatum</i>	Peregrine Falcon, <i>anatum</i> ssp.	Red	SC
<i>Falco peregrinus pealei</i>	Peregrine Falcon, <i>pealei</i> ssp.	Blue	SC

<i>Falco peregrinus tundrius</i>	Peregrine Falcon, <i>tundrius</i> ssp.	Unknown	SC
<i>Glaucidium gnoma swarthi</i>	Northern Pygmy-Owl, <i>swarthi</i> ssp.	Blue	
<i>Hirundo rustica</i>*	Barn Swallow	Blue	
<i>Hydropronge caspia</i>	Caspian Tern	Blue	NAR
<i>Megascops kennicottii kennicottii</i>	Western Screech-Owl, <i>kennicottii</i> ssp	Blue	SC
<i>Patagioenas fasciata</i>	Band-tailed Pigeon	Blue	SC
Mammals			
<i>Sorex palustris brooksii</i>	American Watershrew, <i>brooksii</i> ssp		
<i>Corynorhinus townsendii</i>	Townsend's Big-eared Bat	Blue	
<i>Myotis keenii</i>	Keen's Myotis	Red	DD
<i>Myotis lucifugus</i>*	Little Brown Myotis		E

5.3 Proof-of-Concept Example

This constructed wetland came from a project originating in 2005 that examined the status of Red-legged Frogs (a provincial and federal species of conservation concern) in the Jordan River Watershed. The resulting report suggested that breeding habitat for this species and other pond-breeding amphibians was limited in the watershed, and most of what had originally occurred had been lost during the creation of the Diversion and Bear Creek Reservoirs (Hawkes 2005).

The following example tracks the status of Red-legged Frogs at this site and uses amphibians as a representative group to determine proof-of-concept for the constructed wetland at Diversion Reservoir. Amphibians can be viewed as umbrella species for this project, because not only do they use wetland habitat (which has a diversity of plant species associated with it) for breeding, foraging and overwintering, but the habitats that amphibians occur in are also used by a variety of other wildlife species groups (e.g., birds, mammals, aquatic insects); therefore creating amphibian habitat benefits many other species.

Monitoring surveys in 2012 revealed the presence of three species of amphibian (Red-legged Frog, Pacific Treefrog, Northwestern Salamander), which indicate that the constructed wetland was successful in providing habitat for pond-breeding amphibians. Furthermore, each of these species was documented to have bred in the wetland, as evidenced by the four stages of amphibian development (egg mass, tadpole/larvae, metamorph, and adult). Although egg mass numbers were lower in 2012, the productivity of Red-legged Frogs was especially notable in both the upper and lower ponds of the wetland, with over 55 egg masses (over 100 in 2011), numerous tadpoles, and several metamorphs (see Table 4).

Table 7 outlines the proof-of-concept wetland, relating the parameters monitored during the 2012 surveys to the various performance measures indicative of success associated with amphibians and the creation of pond-breeding wetland habitat.

Table 7: Proof-of-concept of wetland success using amphibians as a representative group at the constructed wetland in Diversion Reservoir.

Concept	Performance Measure	Performance Measure Result (i.e., Proof)	Successful for Amphibian Species
Habitat Creation	Wetland Size	~ 7500 ha of wetland created in 2009 and is still existing in 2012.	Net gain of wetland habitat in the reservoir drawdown zone.
Wetland	Water	Water retention in both wetlands was	Amphibians are able to breed in water that will

Integrity	Retention	maintained throughout 2012. Berms are holding an adequate amount of water in both the upper and lower pond.	remain for the duration of larval development through to metamorphosis.
	Depth Profile	Depth profile of the wetland provided enough variability to promote proper wetland function (e.g., 0 to > 2 m).	Variety of depths provides different aquatic habitat for egg laying, tadpole development and foraging opportunities.
	Coarse Woody Debris	Under 25% CWD floating in upper pond of wetland from May to September.	Provides habitat (e.g., basking sites, cover from predators) and foraging substrate (e.g., algal growth on wood surface) for various life stages of amphibians.
Habitat Quality	Dissolved Oxygen	Wetland was oxygen rich (average DO = 8.10 mg/L)	Wetland has suitable levels of oxygen to support developing larvae.
	Water Temperature	Water temperatures ranged from 10 to 22 °C.	Water temperatures were within the range required for amphibians to develop.
Wetland Community	Plant Richness and Diversity	High aquatic and terrestrial plant richness (n = 68) and diversity ($H_2 = 1.66$) documented at the wetland.	The number and diversity of plant species provides structurally diverse cover from predators, substrate for attaching egg masses, habitat for prey items, structure to prevent erosion and turbidity.
	Wildlife Diversity and Richness	Three species of amphibians, 1 species of snake, 40 species of bird, and 5 species of mammal using the wetland and riparian habitat.	Creation of an ecosystem with various trophic levels (includes both prey and predator species for amphibians).
	Amphibian Productivity	Three of the six species of pond-breeding amphibian bred in constructed wetlands in 2012 (number of egg masses = 86).	Such high numbers of egg masses, especially for species at risk, such as Red-legged Frogs, infers high productivity and habitat quality.

