Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoir Revegetation Management Plan

Implementation Year 8

Reference: CLBMON-12

Revegetation Effectiveness Monitoring of Burton Flats Wildlife Enhancement Project (CLBWORKS-30B)

Study Period: 2022

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates
Sidney, BC

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BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
CLBMON-12 Revegetation Effectiveness Monitoring of Burton Flats Wildlife Enhancement Project (CLBWORKS-30B, Phase 1)




Summary Report
2022

Prepared for

BC Hydro Generation
Water Licence Requirements
6911 Southpoint Drive
Burnaby, BC

Prepared by

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Cover photos

From left to right: Pond B1, Mound C2, Mound C2, Pond A2. Photos © LGL Limited: Mike Miller.

EXECUTIVE SUMMARY

CLBMON-12 monitors the revegetation effectiveness of the CLBWORKS-30B wildlife enhancement project at Burton Flats. Phase 1 of CLBWORKS-30B was completed in 2019; Phase 2 was completed in 2021. This report summarizes effectiveness monitoring results for 2022 (Year 3 of post-construction monitoring under CLBMON-12).

Two revegetation effectiveness assessments were conducted at Burton Flats in 2022: one in May prior to summer inundation, and one in September after inundation. The surviving densities of planted species in the spring survey compared favourably to the densities targeted by the CLBWORKS-30B prescriptions (with some exceptions). However, by the fall of 2022, densities of several woody-stemmed species had declined notably. In some cases (e.g., on the Phase 2 section of mound C3), the die-off appeared to be induced by drought stress related to the limited water-holding capacity of the substrate; in other instances, to direct competition from, or overtopping by, reed canarygrass. The summer inundation event, which affected elevations up to 438.7 mASL, also appeared to produce some woody stem die-off in certain low to mid elevation planting prescriptions (PP2, PP3). Despite these limiting factors, the prescriptions implemented under CLBWORKS-30B have, to date, successfully increased the species diversity, vertical structure, and canopy cover of the constructed wetland and associated mounds over that which would have developed in the absence of treatment. Follow-up monitoring in subsequent years (2023-2024) will assist in determining if the species and vegetation structure contributed by the planting program continues to influence the successional trajectory of this site.

No new occurrences of woody debris deposition were observed in 2022. However, some settling of debris did occur in 2020 that resulted in localized impacts to vegetation. Mobile woody debris thus represents a potential source of disturbance that merits close monitoring. As a possible preventative measure, a log-boom installation that will exclude floating debris from the project area during high water should be considered.

ACKNOWLEDGEMENTS

Mark Sherrington administered this monitoring project for BC Hydro and David Derosa administered the project for ONA. Brittany Briere (ONA) provided field assistance on the May field survey. Kirstyn Falck (ONA) provided field assistance on the September survey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Introduction

As part of its continued implementation of Water License Requirements for the Arrow Lakes Reservoir (ALR), BC Hydro is undertaking a wildlife enhancement project (CLBWORKS-30B) in the mid-reservoir drawdown zone at Burton flats. According to the Columbia Order, Conditional Section, Clause 7.a., the objective of the enhancement program is "to improve conditions for nesting and migratory birds, and wildlife within the drawdown zone of Arrow Lakes Reservoir." The Burton Flats site (coordinates: 11 U 435757 E and 5536952 N) is located south of Burton, B.C. on the east side of the Arrow Lakes Reservoir, just northwest of Highway 6 and is accessed by Robazzo Road (Figure 1-1).

The specific aim of the CLBWORKS-30B project is to increase the spatial and temporal availability of wetland habitat for wildlife in the drawdown zone of the reservoir by creating a series of excavated ponds between elevations 434 mASL (metres above sea level) and full pool (440 mASL) and enhancing riparian and wetland vegetation on the banks of the pond features via a planting program (Miller and Hawkes 2020c). The wetland design includes shallow and deep pond configurations as well as ponds with and without surface flow connectivity to allow a comparative assessment of the effectiveness of different types of configurations. Elevated, planted mounds that create nesting and other wildlife habitat at higher elevations (>439 mASL) are also incorporated into the design for continued learning about habitat enhancement within, and adjacent to, the drawdown zone (KWL 2018).

Wetland construction and the associated revegetation occurred in two phases; construction and revegetation efforts for both phases is now complete. Phase 1 construction and planting occurred in the fall of 2019 (Miller and Hawkes 2020c). Phase 2 construction was completed in the spring of 2021, and Phase 2 planting occurred in the spring and fall of 2021 (Miller and Hawkes 2021). Effectiveness monitoring under CLBMON-12 commenced in 2020 (Miller and Hawkes 2020d), with the most recent monitoring occurring in 2022 (the subject of this report). Table 1 provides a timeline overview of construction, planting, and monitoring activities to date at Burton Flats.

Table 1-1. Timeline of Phase 1 and Phase 2 construction and planting, and CLBMON-12 monitoring activities, at Burton Flats.

Activity	Project	Date(s)
Phase 1 construction completed	CLBWORKS-30B	2019 (fall)
Phase 1 planting completed	CLBWORKS-30B	2019 (fall)
Initial Phase 1 monitoring	CLBMON-12	2020 (spring, fall) 2021 (spring)
Phase 2 construction completed	CLBWORKS-30B	2021 (spring)
Phase 2 planting completed	CLBWORKS-30B	2021 (spring, fall)
Phase 1 & 2 monitoring (ongoing)	CLBMON-12	2021 (fall) 2022 (spring, fall)

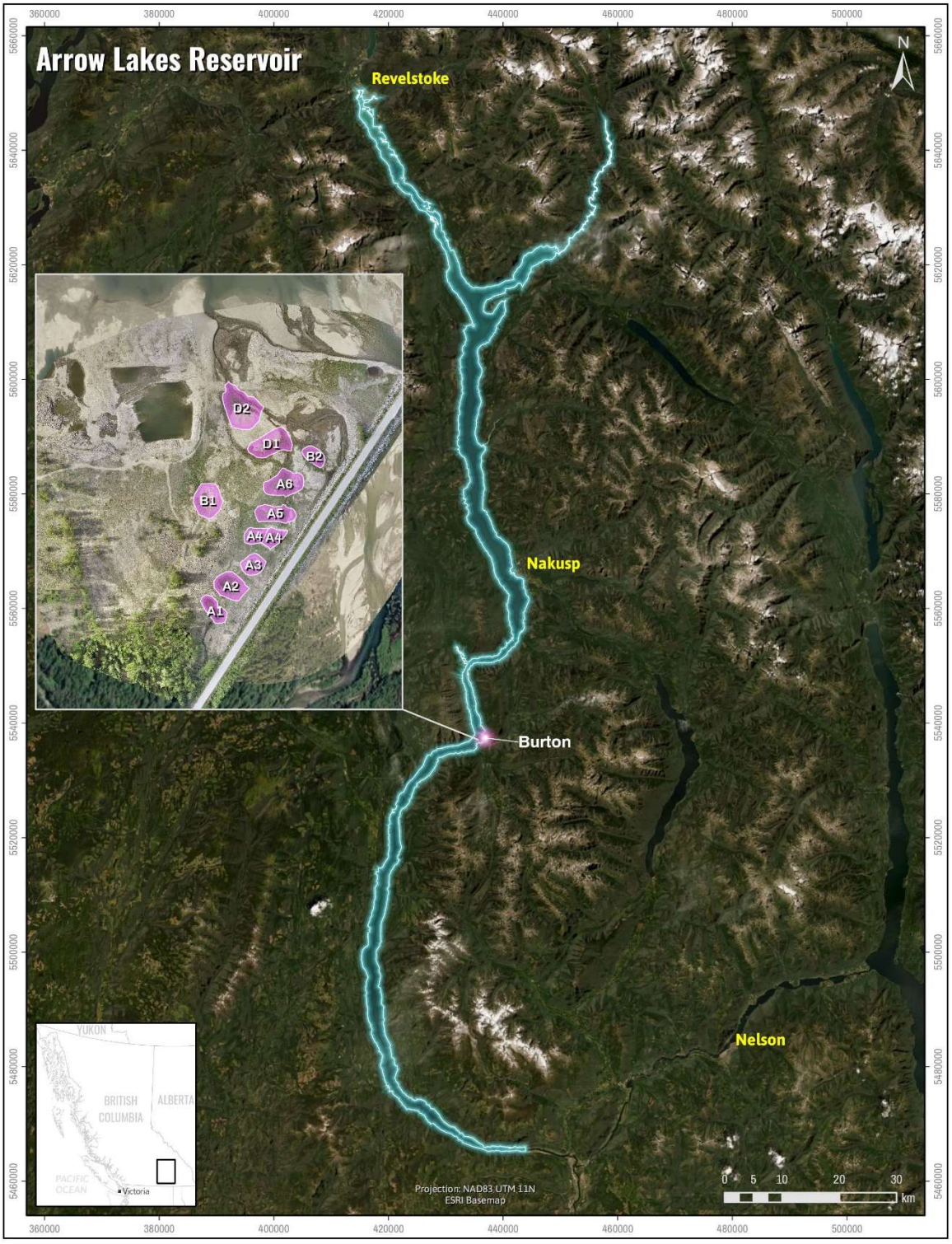


Figure 1-1. Burton Wetland Enhancement Project Location, Arrow Lakes Reservoir (KWL 2021). Inset shows the spatial orientation of constructed pond features. Phase 1 constructions: A1, A2, A3, A4, B1. Phase 2 constructions: A2 (deepening), A3 (deepening), A4 (expansion), A5, A6, B2.

2.0 Revegetation Goals and Approach[1]

The goal of the planting program is to create long-term, self-sustaining native plant communities that improve the available habitat for several wildlife species, including migratory birds, nesting birds, pond-breeding amphibians, reptiles, and mammals (e.g., bats). This goal will be accomplished by establishing emergent native vegetation and shrub habitat to promote foraging and nesting and by encouraging submergent native vegetation to colonize wetland bottoms that can be used by amphibians, migrating waterfowl, and shorebirds. Thus, elevation-specific planting of shrubs and trees was carefully planned to avoid creating ecological traps at lower elevations, which become inundated by the reservoir during the bird nesting season.

The planting program was designed to augment the existing (naturally occurring) emergent vegetation community at high elevation ponds; promote submergent vegetation in ponds staggered across elevations; and establish a riparian habitat consisting of graminoids, shrubs, and trees along the wetland edges and on top of constructed mounds.

Key features of the planting program were as follows:

1. It was implemented in stages over multiple years to align with the phased approach for wetland construction. Phase 1 of the planting program was completed in the fall of 2019, while Phase 2 planting was completed in the spring and fall of 2021.
2. Planting within prescription polygons was iterative, so that initial low-density stocking and subsequent monitoring of plant survival could be used to adaptively guide a replanting investment in later years to maximize revegetation success in terms of both density and diversity of plant species.
3. In addition to using commercial plug and rooted stock, the program relied heavily on opportunities to transplant material salvaged from the project footprint. This material included beaked sedge, Kellogg's sedge, Columbia sedge and small-flowered bulrush. Also utilized were locally harvested (e.g., from transmission rights-of-way) live stakes of cottonwood and willow.
4. The program took a flexible approach in setting targets for stocking densities and diversity because revegetation success is challenging in drawdown zone environments, and because of uncertainties around the availability of both salvaged stock and purchased stock.
5. Detailed documentation of planting effort (such as spatially explicit treatment records for each stock category) was emphasized to facilitate subsequent effectiveness monitoring.

2.1 Treatment Areas

The Phase 1 physical works enhancements are described in detail in KWL (2018) and included the excavation of five ponds (four of which were connected by a pre-existing ephemeral watercourse), and the mounding of excavated material into two elevated hillocks. Revegetation prescriptions were developed for each feature and for the various elevation zones spanned by each feature (Miller and Hawkes 2020c). The Phase 2 physical works enhancements are detailed in KWL (2021) and included the creation of three new shallow ponds (A5, A6, B2); the completion (enlargement) of pond A4; the deepening of ponds A3 and A2 and creation of an island in A2; excavation of two low-elevation, deep water ponds (D1 and D2); and enlargement of mounds C2 and C3 (using fill

[1] Section adapted from *Planting Plan for Phase 1 Construction* (BC Hydro 2018)

from the pond excavations) (Figure 2-1 and Figure 2-3). Revegetation prescriptions were developed for each feature and for the various elevation zones spanned by each feature (LGL Limited 2020).

The planted features, and the corresponding goals for revegetation, are briefly summarized below. A more detailed description of the planting prescriptions for different features and elevations appears in Section 2.2.1.