6.0 Discussion

Constructed wetlands are one example of a habitat restoration technique that can be effectively used to mitigate the loss of aquatic habitat and to offset the impacts of hydroelectric development on wildlife. The strategic water use plan for coastal BC Hydro identified the loss of wetland habitat as having a major impact on wildlife in the Jordan River Watershed on southern Vancouver Island (BC Hydro 2001). The creation (2009), revegetation (2010), and monitoring (2011 and 2012) of the constructed wetland at Diversion Reservoir addresses the two major footprint impacts associated with hydroelectric development in the Jordan River Watershed including the loss of wetland and riparian habitats in the valley bottoms of the watershed and the potentially resulting reduced productivity of plants and wildlife in the area.

The loss of wetlands in flooded valley bottoms (Bear Creek) represents a net loss of riparian habitat in the Jordan River Watershed. Results of the preliminary monitoring surveys in 2010 and monthly surveys in 2011 and 2012 revealed that the newly created wetlands are maintaining their structure (e.g., berm integrity, water retention) and function (e.g., creation of wildlife habitat); thereby representing a net gain of habitat (~7,350 m²) in the Jordan River Watershed for pond-breeding amphibians, waterbirds, terrestrial mammals, bats, and insects. Results of the plant and wildlife monitoring in 2012 revealed a high diversity of plant species (n = 68; $H_s = 1.66$) and indicated that multiple wildlife species (n = 48, $H_s = 1.25$) were using the newly constructed wetland habitat. For example, we documented, three species of amphibian and one species of garter snake, 31 songbird species (including several breeding occurrences), mammal tracks and scat, and six dragonfly species, all of which were either using the wetland itself or in habitats immediately adjacent to the wetland area (e.g., Diversion Reservoir, upland forest).

6.1 Project Objectives

The two main objectives of this created wetland restoration project were: 1) the evaluation of revegetation efforts; and 2) a minimum of one-year of monitoring of the constructed wetland (Block et al. 2003) to obtain metrics of success and to determine the utility of the design for potential future wetland construction projects within the Bridge Coastal area.

6.1.1 Task 1: Revegetation Efforts

The ultimate goals of the revegetation plan for Diversion Reservoir were to: 1) revegetate the bare and disturbed areas around the periphery of the wetland during created during construction, as well as areas that are prone to inundation due to reservoir operations; and 2) develop a self-sustaining system with a diverse plant community. Post-construction site visits in 2010 and 2011 provided evidence that native vegetation was establishing itself at the site, both within the actual wetland itself as well as on the disturbed terrestrial areas around the perimeter. For example, native aquatic plants such as Marsh Speedwell, pondweed (*Potamogeton* spp.), Spreading Rush, and Spring Water-starwort appeared sporadically within the wetland, while terrestrial species such as Wool-grass, Dagger-leaved Rush (*Juncus ensifolius*), and Kellogg's Sedge were re-establishing themselves in areas that had been disturbed by construction activities.

Site visits to the wetland in 2012, revealed a 75% survivorship rate of willow stakes that had been planted in 2010 (n = ~390). Red Alder seedlings had naturally revegetated the inner face of the middle berm, creating a band of seedlings above the lower band of herbaceous vegetation. Aquatic plants and a variety of graminoid and forb species had also established themselves along the shoreline of both the upper and lower wetland ponds (Figure 8).



Figure 8: Revegetation process occurring naturally (left) and by replanting (right) at the constructed wetland at Diversion Reservoir.

Three areas of potential concern for the future of plant communities at the constructed wetland are: 1) the establishment of exotic species; 2) noticeable Canada Goose browse on shoreline vegetation; and 3) the stress of prolonged periods of reservoir inundation. As discussed in the results, 17 species of non-native plants were documented at the site, five of which are invasive. Currently, growth of these exotic plants is restricted to the disturbed areas near the berms and access road, and continued removal by hand should keep most of these plants in check. Future monitoring efforts aimed at improving the conditions at the site should attempt to monitor and control/eradicate these species to

slow or prevent their spread. Other than egg addling in the spring, not much can be done about the grazing impact of Canada Goose on growing vegetation. Similarly, the constructed wetland is frequently flooded by Diversion Reservoir, and as a result, it may take a few years to determine the effects of prolonged water exposure on survivorship of recently established plants.

Given the fact that multiple species of native plants, both aquatic and terrestrial have been present for three years post-construction in the wetland area, it is anticipated that the establishment of a natural vegetation community within the wetland will be successful within a relatively short time span (< 5 years). However, some long-term maintenance is still required for the plant communities at the constructed wetland, especially with regards to the removal of exotic species and the control of Canada Goose browsing. With the continued removal of invasive plant species, revegetation of the wetland with native aquatic and terrestrial plants should occur naturally and does not need to be supplemented by additional planting. Additional vegetation monitoring (e.g., aquatic and terrestrial vegetation cover plots) over time will reveal if the wetland is continuing to progress along its current trajectory (i.e., natural succession occurring) towards a self-sustaining ecosystem.

In five years, if there are noticeable declines in the performance measures outlined for plants (e.g., decreased plant species richness and diversity, decreased vegetation cover, increased ratios of non-native to native plants, decreased survivorship in willow stakes) within the wetland and/or within the adjacent riparian community, then a revegetation plan can be developed at that time and different options for mitigation can be considered. Two potential options include: 1) more drastic methods for exotic species removal (especially in case of Scotch Broom) may need to be employed; or 2) additional planting or transplanting of native species to augment the communities that are already established. Plants that are used to revegetate portions of the drawdown zone in the future will need to be able to withstand a certain amount of wet and dry stress for the inundation and withdrawal of Diversion Reservoir, respectively. A suggested list of native plants (aquatics, semi-aquatics, shrubs) that should be used to create habitat features within and adjacent to the constructed wetland is provided in Table 8.

Table 8: Suggested native plants that could be used in future revegetation plans for the constructed wetland at Diversion Reservoir.

Vegetation Type	Common name	Scientific Name
Shrubs	Salmonberry	<i>Rubus spectabilis</i>
	Thimbleberry	<i>Tubus parviflorus</i>
	Red-osier dogwood	<i>Cornus stolonifera</i>
	High-bush cranberry	<i>Viburnum edule</i>
	Red elderberry	<i>Sambucus racemosa</i>
Wetland Plants	Cattail	<i>Typha latifolia</i>
	Marsh cinquefoil	<i>Potentilla palustris</i>
	Beaked Sedge	<i>Carex utriculata</i>
	Slough Sedge	<i>Carex obnupta</i>
	Creeping spike-rush	<i>Eleocharis palustris</i>
	Yellow-pond lily	<i>Nuphar polysepalum</i>
	Small-flowered bulrush	<i>Scirpus microcarpus</i>
	Watershield	<i>Brasenia schreberi</i>

Pondweed

Potamogeton spp.

6.1.2 Task 2: Monitoring and Determining Proof-of-Concept

Because this wetland was built as a proof-of-concept, it was necessary to determine its success. Success was determined through monitoring a variety of performance measures (see section in the methods for the complete list) assessing the integrity of the wetland itself and the effectiveness of the wetland in meeting the ecological objectives of the project (e.g., providing aquatic and riparian habitat for wildlife in the Jordon River watershed). Results from the 2012 monitoring surveys provide a clear indication that the constructed wetland is currently progressing towards a self-sustaining natural ecosystem with a high degree of plant and wildlife diversity ($n = 120$ species), structural integrity, and does not appear to be adversely effected by current Diversion Reservoir operations. The diversity and richness of wildlife and plants documented at the wetland presumably infers appropriate habitat quality to support plants and wildlife. In particular, the high use of this wetland by pond-breeding amphibians for breeding (e.g., 86 egg masses) exemplifies the success of this proof-of-concept for the constructed wetland at Diversion Reservoir (see Table 4; Table 7).

Table 9 outlines the performance measures for this project, the level of success achieved for this proof-of-concept constructed wetland and considerations for the future of this wetland.

Table 9: Summary of proof-of-concept of wetland design using performance measures to indicate success at the constructed wetland in Diversion Reservoir.