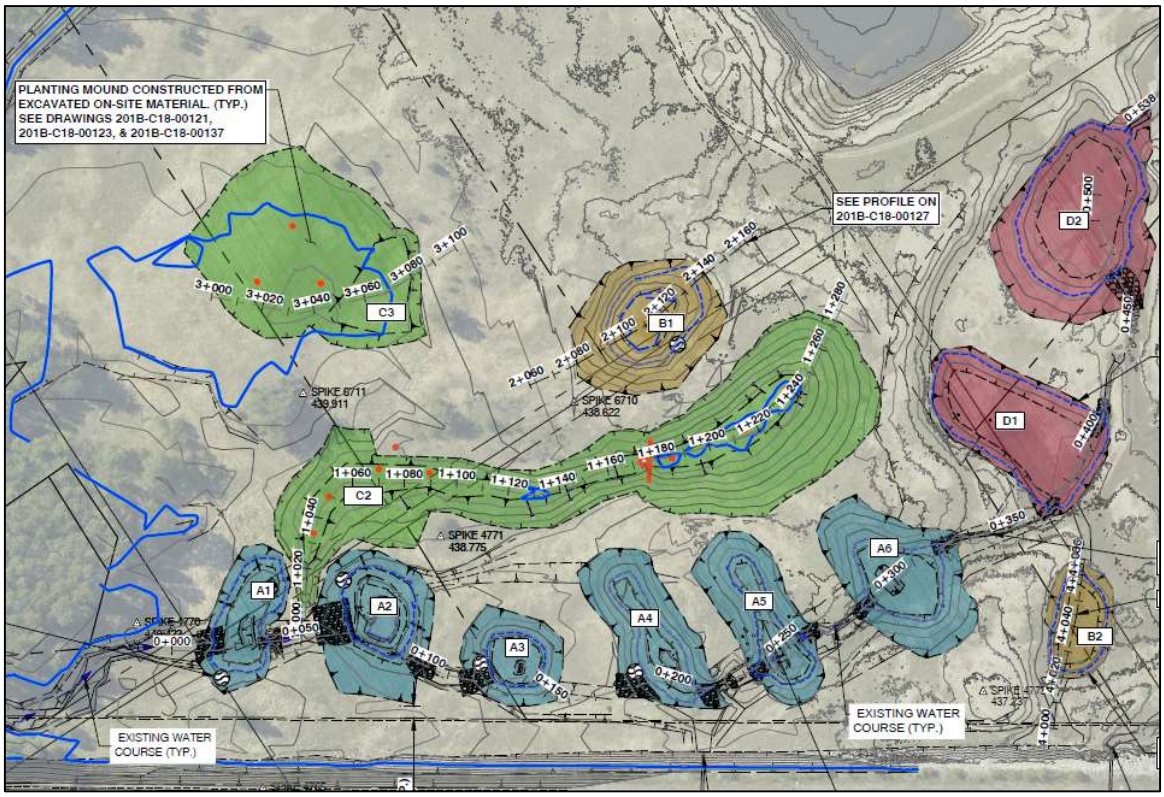


Figure 2-1. Burton Flats Wetland Enhancement Project Design Components (from: KWL Phase 2 Detailed Design 2021). Features A1-A6 (shallow pond wetland complex) are shown in blue; B1 and B2 (isolated ponds) in beige; C2 and C3 (elevated mounds) in green; and D1 and D2 (deep low-elevation waterfowl ponds) in red.

A1-A6; B1 and B2: Shallow Pond Wetland Complex

- A1, A2, A3, A4, A5, and A6 are a series of four shallow ponds (~0.3 to 0.5 m deep) connected by a pre-existing, ephemeral, un-ponded watercourse flowing through a reed canarygrass (RCG)-dominated meadow that previously had low value for wildlife. The six ponds progress in steps downstream along the pre-existing watercourse ending at the A6 pond (~434.5 mASL at its outlet). The uppermost pond, A1 (~438.4 mASL at its outlet), is just downstream from a natural sedge-alder riparian wetland fed by water coming from a culvert under the highway (the upland source of the pre-existing watercourse).
- The upper two ponds, A1 and A2 (438.1 mASL at its outlet), are intended to support both emergent wetland plants as well as a cover of riparian vegetation (both herbaceous and woody), thereby improving wetland complexity and value for riparian/wetland wildlife, including nesting habitat for birds.
- The lower ponds, A3 to A6, along with the two isolated ponds B1 and B2, which are unconnected to the pre-existing watercourse, are intended to support a lighter cover of

riparian vegetation and (potentially) emergents, with the objective of increasing wildlife habitat while minimizing shrub attractants for nesting birds.

D1 and D2: Deep Low-elevation Waterfowl Ponds

- D1 and D2 are large, deep (up to 1.2 m deep with shallow fringes), low-elevation ponds created along the pre-existing watercourse at the lower end of the tiered wetlands. The main objective of these ponds is to increase waterfowl habitat.
- Due to their low position in the drawdown zone (the outlet elevation of D1 is ~433.5 mASL, that of D2 is ~432.5 mASL), the margins of these ponds provide unsuitable conditions for vegetation establishment and hence were not considered for vegetation restoration. However, seeding with submergent plants (macrophytes) might be an effective strategy for these ponds that could be trialed at a future point.

C2-C3: Elevated Mound Features

- The design of mounds using material excavated from the ponds (described above) attempts to maximize crest elevation habitat near or above the normal operating full pool elevation (440.1 mASL), thereby creating safer nesting habitat and potentially an increased diversity of plants bordering the wetlands.
- Mounds were staked and planted to promote nesting, as well as shading to promote reed canarygrass (*Phalaris arundinaceae*) suppression/removal.
- C2 is positioned next to the wetland water course (i.e., ponds A1-A6); due to its expected high organic soil content, C2 was prioritized as the leading mound feature in terms of planting effort.

2.2 Considerations of the Revegetation Plan

The goal of the planting program is to establish native species with high wildlife habitat value in and around the wetlands. To the extent possible, the planting composition will support development of a vegetation community that approaches, in richness and complexity, what might establish along a natural (unregulated) riparian course at this location. The nearest unregulated riparian area (and likely best basis for comparison) is the riparian zone of Burton Creek upstream of the reservoir full pool elevation (east of the highway bridge).

In designing the revegetation plan, key considerations included:

1. plant species' relative value for wildlife
2. the risk of bird nest flooding associated with different revegetation prescriptions across elevations
3. plant tolerances to inundation
4. the management of invasive weeds
5. the suitability of conditions for planted species at each microsite.

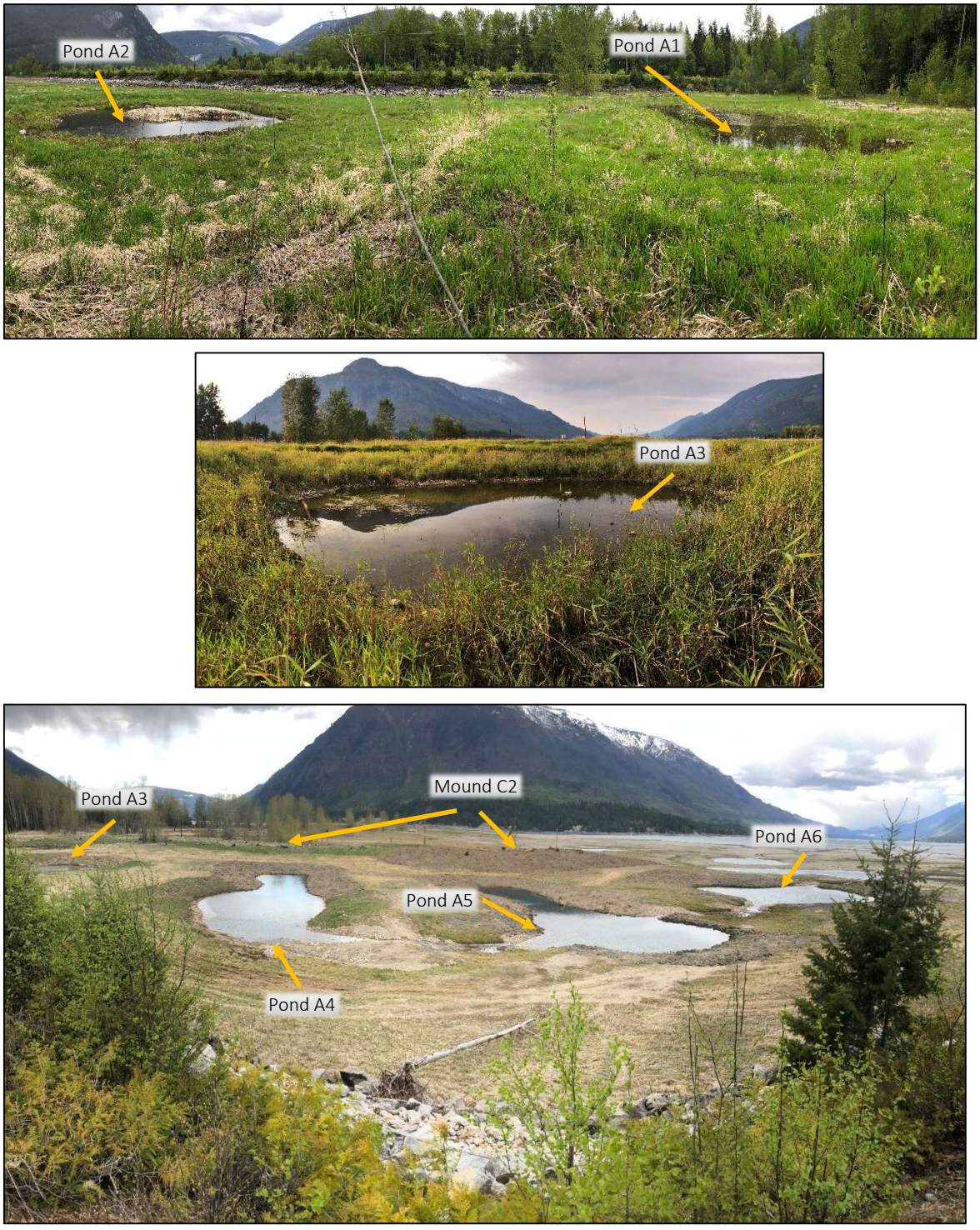


Figure 2-2. Ponds A1 through A3 (Phase 1 construction, photographed September 2022) and Ponds A4 through A6 (Phase 2 construction, photographed April 2021) showing the orientation and shape of constructed ponds in the drawdown zone of Arrow Lakes Reservoir at Burton Flats. Photos: M. Miller.

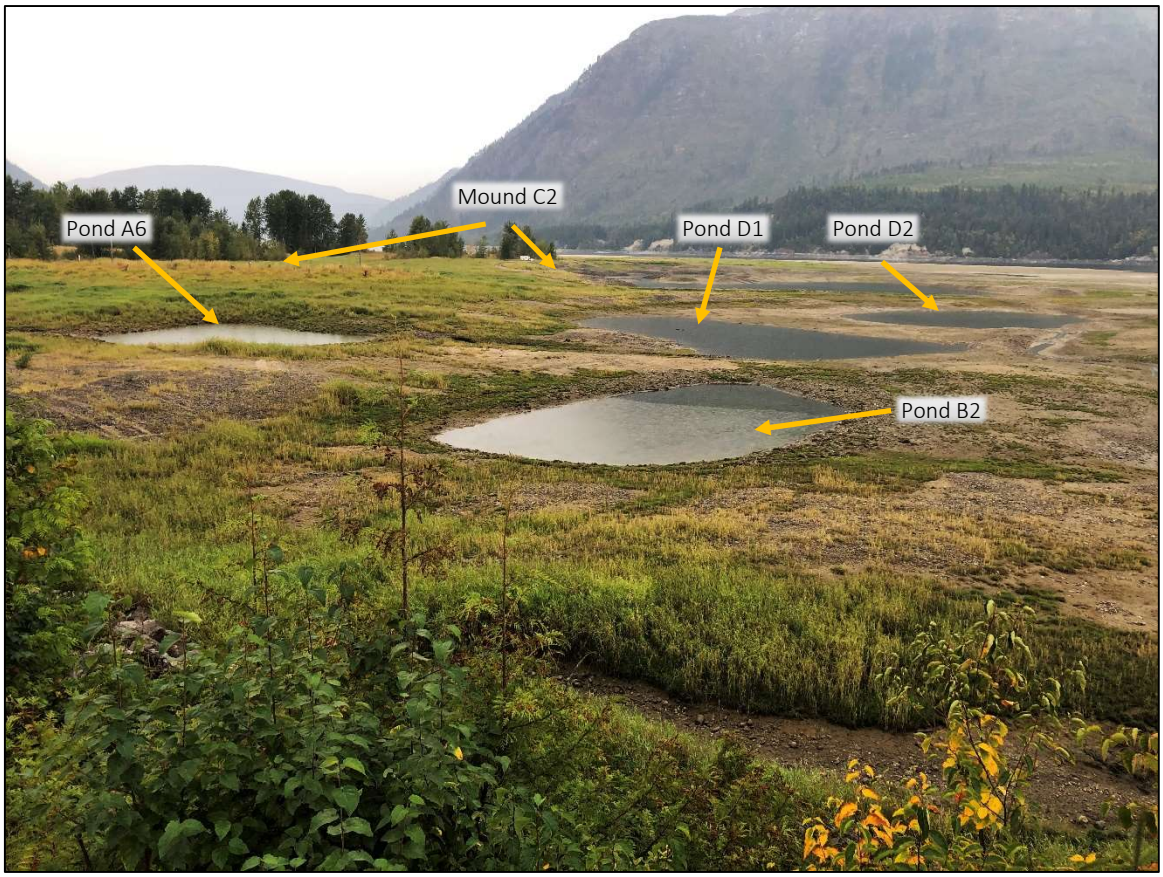


Figure 2-3. Low-elevation ponds at Burton flats (A6, B2, D1, D2) and mound C2, photographed September 2022 Photos: M. Miller.

2.2.1 Planting Prescriptions

A total of six different planting prescriptions (PPs) were developed to reflect these differing site priorities and elevational requirements: (1) Emergent Sedges; (2) Riparian; (3) Terrestrial Sedges (Upper); (4) Terrestrial Sedges (Lower); (5) Terrestrial Mix (general); and (6) Mound Mix (Table 2-1).

A second, detailed table (Table 9-1) specifies how, and in what combinations, the prescriptions were to be applied at each of the constructed features. For example, Pond A3 was prescribed to receive a combination of PPs 1 and 3; Mound C2 was prescribed to receive a combination of PPs 3, 5, and 6 (Table 9-1).

The spatial configuration of the various planting prescriptions was mapped out in a schematic fashion for each project phase. An example of the Phase 1 mapping is provided in (Figure 2-4). The spatial and elevational distributions of the various Phase 2 planting prescriptions are shown in (Figure 2-5). Phase 2 planting targets (stem densities) were similar to those for Phase 1 (Miller and Hawkes 2020).

Table 2-1. **Phase 1 planting prescriptions applied to constructed ponds and mounds at Burton Flats.** Adapted from Miller and Hawkes (2020c).

Planting Prescription (PP)	Description
1: Emergent Sedges	High elevation pond emergent sedges (beaked sedge, small-flowered bulrush). Salvaged, and supplemented by plugs. At ponds positioned below elevations where these emergents are growing naturally, a low density of plugs will be planted as a trial.
2: Riparian	A dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's and Columbia sedge, bluejoint reedgrass).
3a, 3b: Terrestrial Sedges (upper)	Higher elevation (>436 m) terrestrial prescriptions that, above 438.5 m, can include species to encourage nesting. **(3a)** <438.5 m: Variable density stocking with sedges (Kellogg's and Columbia sedge), bluejoint and black cottonwood only. **(3b)** >438.5 m: Variable density stocking with sedges (Kellogg's and Columbia sedge), bluejoint, and flood-tolerant shrubs (primarily black cottonwood, red-osier dogwood, and Sitka willow). Restock microsites in future where survivorship is observed.
4: Terrestrial Sedges (lower)	Lower elevation (<436 m) terrestrial prescription that should not include species to encourage nesting. Variable density stocking with salvaged Kellogg's sedge; this is a more reliable species at low elevations. Restock microsites in future where survivorship is observed.
5a, 5b, 5c: Terrestrial Mix (general)	Applied to disturbance allowances. These polygons span elevations and will be planted as per PP4 (=**5a**), PP3a (=**5b**), or PP3b (=**5c**) depending on site elevations.
6: Mound Mix	Moderate density and high diversity terrestrial vegetation mix (e.g., soopolallie, paper birch, western white pine, western redcedar, trembling aspen, beaked hazelnut, black twinberry, Bebb's willow, saskatoon, snowberry, black cottonwood, red-osier dogwood, and/or prickly rose). This is very much experimental to see which species thrive on the likely arid conditions on mound summits.

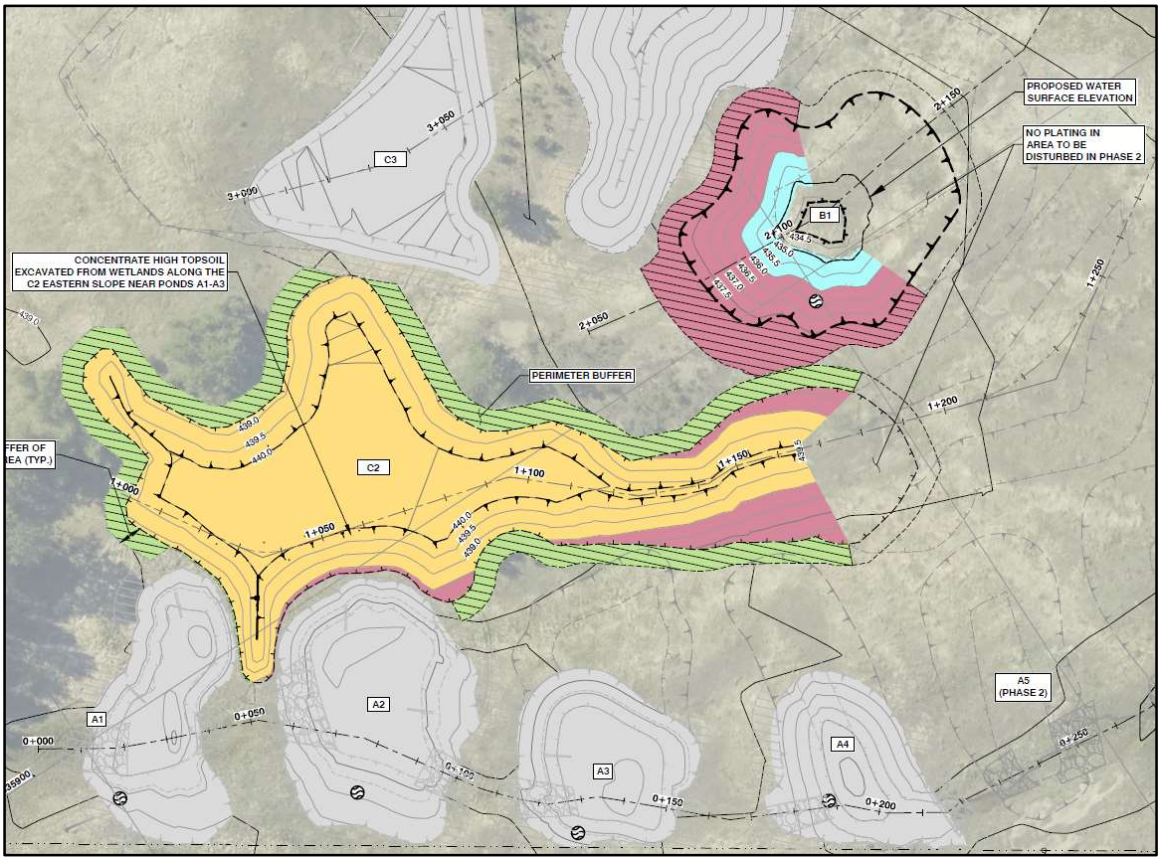
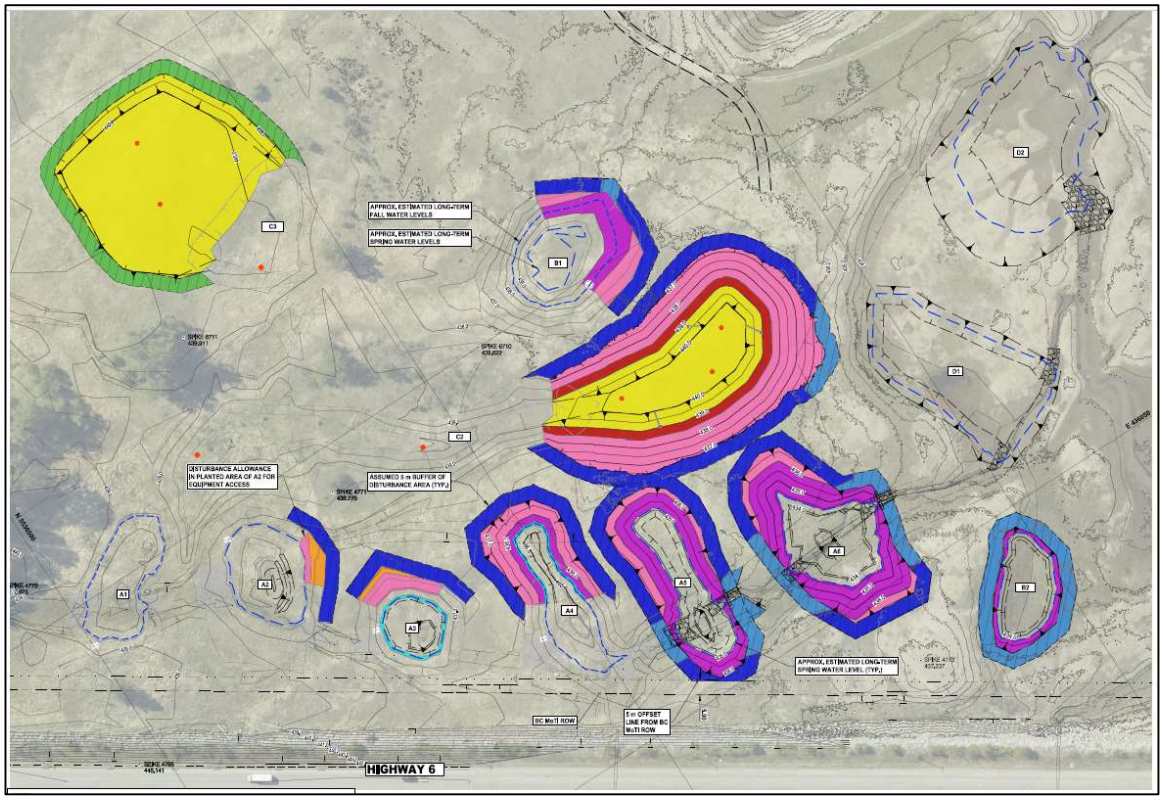


Figure 2-4. Sample schematic of Phase 1 planting prescription (PP) spatial layouts at Burton Flats. The colour-coded configurations for Pond B1 and Mound C2 are displayed. Turquoise = PP 4 (Terrestrial Sedges – lower), pink = PP 3 (Terrestrial Sedges – upper), green = PP 5 (Terrestrial Mix – general), yellow = PP 6 (Mound Mix). From KWL (2018).



PLANTING PRESCRIPTION (PP) LEGEND	
PLANTING PRESCRIPTION	LOCATION AND ELEVATION RANGE (m)
1: EMERGENT SEDGES	PONDS A1 - A4: ESTIMATED WATER SURFACE ELEVATION
2: RIPARIAN	POND BANK: >437.75
3: TERRESTRIAL SEDGE (UPPER)	MOUND: 438.0 TO 438.5
3A: TERRESTRIAL SEDGES (UPPER, NO NESTING SHRUBS)	POND BANK: 436.0 TO 437.75
	MOUND: <438.0
4: TERRESTRIAL SEDGES (LOWER)	POND BANK: 434.0 TO 436.0
5A: TERRESTRIAL MIX (LOWER)	PERIMETER DISTURBANCE ALLOWANCE: <436.0
5B: TERRESTRIAL MIX (MID)	PERIMETER DISTURBANCE ALLOWANCE: 436.0 TO 438.0
5C: TERRESTRIAL MIX (UPPER)	PERIMETER DISTURBANCE ALLOWANCE: >438.0
6: MOUND MIX	MOUND: >438.5

Figure 2-5. Schematic of Phase 2 planting prescription (PP) spatial layouts at Burton Flats. Phase 1 works have been grayed out. Map prepared by Kerr Wood Leidal (KWL) for BC Hydro and LGL Limited, 2021.

3.0 Methods

Two surveys of the Burton Flats site were made in 2022 to assess the performance of revegetation treatments in the first year following planting (Phase 2 treatments) and third year following planting (Phase 1 treatments). The first survey took place on 16-20 May, prior to summer reservoir inundation. The second survey occurred on 26-28 September, following the June-July inundation and subsequent recession of reservoir levels.

3.1 Pre-inundation (Spring) Survey

The same 65 vegetation monitoring plots established in May 2021 (Miller and Hawkes 2022) were surveyed again in May 2022. Another three plots were established in 2022, for a total of 68 sampled (Figure 3-1). Plots were situated within different prescription areas (PPs) at each constructed feature (pond and mound) and feature phase (Phase 1 and/or Phase 2; Figure 3-2). The plot dimension was typically 5x5 m (25 m^2), but was sometimes made longer and narrower (e.g., 2x10 m) to match the particular terrain (e.g., a shoreline). Plot centres were relocated with the aid of UTM coordinates and the previously placed marker pins (12" nails; Figure 3-2). Sample sets at each feature x phase combination ranged in size from *n*=2 to *n*=18, depending on the size and heterogeneity of the feature (Table 3-1).

Table 3-1. Number of vegetation plots and shrub polygons sampled in 2022 per wetland feature and planting phase (Phase 1 or 2), and the proportion (%) of the total feature that was sampled.

Feature	Phase 1*		Phase 2		Total samples	Total area (m^2) sampled	% of feature sampled
	No. veg. plots	No. shrub polygons	No. veg. plots	No. shrub polygons			
Pond A1	6	2			8	605	39%
Pond A2	10	2	1		13	695	33%
Pond A3	8	2			10	640	48%
Pond A4	7				7	340	16%
Pond A5			4		4	200	11%
Pond A6			4		4	200	9%
Pond B1		1			1	150	3%
Pond B2			2		2	100	12%
Mound C2	8	2	13	4	27	2725	21%
Mound C3	4	1	4	2	11	1000	11%

*Some Phase 1 areas also received supplemental planting during Phase 2

At each vegetation plot, the identity and percent covers of all species (both intentionally planted and naturally establishing) were recorded. The number of (apparent) live and (apparent) dead stems of each planted species was also recorded, along with average stem heights (in cm) and estimated plant vigours (on a categorical scale of 0 [dead] to 4 [excellent vigour]). The estimated live densities (per m^2) were later compared against the targeted (prescription) densities.

In addition to the long-term 25 m^2 plots, 11 new shrub polygons/transects, together with four shrub polygons established in 2021, were sampled in different locations for the purpose of assessing shrub survival densities over larger areas than that provided by the 25 m^2 plots (Table 3-1). These were rectangular plots of varying dimensions, ranging in size from 150 m^2 to 600 m^2, with the dimensions determined by the extent of the treated area and by terrain features (Figure 3-1).

As noted, monitoring also included the fall 2021-treated Phase 2 areas. This was done even though this treatment had not yet experienced a full season of growth or, in the case of low-elevation plantings, a single inundation cycle. The primary objective of sampling within the Phase 2 areas in 2022 was to establish a set of baseline conditions for future evaluation and also to track any notable within-year (summer) mortality events (assessment of which occurred during the follow-up September survey, described below). For this purpose, several expanded plots (shrub polygons) and transects established in May 2022 for the purpose of enumerating woody-stemmed plants

were re-surveyed in September and the living stem numbers compared between the two time periods.

Figure 3-1. Distribution of vegetation monitoring plots (shrub transects, shrub polygons, and cover plots) at Burton Flats. Physical works features (mounds and ponds) are labeled in red.