Concept	Performance Measure	Performance Measure Result (i.e., Proof)	Success Achieved	Future Monitoring Considerations
Habitat Creation	Wetland Size	~ 7500 ha of wetland created in 2009 and is still existing in 2012.	Net gain of wetland habitat in the reservoir drawdown zone.	Does wetland area change over time?
Wetland Integrity	Water Retention	Water retention in both wetlands was maintained throughout 2012. Berms are holding an adequate amount of water in both the upper and lower pond.	Wetland habitat was available for aquatic plants, macroinvertebrates and wildlife (e.g., amphibians, birds, bats, insects) to use for the active season (e.g., April to September).	Is water retained in both ponds of the wetland over time? In the future with any decreases in reservoir elevations, does the wetland still retain water throughout the year?
	Depth Profile	Depth profile of the wetland provided enough variability to promote proper wetland function (e.g., 0 to > 2 m).	Variety of depths provides different aquatic habitat for aquatic plants, macroinvertebrates and wildlife that inhabit the wetland.	Does depth in the ponds vary from year to year? How is this influenced by reservoir operations?
	Coarse Woody Debris	Under 25% CWD floating in upper pond of wetland from May to September.	Provides habitat (e.g., basking sites, cover from predators) and foraging substrate (e.g., algal growth on wood surface) for wildlife using the pond.	Does the abundance of CWD change over time? Increased levels of > 50% surface coverage are not ideal for wetland health.
Habitat Quality	Dissolved Oxygen	Wetland was oxygen rich (average DO = 8.10 mg/L)	Wetland had suitable levels of oxygen to support developing aquatic life.	Does this change seasonally? From year to year?
	Water Temperature	Water temperatures ranged from 10 to 22 °C.	Water temperatures were within the range required for amphibian development.	Does this change seasonally? From year to year?
Wetland Community	Plant Richness and Diversity	High aquatic and terrestrial plant richness (n = 71) and diversity (H ₂ = 1.66) documented at the wetland.	The number and diversity of plant species provided a structurally diverse plant community for a variety of wildlife uses: cover from predators, substrate for attaching egg masses, foraging, structure to prevent erosion and turbidity.	Is plant richness and diversity increasing over time? Are exotic plants increasing in coverage over time?
	Wildlife Diversity and Richness	Three species of amphibians, one species of snake, 40 species of bird, and 5 species of mammal using the wetland and riparian habitat.	Creation of an ecosystem with various trophic levels (both prey and predator species).	Is wildlife richness and diversity increasing over time?
	Amphibian Productivity	Three of the six species of pond-breeding amphibian bred in constructed wetlands in 2012 (egg mass n = 86).	High numbers of egg masses, especially for species at risk, such as Red-legged Frogs, infers high productivity and habitat quality.	Is the number of Red-legged Frogs egg masses increasing or decreasing over time?

7.0 Recommendations

Monitoring of the constructed wetland site in 2012 indicates that this project has been successful in creating habitat for wetland-associated species (particularly amphibians) and has provided a habitat type that is rare or infrequent in the watershed since the creation of the Diversion and Bear Creek Reservoirs flooded similar valley-bottom habitats. The success of this constructed wetland provides a model that could be applied to other watersheds in BC affected by the impoundment of rivers and creation of reservoirs.

A critical component of all wetland restoration projects is the ability for adaptive management following the completion of the construction and revegetation phases to increase the likelihood of success associated with the project (Patten 2006). Periodic monitoring of the site following its completion enables the architects of the wetland to follow the maturation of the habitat and, should problems arise such as poor germination of revegetated areas or invasion of exotic plants, the managers are able to identify the problem, quantify the magnitude its impact, and come up with solutions to bring the wetland back to a natural and healthy state. The chances of success of the project drop significantly in the absence of such an adaptive management scheme.

To further ensure success of this wetland over time, we recommend periodic monitoring of the site over the long-term (~5 to 10 year) in order to ensure that the trajectory of the established ecosystem is proceeding in a direction that is consistent with the outlined performance measures for this project and to ensure that it is meeting its stated goal of providing habitat for native wildlife, such as the Red-legged Frog and other pond-breeding amphibians. Although initial results from 2010 to 2012 indicate that this wetland is on the right track, the project can only be considered a success if the resulting ecosystems can be shown to be self-sustaining and to provide habitat for native plant and wildlife species over time. Such a designation requires periodic assessments of the site into the short term (5 years of annual visits), with occasional assessments into the longer term (10 years). These assessments will allow managers to employ adaptive management techniques such as removal of invasive exotic species (Scotch Broom, Himalayan Blackberry, etc.) or the augmentation of native plant populations with additional planted individuals if the conditions at the site are found to require such interventions. For example, a number of Scotch Broom seedlings were detected on the middle berm from 2010 to 2012 (and were subsequently removed), indicating that this will likely be an issue that requires continued attention into both the near-term and long-term future.

The following describes a proposed monitoring scheme, with additional monitoring or site visits advisable if intervention is required:

- Regular (3-4 visits per year) monitoring for the first 3 years (2010 – 2012)
- Less frequent (2 visits per year) monitoring for year 5 (2014)
- Occasional (~1 visit per year) monitoring for years 8 and 10 (2017 – 2019)

7.1 Influences of Logging on the Constructed Wetland

A notable change to the habitat surrounding the constructed wetland occurred in July 2011 with logging of the northern slope of forested area, immediately adjacent to the wetland (Figure 9). Although a riparian buffer of approximately 30 m of forested land was established during the logging process, there is a potential for these activities to influence wetland conditions over time. Potential impacts to the wetland could include:

- decline of Red-legged Frog population using the constructed wetlands, as the surrounding upland forested habitat was likely used by adult individuals during the fall and winter for foraging and hibernation;
- changes in the diversity or abundance of other wildlife species that use both the wetland and bordering forested areas;
- changes in environmental or chemical conditions in the wetland and immediate riparian areas (e.g., temperature, water inputs, pH, dissolved oxygen, etc.); and/or
- changes in sedimentation or turbidity in wetland ponds.



Figure 9: Photographs of recent logging activities immediately north of the constructed wetland at Diversion Reservoir, 2011-2012. Constructed wetland located left down the access road in the left photograph.