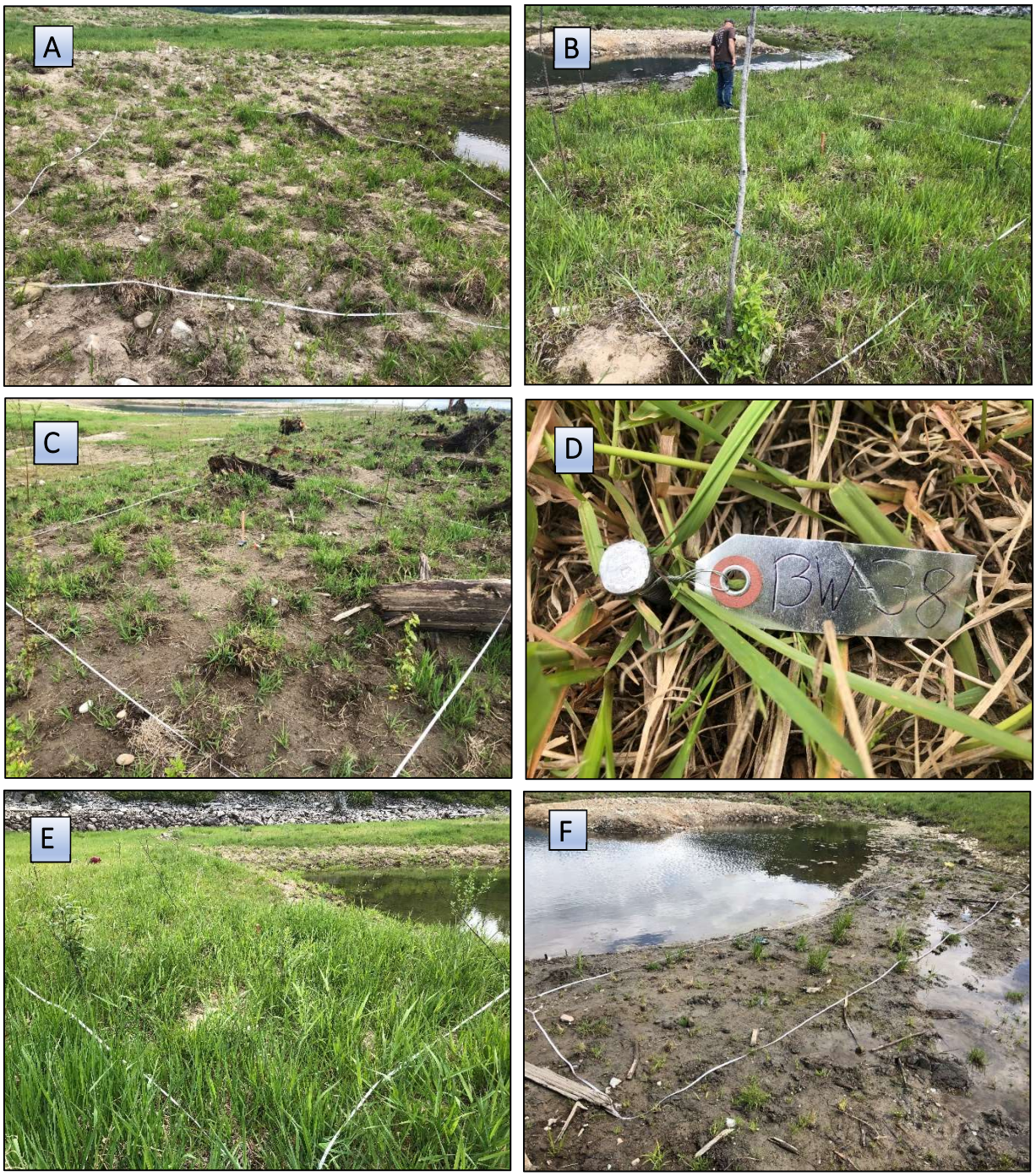


Figure 3-2. Monitoring plots established in May 2021 for purposes of tracking status of plantings and overall vegetation percent cover. A: pond A5 (Phase 2). B: pond A2 (Phase 1). C: mound C2 (Phase 2). D: plot centre label. E: pond A3 (Phase 1). pond A2 emergent zone (Phase 1). Photos: M. Miller.

3.2 Post-inundation (Fall) Survey

During the second (post-inundation) site visit (26-28 Sept.), we re-counted sedge plantings in a subset of low-elevation plots (Ponds A4, A5, A6, B2) and conducted a rapid resurvey of 10 of the 11 large shrub polygons/transects. These sedge and shrub resurveys consisted of stem counts only; cover data were not recorded as many herbaceous species had entered seasonal dormancy by late September. Heavy summer growth of reed canarygrass (*Phalaris arundinacea*) also made it difficult to view reliably much of the underlying vegetation. The primary aim of this rapid and more informal survey was to assess the current conditions of the site and identify any obvious physical impacts to vegetation and constructed features stemming from the 2022 summer inundation event and other factors, such as woody debris deposition or anthropogenic disturbance.

4.0 Results

4.1 Revegetation performance

With the apparent exception of soopolallie, all /transplanted and nursery-raised species planted at Burton Flats in the fall of 2019, and in the spring and fall of 2021, were still present (at some density) in the spring of 2022 (Figure 4-1). With some exceptions, the observed densities were close to or exceeding the prescribed (target) densities for a given prescription (Table 4-1). Possible exceptions included:

- *Salix sitchensis* (Sitka willow) (many of the shorter stakes were overgrown by reed canarygrass)
- *Cornus stolonifera* (red-osier dogwood) (reflecting limited nursery supply and relatively low establishment success overall)
- *Pinus monticola* (western white pine) planted at lower elevation (plugs of this species proved intolerant of even brief periods of inundation but have performed well on the tops of mounds)
- *Scirpus microcarpus* (small-flowered bulrush) (reflecting limited availability of salvage material during Phase 1 planting)
- *Shepherdia canadensis* (soopolallie) (this small-statured nursery stock has been overgrown by reed canarygrass, and was not observed in sample plots in 2022)

Species appearing to meet or exceed the original prescription targets, in terms of stem density, included (Table 4-1):

- *Amelanchier alnifolia* (saskatoon) and *Betula papyrifera* (paper birch) (mound prescription)
- *Spiraea douglasii* (hardhack) (riparian prescription)
- *Calamagrosits canadensis* (bluejoint) (emergent prescription)
- *Carex kelloggii* and *C. aperta* (Kellogg's and Columbia sedge) (various prescriptions)
- *Carex utriculata* (beaked sedge) (emergent prescription)
- *Lonicera involucrata* (black twinberry) (mound prescription)
- *Populus trichocarpa* (black cottonwood) (riparian and mound prescriptions)

Note that, although there appeared to be an absence of surviving bluejoint on mounds (PP6), this was more reflective of the survey effort accorded this species than to actual establishment success. This species was in the form of small, brown, inconspicuous plugs that were difficult to see when

growing in association with other ground vegetation, hence formal counts were not attempted in all sample plots.

Also note that because salvaged and nursery-raised sedges were closely interplanted in many microsites, no systematic attempt was made to distinguish between the different plant origins. Nursery-propagated cuttings of cottonwood and willow (bareroot containers) were likewise not easily distinguishable from harvested live stakes (when these two types were interplanted), and hence were not systematically distinguished.

Comparing stem counts from May 2022 and September 2022, sedge plantings showed almost no attrition between the two periods (Figure 4-2). This finding applied primarily to the low elevation (pond-associated) plantings (Figure 4-3); heavy reed canarygrass growth at the high elevation ponds and mounds had obscured these species (both nursery stock and transplanted salvage material) from view by the fall and the stems could not be reliably enumerated. In contrast, there was a notable degree of within-year attrition for some of the woody-stemmed species used in the mid-elevation prescriptions (PP3/3a) such as red-osier dogwood, cottonwood, and snowberry. For example, red-osier dogwood declined by ~45% (Figure 4-2). Stem counts of some woody species also decreased markedly for the riparian prescription (PP2), often by >50%. For example, no stems of either paper birch or black twinberry were recorded in riparian plots (ponds A1 and A2) during the September survey. That said, by September the cover of reed canarygrass had grown so high and dense in these higher habitats that it was often very difficult to locate the planted stems among the grass. Consequently, it is likely that stem abundances for many species were underestimated during the follow-up survey.

High elevation mound plantings also exhibited substantial attrition between May and September 2022 (Figure 4-2). Much of this fall-off was attributable to mound C3, where few of the Phase 2 woody plantings installed in 2021 could be relocated in the fall of 2022 (Figure 4-4). This includes seedlings installed in September 2021, three months after the 2021 heat dome event (and which were therefore not affected by that event). Plantings on mound C2 generally performed better (Figure 4-4). Saskatoon, paper birch, black twinberry, snowberry, and western redcedar were among those with markedly lower presence than in the spring survey, while mountain alder, western white pine, red-osier dogwood, and hardhack showed less overall decline (Figure 4-2). Note that, as in the case of the mid-elevation habitats, stem counts for smaller-statured species were likely influenced by reduced detectability due to the heavy summer ingrowth of reed canarygrass.

Despite the apparent over-summer attrition, many examples of vigorous shrub establishment and growth were noted in the fall survey, both on riparian banks and on the elevated portions of mounds (Figure 4-5). We also observed promising levels of establishment of salvaged wetland graminoids (such as beaked sedge) that had been intentionally reintroduced into the emergent plant zones around the margins of the upper ponds. As noted in the prior annual report (Miller and Hawkes 2022), this material has begun to spread vegetatively around the margins of ponds A1, A2, and A4 (Figure 4-5). There are also indications that it is now providing microhabitat cover

for riparian-associated wildlife such as macroinvertebrates, amphibians, and snakes (

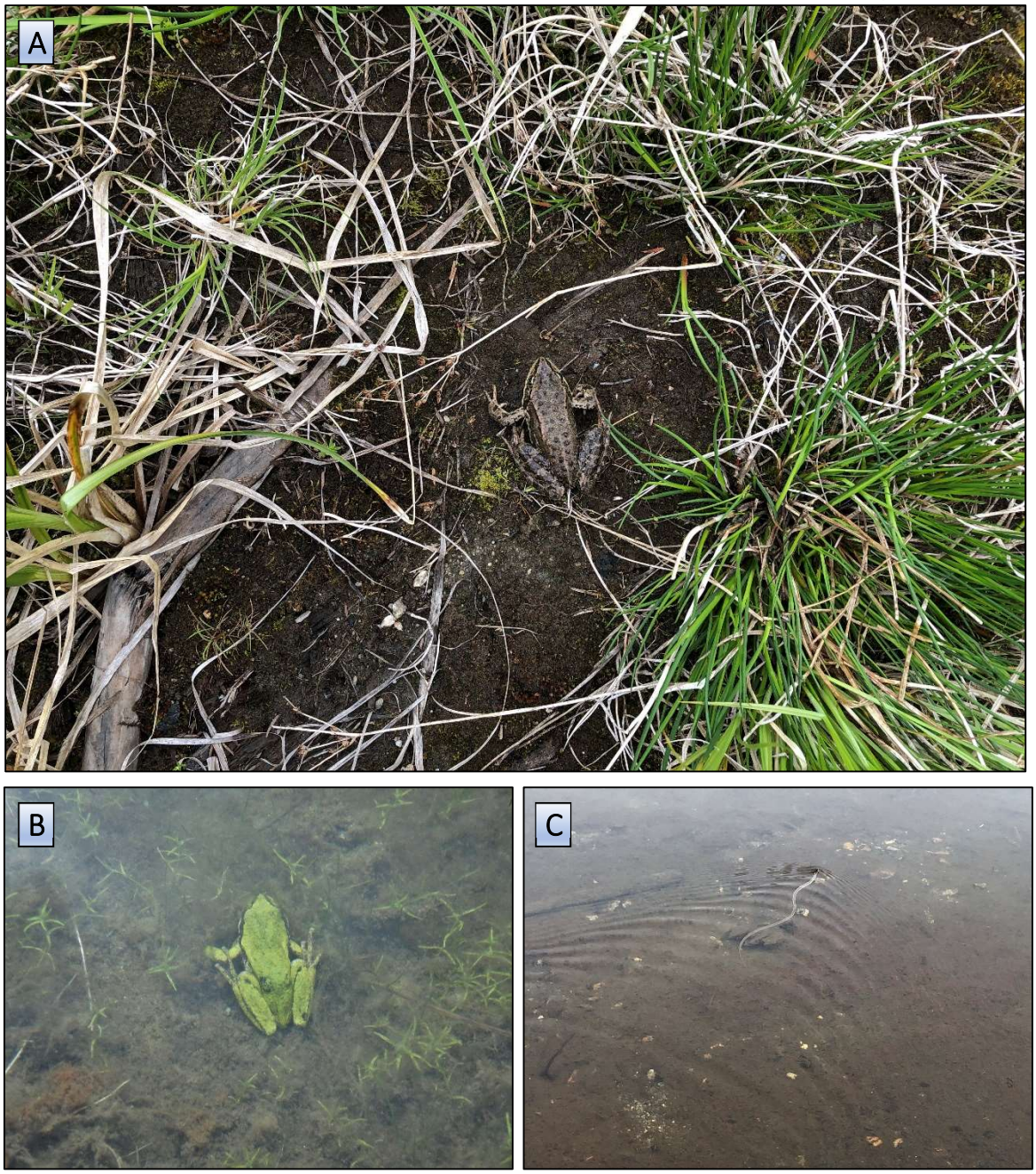


Figure 4-6).

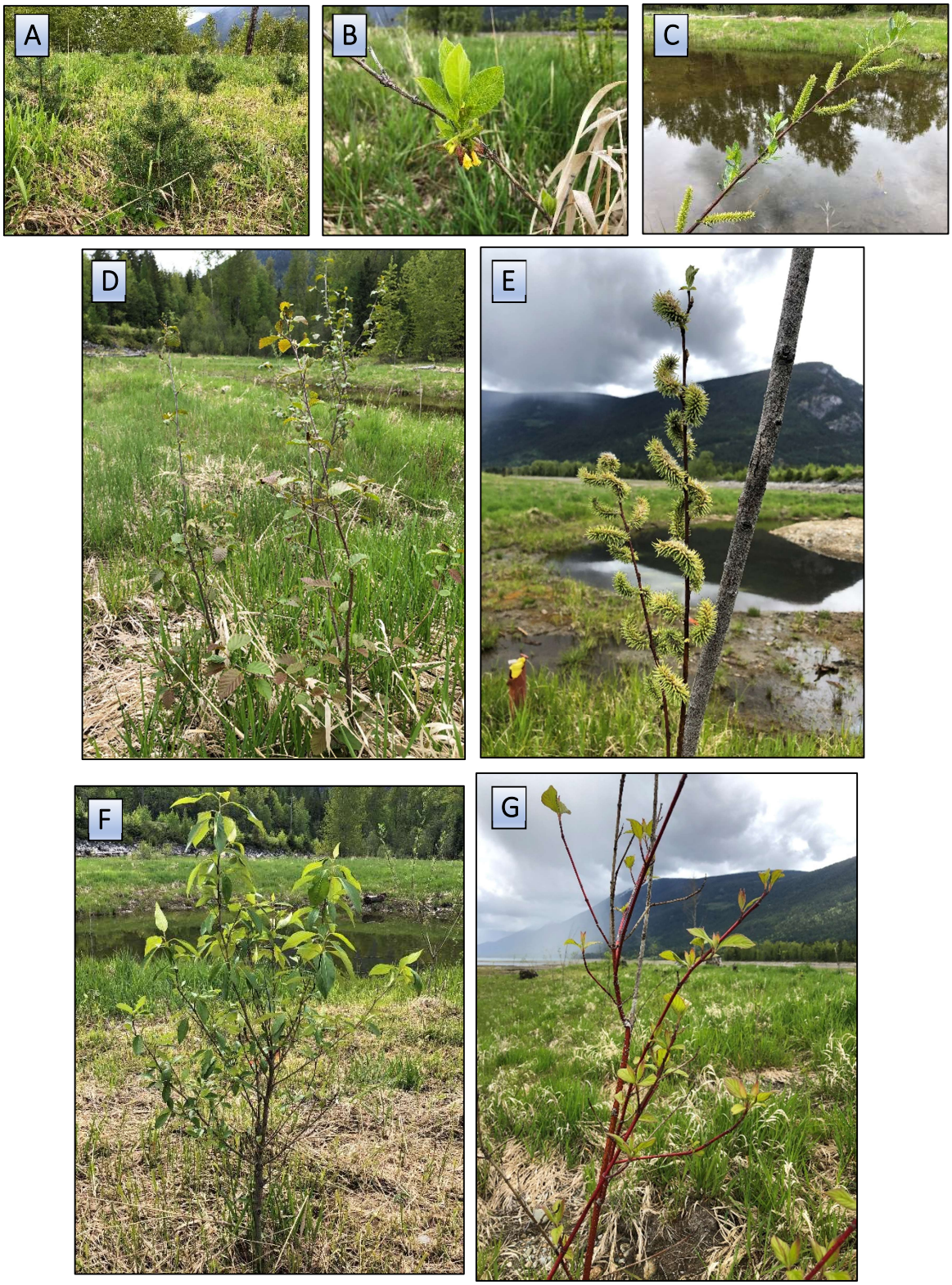


Figure 4-1. Examples of revegetation condition in spring 2022. A: Western white pine, mound C2. B: Black twinberry, pond A2. C: Sitka willow, pond A3. D: Mountain alder, mound C2. E: Bebb's willow, pond A1. F: Black cottonwood, pond A3. G: Red-osier dogwood, mound C2. Photos: M. Miller.

Table 4-1. **Density of surviving plantings per m^2 (versus the prescribed target density in parenthesis) of each species in sample 5x5m plots at Phase 1 and Phase 2 treatment sites in May 2022, by prescription category (Table 2-1)**. For example, a value of 0.04 stems per m^2 equates to 1 stem per 25 m^2, 4 stems per 100 m^2, or 400 stems per ha. A value of 0.002 stems per m^2 equates to 20 stems per ha. Target stem densities meant as guidance only; actual stocking numbers were anticipated to be influenced by the availability of nursery stock and salvaged material. '(0)' indicates that no value for that species was specified in the original prescription (Miller and Hawkes 2020).

Species	Planting Prescription (PP)				
	1 (*n*=4)	**2** (*n*=13)	**3/3a** (*n*=16)	**4** (*n*=16)	**6** (*n*=20)
Alnus incana (mountain alder)		0.01 (0.01)	0.01 (0)		0.01 (0.01)
Amelanchier alnifolia (saskatoon)		0.003 (0)	0.003 (0)		0.09 (0.03)
Betula papyrifera (paper birch)		0 (0.002)	0.01 (0)		0.04 (0.05)
Calamagrostis canadensis (bluejoint)	0.4 (0)	0.12 (0.2)	0.03 (0.05)		? (0.1)
Carex aperta (Columbia sedge)**		0.19 (0.02)	0.11 (0.02)	0.23 (0)	? (0.01)
Carex kelloggii (Kellogg's sedge)**	2.5 (0)	0.25 (0.05)	0.33 (0.05)	1.49 (0.05)	? (0.01)
Carex utriculata (beaked sedge)*	3.4 (0.2)				
Carex aquatilis, C. rostrata, C. stipata (mixed water sedges)	? (0)				
Cornus stolonifera (red-osier dogwood)		0.003 (0.2)	0.02 (0.1)		0.01 (0.05)
Corylus cornuta (beaked hazelnut)					0.01 (0.01)
Lonicera involucrata (black twinberry)		0.003 (0.01)	0.01 (0)		0.03 (0.02)
Pinus monticola (western white pine)		0 (0.002)			0.04 (0.01)
Populus tremuloides (trembling aspen)					0.03 (0)
Populus trichocarpa (black cottonwood)***		0.03 (0)	0.09 (0.1)		0.02 (0.002)
Rosa acicularis (prickly rose)					0.02 (0.01)
Salix bebbiana (Bebb's willow)		0.01 (0)	0.003 (0)		0.004 (0.05)
Salix sitchensis (Sitka willow)***		0.08 (0.2)	0.05 (0.1)		0.02 (0.05)
Scirpus microcarpus (small-flowered bulrush)*	? (0.2)				
Shepherdia canadensis (soopalallie)					? (0.05)
Spiraea douglasii (hardhack)		0.16 (0.02)	0.02 (0)		0.01 (0.01)
Symphoricarpos albus (snowberry)		0.003 (0)	0.03 (0)		0.02 (0.03)
Thuja plicata (western redcedar)					0.04 (0)

*Salvaged material
**Mix of nursery plugs and salvage material
***Mix of nursery containers and locally harvested stakes. A few misc. *Salix* spp. also included here.

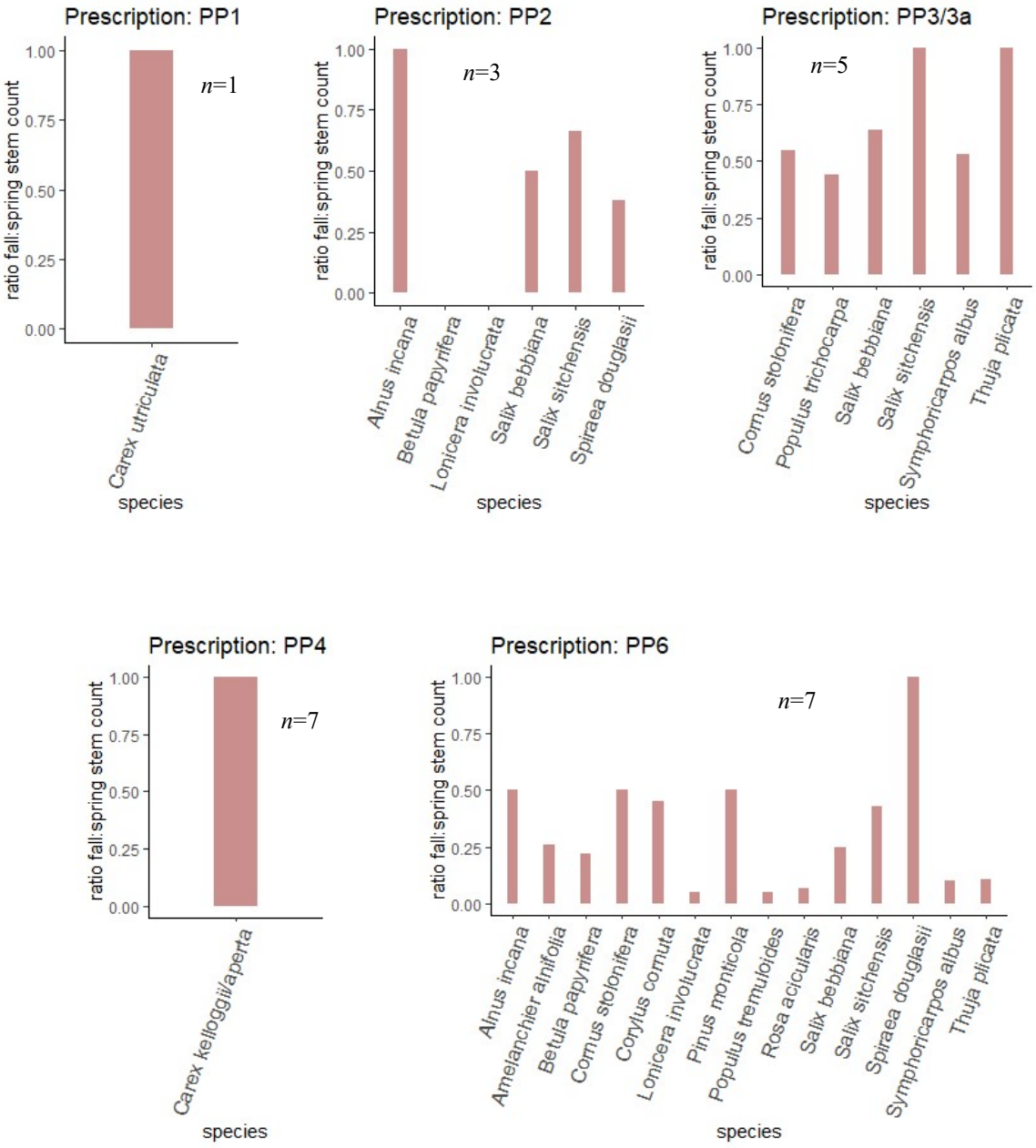


Figure 4-2. **Number of surviving planted stems counted in September 2022 compared to the number counted in May in the same sample plots, expressed as a proportion for each planting prescription.** A ratio of 1.0 implies 0% decrease between spring and summer counts, while a ratio of 0.5 implies a 50% decline in the number of stems present.

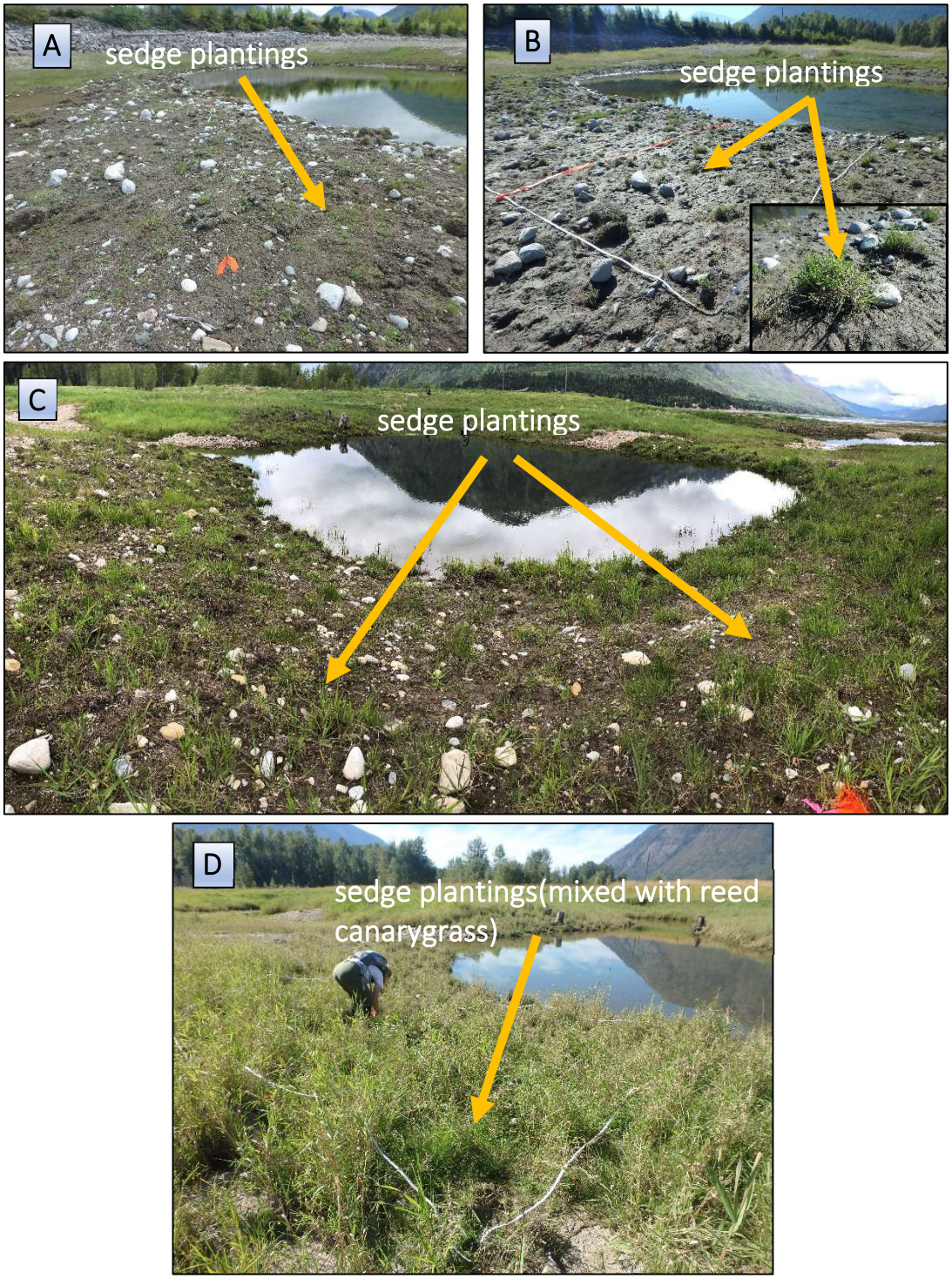


Figure 4-3. Low elevation transplants of salvaged Kellogg's sedge before and after 2022 summer inundation. Photo (A) shows a monitoring plot at pond A5 in May 2022, one year after planting. Photo (B) shows the same plot in September 2022. (C): Overview of pond A5 plantings in May 2022. (D): Overview of the same treatment in September. Note the increase in the cover of reed canarygrass at this location between May and September. Photos: M. Miller.