It will be important to monitor any changes in the constructed wetland that may result over time as a result of this forestry activity. Unfortunately, it may be difficult to distinguish between any changes to wetland productivity and success that occur due to the clear cut from the natural wetland succession that would have happened over time without the influence of this change of habitat.

7.2 Performance Measures over Time

In addition to the performance measures monitoring in 2011 and 2012, a variety of other metrics and factors could be monitored in the future. The ultimate goal is to examine these performance measures over time, in order to compare the conditions at the wetland site against desired conditions and determine if natural ecosystems are becoming established. The results of these assessments will enable monitors to recognize any concerns with the wetland ecosystem establishment and potentially identify opportunities for intervention. Recommended factors to be investigated during future assessments include:

Established Performance Measures:

- general monitoring of wetland integrity (e.g., berm integrity, water retention, CWD accumulation) and water chemistry characteristics (e.g., pH, conductivity, temperature, dissolved O₂)
- specific assessment of berm integrity by an engineer 5 and 10 years after the build (2014 and 2019)
- total species diversity of plants and wildlife over time;
- survivorship of willow stakes;

- total cover of native vs. introduced plant species;
- presence of Red-legged Frogs and abundance (e.g., productivity, diversity) of breeding amphibians (using egg mass counts); and
- length of period of inundation by Diversion Reservoir.

Additional Performance Measures:

- surveys targeting species at risk to produce long-term population datasets;
- the presence/absence of Western Toad at the site (diversity and productivity);
- ongoing placement of bat detectors and additional mist net surveys (diversity and productivity);
- browse impact by Canada Geese to native riparian vegetation (invasive species impacts);
- fish presence, species richness and diversity in the wetland;
- biomass surveys for aquatic and terrestrial plants (i.e., macrophytes)
- diversity and abundance of aquatic invertebrates (diversity and productivity);
- rare plant surveys (e.g., Vancouver Island Beggarticks) ; and/or
- other general water chemistry characteristics (e.g., turbidity, sedimentation).

Regular assessments and adaptive monitoring are the final, but one of the most critical, components of this project. By reassessing the conditions at the constructed wetland site on an annual basis and providing opportunities to remedy undesired conditions (e.g., higher ratio of non-native to native plants, presence of American Bull Frogs [*Lithobates catesbeianus*], increased water turbidity or sedimentation, > 50% coarse woody debris in ponds, berm failure or erosion, etc.) or augment beneficial conditions (e.g., high quality wetland habitat for breeding amphibians, high species richness and diversity for plants and wildlife, established populations of native and rare plant populations, eradication of invasive plant species, etc.), the potential for success of the project and its ability to meet the initial objectives is greatly enhanced. As this project was a proof-of-concept, adaptation of the design and methods also allows for fine-tuning so that, should the concept be taken into other watersheds, its chances of success will be increased even further.

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10.0 Appendices

Appendix A. List of plant species for the constructed wetlands at Diversion Reservoir.

Table 10: List of plant species documented in 2012. Plants are categorized as tree, shrub, graminoid, or forb, and classified as native or introduced.