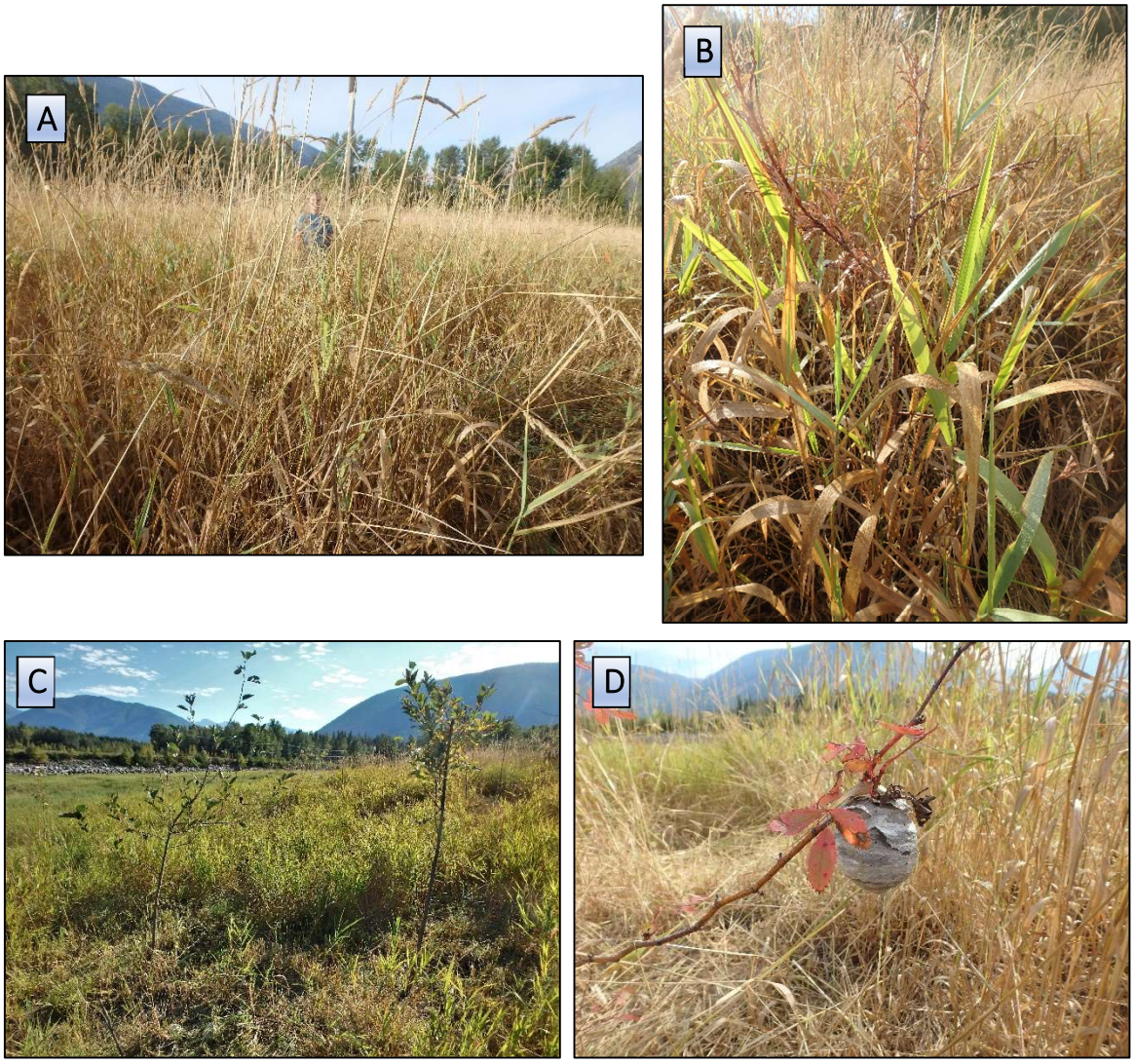


Figure 4-4. Examples of within-year (over-summer) planting attrition and survival. A: Competition from reed canarygrass, combined with soil moisture deficits during the dry summer months, probably contributed to poor establishment at mound C3 B: A dead western redcedar plug, mound C3. C: Successfully establishing mountain alder and cottonwood at mound C2. D: Prickly rose with wasp nest, mound C2. Photographed September 2022. Photos: M. Miller.

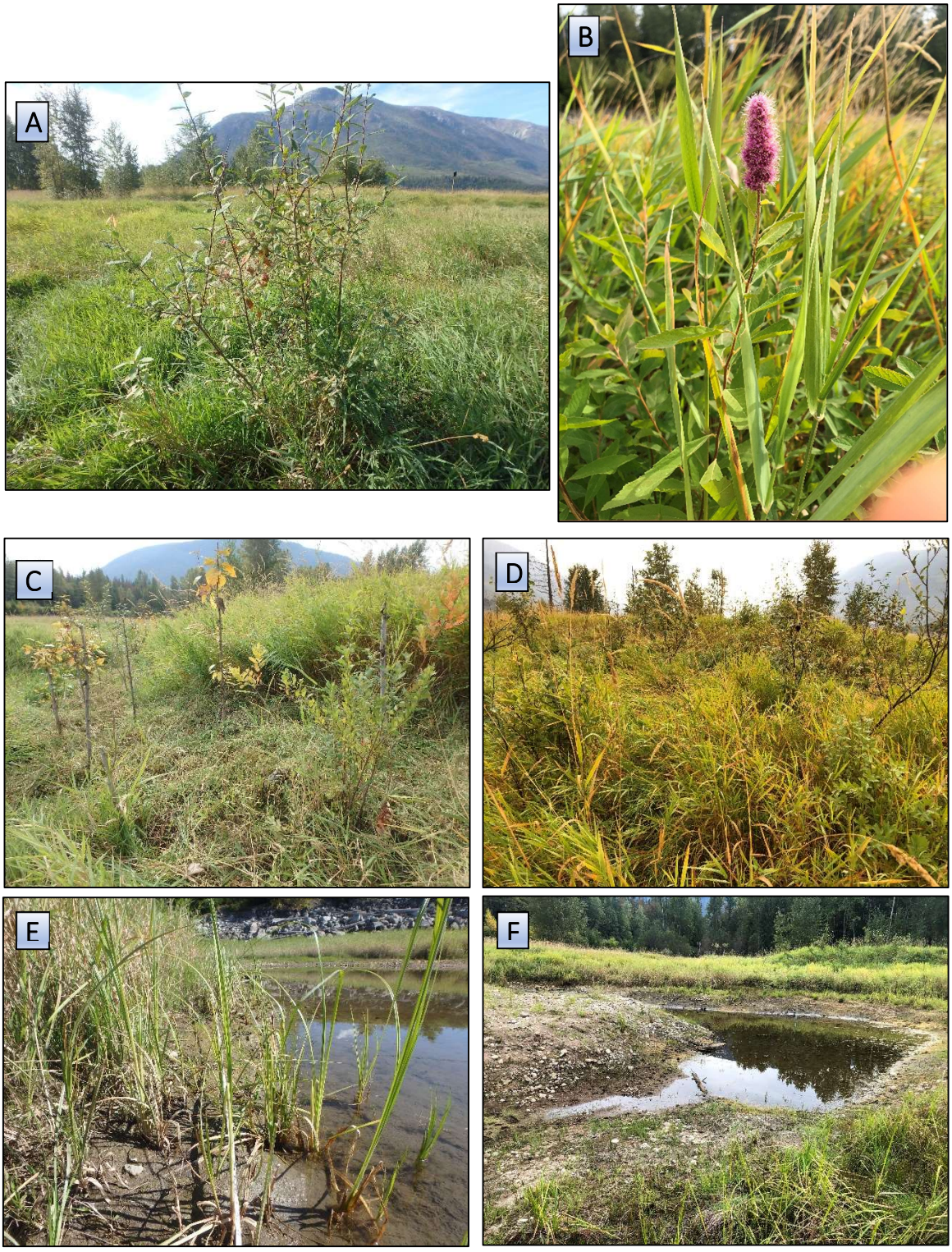


Figure 4-5. **Examples of post-inundation (fall) growth, 1-3 years post-planting.** A: willow. B: hardhack. C: cottonwood and hardhack. D: mixed shrubs. E: beaked sedge. F: Developing emergent plant zone around pond A2 margin. Photos: M. Miller.

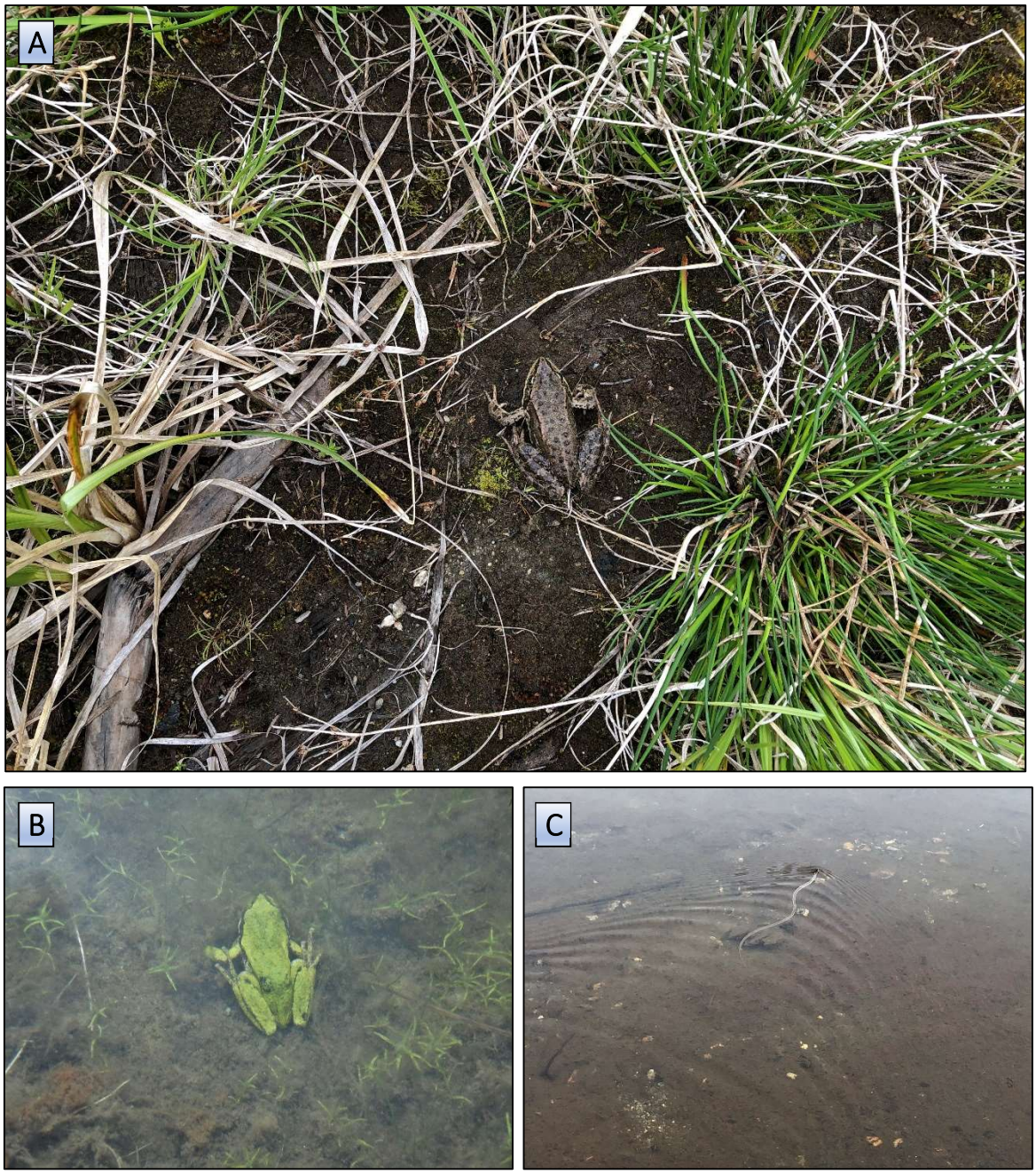


Figure 4-6. Wildlife observed in developing emergent vegetation at ponds A1 and A2. A: Columbia Spotted Frog. B: Pacific Chorus Frog. C: Common Garter Snake (swimming). Photos: M. Miller.

4.2 Overall vegetation composition and cover

Over 70 different plant species were recorded in 2022 on the constructed features at Burton Flats (Appendix: Table 9-1. Feature- and elevation- specific planting prescriptions for constructed ponds and mounds at Burton flats. mASL: metres above sea level. Adapted from Miller and Hawkes (2020c).

Elevation Range (mASL)	Area (m2)	Planting Prescription	Description
A1 – Pond Feature			
Wetland Fringe	~199.5	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of permanent water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
438.4 to TOB (approx. 439)	~648	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasized. Establishment of hardhack with spaced alders is a primary aim.
Perimeter Disturbance Allowance (>438)	~702	5c: Terrestrial Mix (upper)	Infill planting as needed to achieve Phase 1 target densities (low density sedge, bluejoint, cottonwood, willow, red-osier dogwood).
A2 - Pond Feature			
Wetland Fringe	~152	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of new (realised) water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
Island	~20	3a: Terrestrial Sedges (upper, no nesting shrubs)	Low density stocking of the small, newly created gravel island in A2 using a mix of Kellogg's sedge and Columbia sedge.
438 to TOB (approx. 438.5)	~884 + 81	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasised. Establishment of hardhack with spaced alders is a primary aim.
<438	n/a + 36	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).