Species	Common Name	Plant Form	Category	Native/Introduced
<i>Alnus rubra</i>	Red Alder	Tree	Terrestrial	Native
<i>Pseudotsuga menziesii</i>	Douglas-fir	Tree	Terrestrial	Native
<i>Salix lucida</i> ssp. <i>lasiandra</i>	Pacific Willow	Tree	Terrestrial	Native
<i>Salix sitchensis</i>	Sitka Willow	Tree	Terrestrial	Native
<i>Thuja plicata</i>	Western Redcedar	Tree	Terrestrial	Native
<i>Tsuga heterophylla</i>	Western Hemlock	Tree	Terrestrial	Native
<i>Cytisus scoparius</i>	Scotch Broom	Shrub	Terrestrial	Introduced
<i>Gaultheria shallon</i>	Salal	Shrub	Terrestrial	Native
<i>Rubus armeniacus</i>	Himalayan Blackberry	Shrub	Terrestrial	Introduced
<i>Rubus spectabilis</i>	Salmonberry	Shrub	Riparian	Native
<i>Rubus ursinus</i>	Trailing Blackberry	Shrub	Riparian	Native
<i>Sambucus racemosa</i>	Red Elderberry	Shrub	Terrestrial	Native
<i>Symphoricarpos albus</i>	Common Snowberry	Shrub	Terrestrial	Native
<i>Vaccinium parvifolium</i>	Red Huckleberry	Shrub	Terrestrial	Native
<i>Viburnum edule</i>	Highbush Cranberry	Shrub	Terrestrial	Native
<i>Agrostis stolonifera</i>	Creeping Bentgrass	Graminoid	Terrestrial	Introduced
<i>Callitriche palustris</i>	Spring Water-starwort	Graminoid	Aquatic	Native
<i>Callitriche stagnalis</i>	Pond Water-starwort	Graminoid	Aquatic	Introduced
<i>Carex lenticularis</i>	Kellogg's Sedge	Graminoid	Terrestrial	Introduced
<i>Juncus articulatus</i>	Tapered Rush	Graminoid	Aquatic	Native
<i>Juncus bufonius</i>	Toad Rush	Graminoid	Aquatic	Native
<i>Juncus effusus</i>	Common Rush	Graminoid	Aquatic	Native
<i>Juncus ensifolius</i>	Swordleaf Rush	Graminoid	Aquatic	Native
<i>Juncus supiniformis</i>	Spreading Rush	Graminoid	Aquatic	Native
<i>Luzula parviflora</i>	Small-flowered Wood-rush	Graminoid	Terrestrial	Native
<i>Poa pratensis</i>	Kentucky Bluegrass	Graminoid	Terrestrial	Introduced
<i>Scirpus cyperinus</i>	Wool-grass	Graminoid	Aquatic	Native
<i>Anaphalis margaritacea</i>	Pearly Everlasting	Forb	Terrestrial	Native
<i>Antennaria</i> spp.	Pussytoes spp.	Forb	Terrestrial	Native
<i>Athyrium filix-femina</i>	Lady Fern	Forb	Terrestrial	Native
<i>Blechnum spicant</i>	Deer Fern	Forb	Terrestrial	Native
<i>Boykinia occidentalis</i>	Coast Boykinia	Forb	Terrestrial	Native
<i>Cirsium arvense</i>	Canada Thistle	Forb	Terrestrial	Introduced
<i>Cirsium vulgare</i>	Bull Thistle	Forb	Terrestrial	Introduced
<i>Epilobium angustifolium</i>	Fireweed	Forb	Terrestrial	Native
<i>Epilobium ciliatum</i>	Purple-leaved Willowherb	Forb	Terrestrial	Native
<i>Equisetum arvense</i>	Common Horsetail	Forb	Aquatic	Native
<i>Equisetum telmateia</i>	Giant Horsetail	Forb	Aquatic	Native
<i>Fragaria chiloensis</i>	Coastal Strawberry	Forb	Terrestrial	Native
<i>Galium trifidum</i>	Small Bedstraw	Forb	Terrestrial	Native
<i>Geum macrophyllum</i>	Large-leaved Avens	Forb	Terrestrial	Native
<i>Gnaphalium uliginosum</i>	Marsh Cudweed	Forb	Terrestrial	Introduced
<i>Hypochaeris radicata</i>	Hairy Cat's-ear	Forb	Terrestrial	Introduced
<i>Lysichiton americanum</i>	Skunk Cabbage	Forb	Terrestrial	Native
<i>Maianthemum dilatatum</i>	False Lily-of-the-valley	Forb	Terrestrial	Native
<i>Mimulus guttatus</i>	Yellow Monkey-flower	Forb	Aquatic	Native
<i>Myosotis laxa</i>	Small-flowered Forget-me-not	Forb	Aquatic	Native
<i>Oenanthe sarmentosa</i>	Pacific Water-parsley	Forb	Aquatic	Native
<i>Polygonum persicaria</i>	Lady's-thumb	Forb	Terrestrial	Introduced

<i>Polystichum munitum</i>	Sword Fern	Forb	Terrestrial	Native
<i>Potamogeton foliosus</i>	Leafy Pondweed	Forb	Aquatic	Native
<i>Prunella vulgaris</i>	Self Heal	Forb	Terrestrial	Native
<i>Ranunculus flammula</i>	Creeping Spearwort	Forb	Aquatic	Native
<i>Rorippa curvisiliqua</i>	Western Yellow-cress	Forb	Terrestrial	Native
<i>Rorippa palustris</i>	Marsh Yellow-cress	Forb	Terrestrial	Native
<i>Rumex obtusifolius</i>	Broad-leaved Dock	Forb	Terrestrial	Introduced
<i>Senecio jacobaea</i>	Tansy Ragwort	Forb	Terrestrial	Introduced
<i>Senecio vulgaris</i>	Common Groundsel	Forb	Terrestrial	Introduced
<i>Scutellaria lateriflora</i>	Blue Skullcap	Forb	Terrestrial	Native
<i>Spergularia rubra</i>	Red Sand-spurry	Forb	Terrestrial	Introduced
<i>Spirea douglasii</i>	Hardhack	Forb	Terrestrial	Native
<i>Streptopus lanceolatus</i>	Rosy Twistedstalk	Forb	Terrestrial	Native
<i>Taraxacum officinale</i>	Common Dandelion	Forb	Terrestrial	Introduced
<i>Tiarella trifoliata</i>	Three-leaved Foamflower	Forb	Terrestrial	Native
<i>Tolmiea menziesii</i>	Piggyback Plant	Forb	Terrestrial	Native
<i>Trautvetteria caroliniensis</i>	False Bugbane	Forb	Terrestrial	Native
<i>Typha latifolia</i>	Common Cattail	Forb	Aquatic	Native
<i>Veronica arvensis</i>	Wall Speedwell	Forb	Aquatic	Introduced
<i>Veronica beccabunga</i>	American Brooklime	Forb	Aquatic	Native
<i>Veronica scutellata</i>	Marsh Speedwell	Forb	Aquatic	Native
<i>Polytrichum spp.</i>	Moss spp.	Moss	Aquatic	Native

Appendix B. List of wildlife species for the constructed wetlands at Diversion Reservoir.