Perimeter Disturbance Allowance (>436<438)	~705 + 226	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A3 - Pond Feature			
Wetland Fringe	~71.1 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation, or too far removed from the permanent water/seepage course, for these species to flourish. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
436.9 to TOB (approx. 437.5)	~339 + 190	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~390 + 260	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A4 - Pond Feature			
Wetland Fringe	~90.7 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation for these species to flourish.
436 to TOB	n/a + 486	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	~390 + 149	4: Terrestrial Sedges (lower)	Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (>436<438)	~387 + 547	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.

A5 - Pond Feature			
436 to TOB	247	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	734	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	647	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	261	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
A6 - Pond Feature			
436 to TOB	241	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	1063	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	625	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	391	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
B1 - Pond Feature			
436 to TOB (approx. 437.5)	~1480 + 220	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge), bluejoint, and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint reedgrass plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood below 438.5 m (to prevent unwanted nesting habitat).
<436	~690 + 377	4: Terrestrial Sedges (lower)	Completion of planting on section not completed in Phase 1. Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.

Perimeter Disturbance Allowance (<438)	1268 + 398	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
B2 - Pond Feature			
<436 to TOB	205	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (<436)	643	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
C2 - Mound			
438.5 to Toe (approx. 436)	~848 + 2890	3: Terrestrial Sedges (upper) 3a: Terrestrial Sedges (upper, no nesting shrubs)	On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Both sedge species can be salvaged and/or stocked with plugs. Shrubs (cottonwood, Sitka willow, and red-osier dogwood) can be stakes (locally harvested) or nursery stock. Infill planting of Phase 1 treatment area to meet target densities of sedge and shrubs within low density microsites. Reapplication of bluejoint reedgrass plugs if initial trials appear successful.
>438.5	~5847 + TBD	6: Mound Mix	The summit of this mound is a high priority for attempting to foster a diverse upland community of multi-layer vegetation suitable for nesting birds, roosting bats, and other terrestrial wildlife. Infill planting as needed to achieve Phase 1 target densities within low density microsites. On newly constructed sections, moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Experimental staking, but at a relatively high density, and a diversity of stocked plants. Species from the Phase 1 trial showing promising initial establishment were emphasised. Infill planting as needed to achieve Phase 1 target densities within low density microsites. A priority site for augmentation with the best available soils. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.
Perimeter Disturbance Allowance (<438)	~2217 + 1323	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
C3 - Mound			
Perimeter Disturbance Allowance	~2149 + 960	5c: Terrestrial Mix (upper)	On new perimeter disturbance allowance, low density stocking of willow, red-osier dogwood, cottonwood, Kellogg's and Columbia sedge, and bluejoint with reduced diversity at low elevations. Species mix weighted in favour of the most promising species based on Phase 1 results at other comparable microsites. Infill planting of Phase 1 treatment area to meet target densities within low density microsites.

>438.5	~2445 + 3689	6: Mound Mix	The objective for this mound is moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Species from the Phase 1 trial showing promising initial establishment were emphasised. Experimental staking. Infill planting as needed to achieve Phase 1 target densities within low density microsites. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.

Table 9-2. **Complete vascular plant species list for plots sampled in 2022, indicating the constructed wetland features where each species was found, the nativity of the species, and whether it is a naturally establishing (versus a planted) species.** *: Species present in 2021 and 2022. **: Species recorded in 2021 only. ±: Species first recorded in 2022

, Figure 4-9, Figure 4-10, Figure 4-11). Species richness was similar to that reported in 2021 (Miller and Hawkes 2022), although with some turnover of species as might be expected in in this early stage of plant community development (Appendix: Table 9-1. Feature- and elevation- specific planting prescriptions for constructed ponds and mounds at Burton flats. mASL: metres above sea level. Adapted from Miller and Hawkes (2020c).

Elevation Range (mASL)	Area (m2)	Planting Prescription	Description
A1 – Pond Feature			
Wetland Fringe	~199.5	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of permanent water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
438.4 to TOB (approx. 439)	~648	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasized. Establishment of hardhack with spaced alders is a primary aim.
Perimeter Disturbance Allowance (>438)	~702	5c: Terrestrial Mix (upper)	Infill planting as needed to achieve Phase 1 target densities (low density sedge, bluejoint, cottonwood, willow, red-osier dogwood).
A2 - Pond Feature			
Wetland Fringe	~152	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of new (realised) water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
Island	~20	3a: Terrestrial Sedges (upper, no nesting shrubs)	Low density stocking of the small, newly created gravel island in A2 using a mix of Kellogg's sedge and Columbia sedge.

438 to TOB (approx. 438.5)	~884 + 81	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasised. Establishment of hardhack with spaced alders is a primary aim.
<438	n/a + 36	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~705 + 226	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A3 - Pond Feature			
Wetland Fringe	~71.1 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation, or too far removed from the permanent water/seepage course, for these species to flourish. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
436.9 to TOB (approx. 437.5)	~339 + 190	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~390 + 260	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A4 - Pond Feature			

Wetland Fringe	~90.7 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation for these species to flourish.
436 to TOB	n/a + 486	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	~390 + 149	4: Terrestrial Sedges (lower)	Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (>436<438)	~387 + 547	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A5 - Pond Feature			
436 to TOB	247	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	734	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	647	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	261	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
A6 - Pond Feature			
436 to TOB	241	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).

<436	1063	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	625	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	391	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
B1 - Pond Feature			
436 to TOB (approx. 437.5)	~1480 + 220	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge), bluejoint, and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint reedgrass plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood below 438.5 m (to prevent unwanted nesting habitat).
<436	~690 + 377	4: Terrestrial Sedges (lower)	Completion of planting on section not completed in Phase 1. Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (<438)	1268 + 398	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
B2 - Pond Feature			
<436 to TOB	205	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (<436)	643	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
C2 - Mound			
438.5 to Toe (approx. 436)	~848 + 2890	3: Terrestrial Sedges (upper) 3a: Terrestrial Sedges (upper, no nesting shrubs)	On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Both sedge species can be salvaged and/or stocked with plugs. Shrubs (cottonwood, Sitka willow, and red-osier dogwood) can be stakes (locally harvested) or nursery stock. Infill planting of Phase 1 treatment area to meet target densities of sedge and shrubs within low density microsites. Reapplication of bluejoint reedgrass plugs if initial trials appear successful.

>438.5	~5847 + TBD	6: Mound Mix	The summit of this mound is a high priority for attempting to foster a diverse upland community of multi-layer vegetation suitable for nesting birds, roosting bats, and other terrestrial wildlife. Infill planting as needed to achieve Phase 1 target densities within low density microsites. On newly constructed sections, moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Experimental staking, but at a relatively high density, and a diversity of stocked plants. Species from the Phase 1 trial showing promising initial establishment were emphasised. Infill planting as needed to achieve Phase 1 target densities within low density microsites. A priority site for augmentation with the best available soils. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.
Perimeter Disturbance Allowance (<438)	~2217 + 1323	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
C3 - Mound			
Perimeter Disturbance Allowance	~2149 + 960	5c: Terrestrial Mix (upper)	On new perimeter disturbance allowance, low density stocking of willow, red-osier dogwood, cottonwood, Kellogg's and Columbia sedge, and bluejoint with reduced diversity at low elevations. Species mix weighted in favour of the most promising species based on Phase 1 results at other comparable microsites. Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
>438.5	~2445 + 3689	6: Mound Mix	The objective for this mound is moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Species from the Phase 1 trial showing promising initial establishment were emphasised. Experimental staking. Infill planting as needed to achieve Phase 1 target densities within low density microsites. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.

Table 9-2. **Complete vascular plant species list for plots sampled in 2022, indicating the constructed wetland features where each species was found, the nativity of the species, and whether it is a naturally establishing (versus a planted) species.** *: Species present in 2021 and 2022. **: Species recorded in 2021 only. ±: Species first recorded in 2022

). Of the taxa noted, 49 were natural "regen" (as opposed to planted), of which another 27 were native species and 22 were exotic. As in 2021, the highest species richness was on the elevated mounds (C2=52 species, C3=32 species) and at the two upper-elevation ponds and riparian margins (A1=22 species, A2=23 species) (Appendix: Table 9-1. Feature- and elevation-specific planting prescriptions for constructed ponds and mounds at Burton flats. mASL: metres above sea level. Adapted from Miller and Hawkes (2020c).

Elevation Range (mASL)	Area (m2)	Planting Prescription	Description
A1 – Pond Feature			
Wetland Fringe	~199.5	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of permanent water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
438.4 to TOB (approx. 439)	~648	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasized. Establishment of hardhack with spaced alders is a primary aim.
Perimeter Disturbance Allowance (>438)	~702	5c: Terrestrial Mix (upper)	Infill planting as needed to achieve Phase 1 target densities (low density sedge, bluejoint, cottonwood, willow, red-osier dogwood).
A2 - Pond Feature			
Wetland Fringe	~152	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of new (realised) water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
Island	~20	3a: Terrestrial Sedges (upper, no nesting shrubs)	Low density stocking of the small, newly created gravel island in A2 using a mix of Kellogg's sedge and Columbia sedge.

438 to TOB (approx. 438.5)	~884 + 81	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasised. Establishment of hardhack with spaced alders is a primary aim.
<438	n/a + 36	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~705 + 226	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A3 - Pond Feature			
Wetland Fringe	~71.1 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation, or too far removed from the permanent water/seepage course, for these species to flourish. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
436.9 to TOB (approx. 437.5)	~339 + 190	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~390 + 260	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A4 - Pond Feature			

Wetland Fringe	~90.7 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation for these species to flourish.
436 to TOB	n/a + 486	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	~390 + 149	4: Terrestrial Sedges (lower)	Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (>436<438)	~387 + 547	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A5 - Pond Feature			
436 to TOB	247	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	734	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	647	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	261	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
A6 - Pond Feature			
436 to TOB	241	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).

<436	1063	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	625	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	391	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
B1 - Pond Feature			
436 to TOB (approx. 437.5)	~1480 + 220	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge), bluejoint, and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint reedgrass plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood below 438.5 m (to prevent unwanted nesting habitat).
<436	~690 + 377	4: Terrestrial Sedges (lower)	Completion of planting on section not completed in Phase 1. Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (<438)	1268 + 398	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
B2 - Pond Feature			
<436 to TOB	205	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (<436)	643	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
C2 - Mound			
438.5 to Toe (approx. 436)	~848 + 2890	3: Terrestrial Sedges (upper) 3a: Terrestrial Sedges (upper, no nesting shrubs)	On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Both sedge species can be salvaged and/or stocked with plugs. Shrubs (cottonwood, Sitka willow, and red-osier dogwood) can be stakes (locally harvested) or nursery stock. Infill planting of Phase 1 treatment area to meet target densities of sedge and shrubs within low density microsites. Reapplication of bluejoint reedgrass plugs if initial trials appear successful.

>438.5	~5847 + TBD	6: Mound Mix	The summit of this mound is a high priority for attempting to foster a diverse upland community of multi-layer vegetation suitable for nesting birds, roosting bats, and other terrestrial wildlife. Infill planting as needed to achieve Phase 1 target densities within low density microsites. On newly constructed sections, moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Experimental staking, but at a relatively high density, and a diversity of stocked plants. Species from the Phase 1 trial showing promising initial establishment were emphasised. Infill planting as needed to achieve Phase 1 target densities within low density microsites. A priority site for augmentation with the best available soils. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.
Perimeter Disturbance Allowance (<438)	~2217 + 1323	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
C3 - Mound			
Perimeter Disturbance Allowance	~2149 + 960	5c: Terrestrial Mix (upper)	On new perimeter disturbance allowance, low density stocking of willow, red-osier dogwood, cottonwood, Kellogg's and Columbia sedge, and bluejoint with reduced diversity at low elevations. Species mix weighted in favour of the most promising species based on Phase 1 results at other comparable microsites. Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
>438.5	~2445 + 3689	6: Mound Mix	The objective for this mound is moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Species from the Phase 1 trial showing promising initial establishment were emphasised. Experimental staking. Infill planting as needed to achieve Phase 1 target densities within low density microsites. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.

Table 9-2. **Complete vascular plant species list for plots sampled in 2022, indicating the constructed wetland features where each species was found, the nativity of the species, and whether it is a naturally establishing (versus a planted) species.** *: Species present in 2021 and 2022. **: Species recorded in 2021 only. ±: Species first recorded in 2022

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As in 2021, notable volunteer woody species on mounds and banks included *Rubus parviflorus* (thimbleberry), *Rubus idaeus* (red raspberry), and *Populus trichocarpa* (black cottonwood) (Figure 4-7). Continuing to establish voluntarily on exposed mud flats of the upper ponds were various sedges, rushes, and forbs that were not present prior to physical works including *Juncus ensifolius* (dagger-leaf rush), *J. alpinoarticulatus* (alpine rush), *Carex crawfordii* (Crawford's sedge), *Veronica peregrina* (purslane speedwell), and *Rorippa curvipes* (bluntleaf yellowcress). As noted above, *C. utriculata* (beaked sedge), which was one of the primary species to be salvaged from the footprint then replanted around pond margins during Phase 1 construction, has established well and now is steadily expanding its cover via rhizomatous spread. In the submerged portions of the upper and mid-elevation ponds (A1 to A4) we noted some small aquatic macrophytes such as *Ranunculus gmelinii* (small yellow water-buttercup) and *Callitriche palustris* (spring water-starwort), but these were present in relatively sparse numbers and the aquatic plant community remains minimally developed overall.