Table 11: Wildlife species observed during 2012 field visits to constructed wetlands at Diversion Reservoir. Wildlife observations are categorized by group. FO = Flyover; FOR = Forest; RES = Reservoir; RIP = Riparian; WET = Wetland.

Common Name	Species Name	Group	Habitat	Sign
Northwestern Salamander	<i>Ambystoma gracile</i>	Amphibian	WET, RIP	Visual
Pacific Chorus Frog	<i>Pseudacris regilla</i>	Amphibian	WET, RIP	Visual
Red-Legged Frog	<i>Rana aurora</i>	Amphibian	WET, RIP	Visual
American Pipit	<i>Anthus rubescens</i>	Bird	FO	Visual
American Robin	<i>Turdus migratorius</i>	Bird	WET, RIP	Visual
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Bird	FO	Visual
Barn Swallow	<i>Hirundo rustica</i>	Bird	WET, RIP	Visual
Barrow's Goldeneye	<i>Bucephala islandica</i>	Bird	WET	Visual
Belted Kingfisher	<i>Megaceryle alcyon</i>	Bird	WET	Visual
Brown Creeper	<i>Certhia americana</i>	Bird	FOR	Call
Canada Goose	<i>Branta canadensis</i>	Bird	WET, RES	Visual
Cedar Waxwing	<i>Bombycilla cedrorum</i>	Bird	WET, RIP	Visual
Chestnut-backed Chickadee	<i>Poecile rufescens</i>	Bird	FOR	Visual
Chipping Sparrow	<i>Spizella passerina</i>	Bird	RIP	Visual
Common Raven	<i>Corvus corax</i>	Bird	FO	Visual
Common Yellowthroat	<i>Geothlypis trichas</i>	Bird	WET	Visual
Dark-eyed Junco	<i>Junco hyemalis</i>	Bird	RIP, FOR	Visual
Fox Sparrow	<i>Passerella iliaca</i>	Bird	RIP	Visual
Golden-crowned Kinglet	<i>Regulus satrapa</i>	Bird	RIP, FOR	Visual
Great Blue Heron	<i>Ardea herodias</i>	Bird	WET	Visual
Hairy Woodpecker	<i>Picoides villosus</i>	Bird	FOR	Call
Hermit Thrush	<i>Catharus guttatus</i>	Bird	WET, RIP	Visual
Hooded Merganser	<i>Lophodytes cucullatus</i>	Bird	WET	Visual
Lincoln's Sparrow	<i>Melospiza lincolni</i>	Bird	FOR	Call
Orange-crowned Warbler	<i>Vermivora celata</i>	Bird	FOR	Call
Osprey	<i>Pandion haliaetus</i>	Bird	FO	Visual
Pacific Wren	<i>Troglodytes pacificus</i>	Bird	FOR	Call

Pacific-slope Flycatcher	<i>Empidonax difficilis</i>	Bird	FOR	Call
Pine Siskin	<i>Carduelis pinus</i>	Bird	FO	Visual
Red Crossbill	<i>Loxia curvirostra</i>	Bird	FO	Visual
Ruby-crowned Kinglet	<i>Regulus calendula</i>	Bird	RIP, FOR	Call
Ruffed Grouse	<i>Bonasa umbellus</i>	Bird	RIP, FOR	Drumming
Rufous Hummingbird	<i>Selasphorus rufus</i>	Bird	RIP	Visual
Song Sparrow	<i>Melospiza melodia</i>	Bird	WET, RIP	Visual
Spotted Sandpiper	<i>Actitis macularius</i>	Bird	WET, RIP	Visual
Stellar's Jay	<i>Cyanocitta stelleri</i>	Bird	RIP, FOR	Visual
Swainson's Thrush	<i>Catharus ustulatus</i>	Bird	WET, RIP	Visual
Townsend's Warbler	<i>Dendroica townsendi</i>	Bird	FOR	Call
Varied Thrush	<i>Ixoreus naevius</i>	Bird	FOR	Call
Warbling Vireo	<i>Vireo gilvus</i>	Bird	RIP	Call
Wilson's Warbler	<i>Wilsonia pusilla</i>	Bird	RIP, FOR	Visual
Yellow Warbler	<i>Dendroica petechia</i>	Bird	WET, RIP	Call
Yellow-rumped Warbler	<i>Dendroica coronata</i>	Bird	WET, RIP	Visual
Black Bear	<i>Ursus americanus</i>	Mammal	RIP	Scat
Columbian Black-tailed Deer	<i>Odocoileus hemionus columbianus</i>	Mammal	WET, RIP	Tracks
Grey Wolf	<i>Canis lupis</i>	Mammal	FOR	Scat
Red Squirrel	<i>Tamiasciurus hudsonicus</i>	Mammal	WET, RIP	Tracks
American Mink	<i>Neovison vison</i>	Mammal	WET, RIP	Tracks

Appendix C. Final Report Forms: Financial Statement (I); Performance Measures – Actual Outcomes (II); and Confirmation of BCRP/FWCP Recognition (III).

**Appendix I to Final Report
Financial Statement**

BC HYDRO
FISH
 BRIDGE COASTAL RESTORATION PROGRAM

WILDLIFE

Project No. 12.W.JOR.01

Financial Statement Form

	BUDGET		ACTUAL	
	BCRP	Other	BCRP	Other
INCOME				
Total Income by Source				
Grand Total Income (BCRP + other)		\$ 8,399.50		\$ 8,399.50
EXPENSES				
Project Personnel				
Wages		\$ 7,229.50		\$ 7,819.93
Consultant Fees				
Technicians				
Materials & Equipment				
Equipment Rental		\$ 100.00		
Materials Purchased				\$ 2.12
Travel Expenses		\$ 720.00		\$ 509.05
Permits				
Administration				
Office Supplies				\$ 43.27
Photocopies & Printing		\$ 350.00		\$ 25.13
Postage				
Travel & Living				
Total Expenses				
Grand Total Expenses		\$ 8,399.50		\$ 8,399.50
BALANCE				
(Grand Total Income - Grand Total Expenses)		\$ -		\$ -

Appendix II to Final Report Performance Measures

Performance Measures – Target Outcomes												
Project Type	Primary habitat benefit targeted of project (sq.m.)	Primary Target Species	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation												
Fish passage technologies	Area of habitat made available to target species											
Drawdown zone revegetation/stabilization	Area turned into productive habitat	Wildlife										7350
Wildlife migration improvement	Area of habitat made available to target species											
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)											
Habitat Conservation												
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and management											
	Functional habitat conserved by other measures (e.g. riprapping)											
Designated rare/special habitat (subset)	Rare/special habitat protected											
Maintain or Restore Habitat forming process												
Artificial gravel recruitment	Area of stream habitat improved by gravel placement											
Artificial wood debris recruitment	Area of stream habitat improved by LWD placement											
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing											7350
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved											
Habitat Development												
New habitat created	Functional area created											7350

**Appendix III to Final Report
Confirmation of FWCP Recognition**

News Release – June 20, 2012

Habitat research funds announced for Jordan River \$8,400 in project funding from the FWCP

The Fish and Wildlife Compensation Program (FWCP) has announced \$8,400 in funding to LGL Limited that will go towards monitoring the newly created habitat at the Diversion Reservoir in the Jordan River Watershed. In 2010, a two-tiered wetland system was completed at the Diversion Reservoir and resulted in the creation of two new ponds and a habitat area similar to the size of an international soccer field.

"This is important research that follows the completion of a previous project," says FWCP Coastal Board Chair, Brian Assu. "It also reinforces the continued positive partnerships between the FWCP, local First Nations and community groups." The FWCP is delivered through a partnership between BC Hydro, the Province of B.C. and Fisheries and Oceans Canada.

Results of initial post-construction monitoring indicate that multiple species groups are using the wetland habitat. In addition to the red-legged frog, waterfowl, songbirds, two species of garter snakes, bats and other mammals have been found using the new habitat. As the wetland matures it will likely be utilized by more species.

"The project has shown signs of success far beyond our plans in improving amphibian habitat, and these anticipated benefits will continue to increase as natural vegetation becomes better established at the site," says Virgil Hawkes from LGL Limited. "We're looking forward to seeing the results of our habitat monitoring over the next year."

Applications are reviewed annually in the Coastal region by both technical and board-level committees that include representation from all program partners, First Nations and the public. "It's important to have all groups involved in reviewing the proposals and allocating the funds," says FWCP Coastal program manager, Allister McLean. "Projects are chosen based on technical merit, cost vs. benefit, level of partnership, linkages to watershed-specific priorities and overall benefit to the FWCP's mandate and vision."

The FWCP funds projects to conserve and enhance fish, wildlife and their supporting habitats affected by the creation of BC Hydro owned and operated generation facilities in the Coastal, Columbia and Peace regions of British Columbia. For 2012, the FWCP's total funding for the 15 hydroelectric systems within the Coastal region will be \$1.5 million. All research and project work will take place in 2012/2013.

For more information and to find out how your project can apply for next year's funding visit fwcp.ca.

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The FWCP is a partnership of:

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