Despite the relatively high species diversity that has developed on the physical works features since their construction, plant canopy cover is overwhelmingly being contributed by a single species: *Phalaris arundinacea* (reed canarygrass or RCG). In all but the lowermost ponds, the cover of this non-native grass ranged from ~15%-60% when assessed in sample plots in May (Figure 4-9, Figure 4-10, Figure 4-11). By the second (September) survey, informal observations indicated that RCG had grown substantially denser and higher, with a canopy approaching 100% cover in many locations (Figure 4-12). This was consistent with the seasonal trend observed in 2021 (Miller and Hawkes 2022),

Figure 4-7. **Volunteer woody establishment, mound C2.** A: Thimbleberry (*Rubus parviflorus*). B: Black cottonwood. Photos: M. Miller.

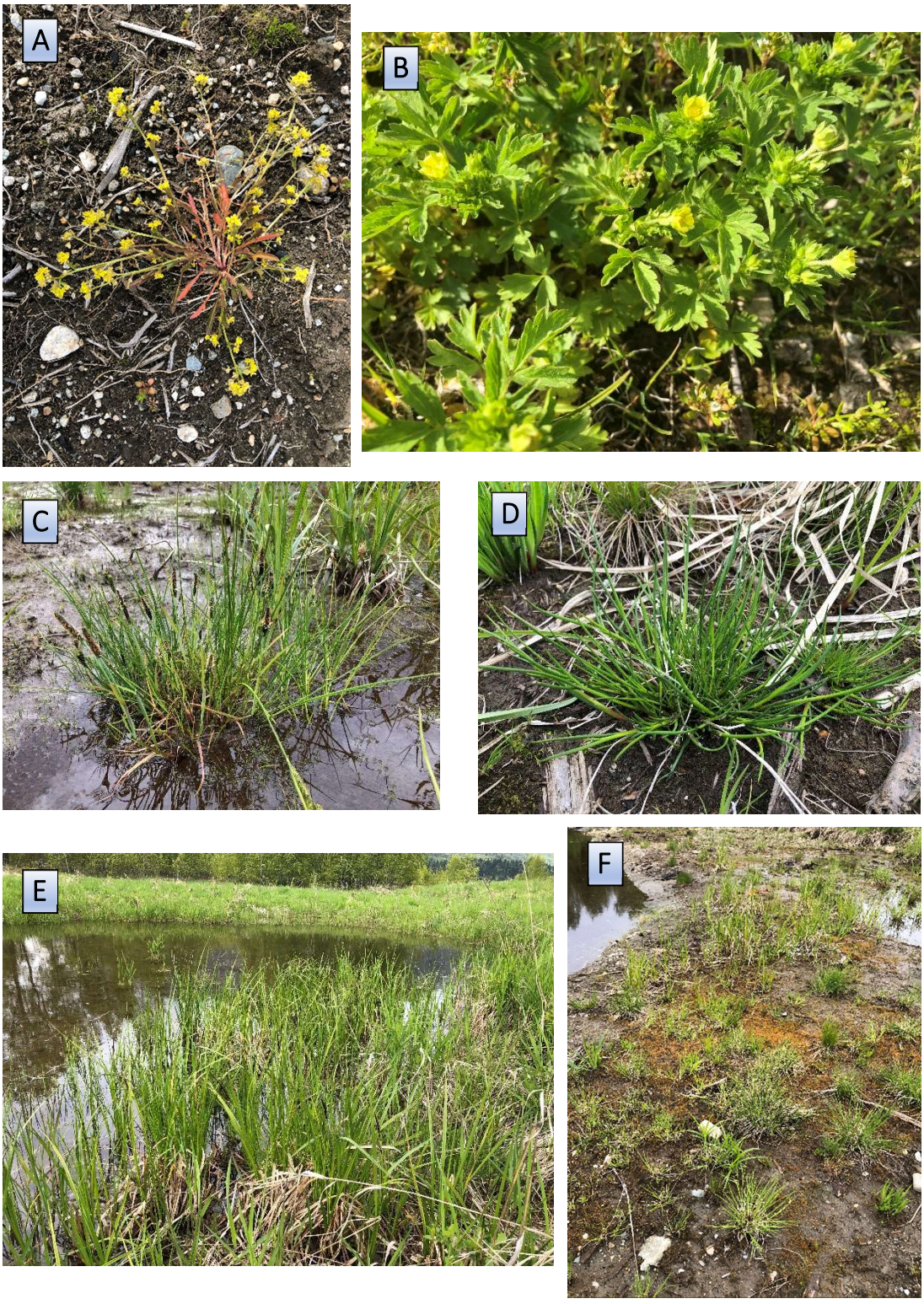


Figure 4-8. **Photos illustrating colonization of pond riparian margins.** A: *Rorippa curvi*pes (bluntleaf yellowcress). B: *Potentilla rivalis* (brook cinquefoil). C: *Alopecurus aequalis* (little meadow-foxtail). D: *Juncus alpinoarticulatis* (alpine rush). E: *Carex utriculata* (beaked sedge), expanding from transplanted salvage. F: Mixed graminoids (some planted, some natural).

Photos: M. Miller.

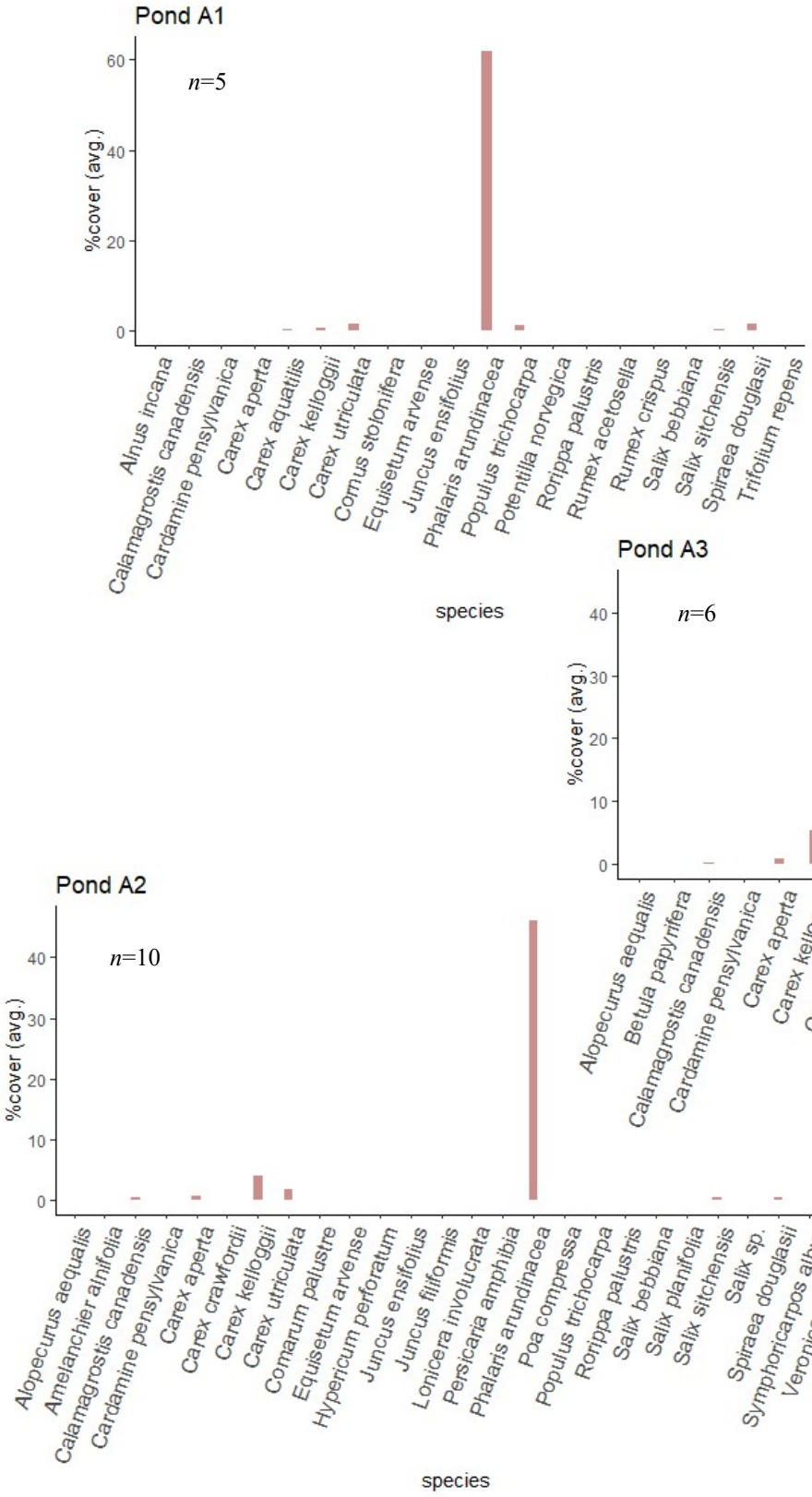
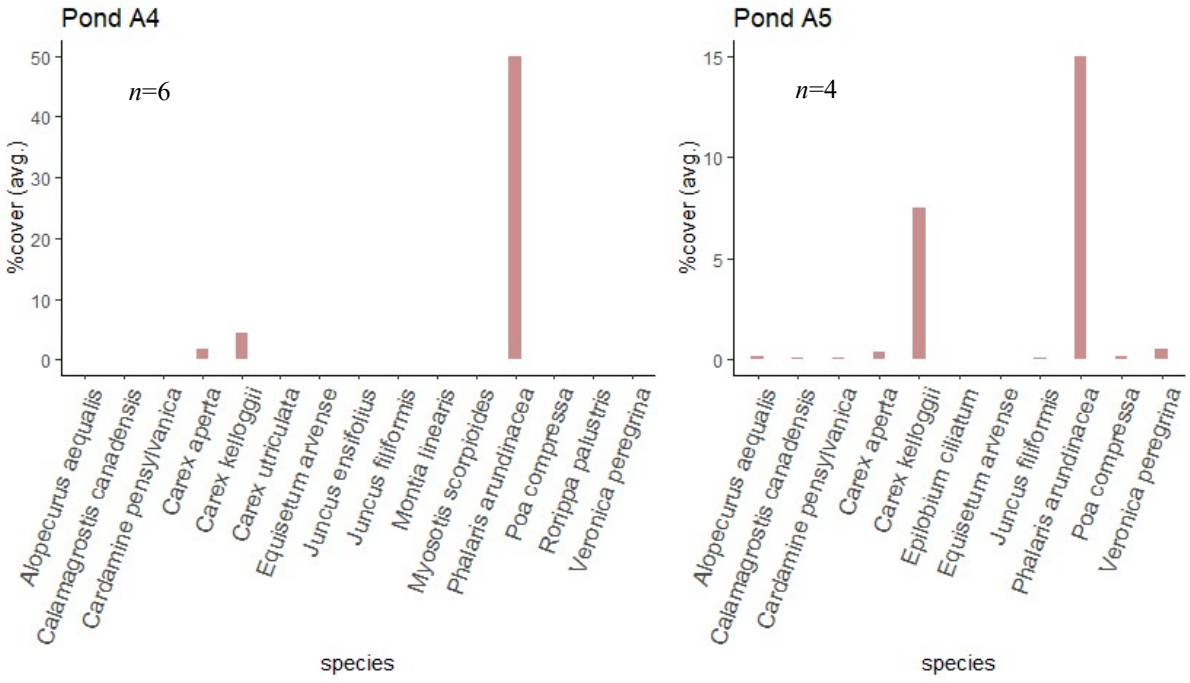


Figure 4-9. Average species covers recorded at Ponds A1, A2,and A3 in May 2022. Species with nil covers indicated on the charts were in fact present, but only in trace amounts.



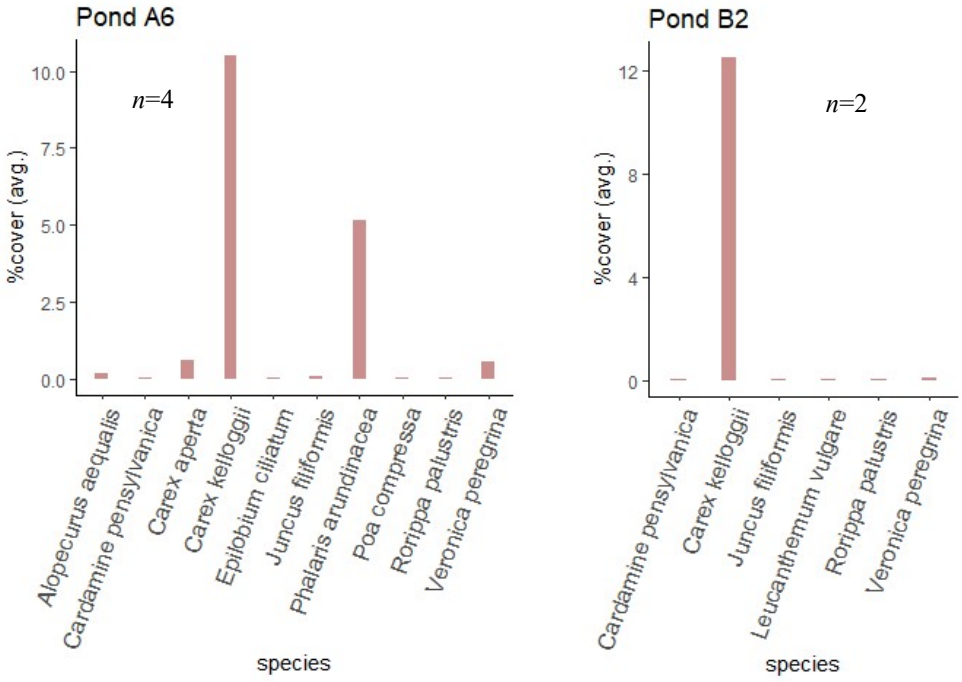


Figure 4-10. Average species covers recorded at ponds A4, A5, A6, and B2 in May 2022. Species covers were not formally assessed at pond B1 in 2022, as this feature was not retaining water as per the intended design. Species with nil covers indicated on the charts were in fact present, but only in trace amounts.

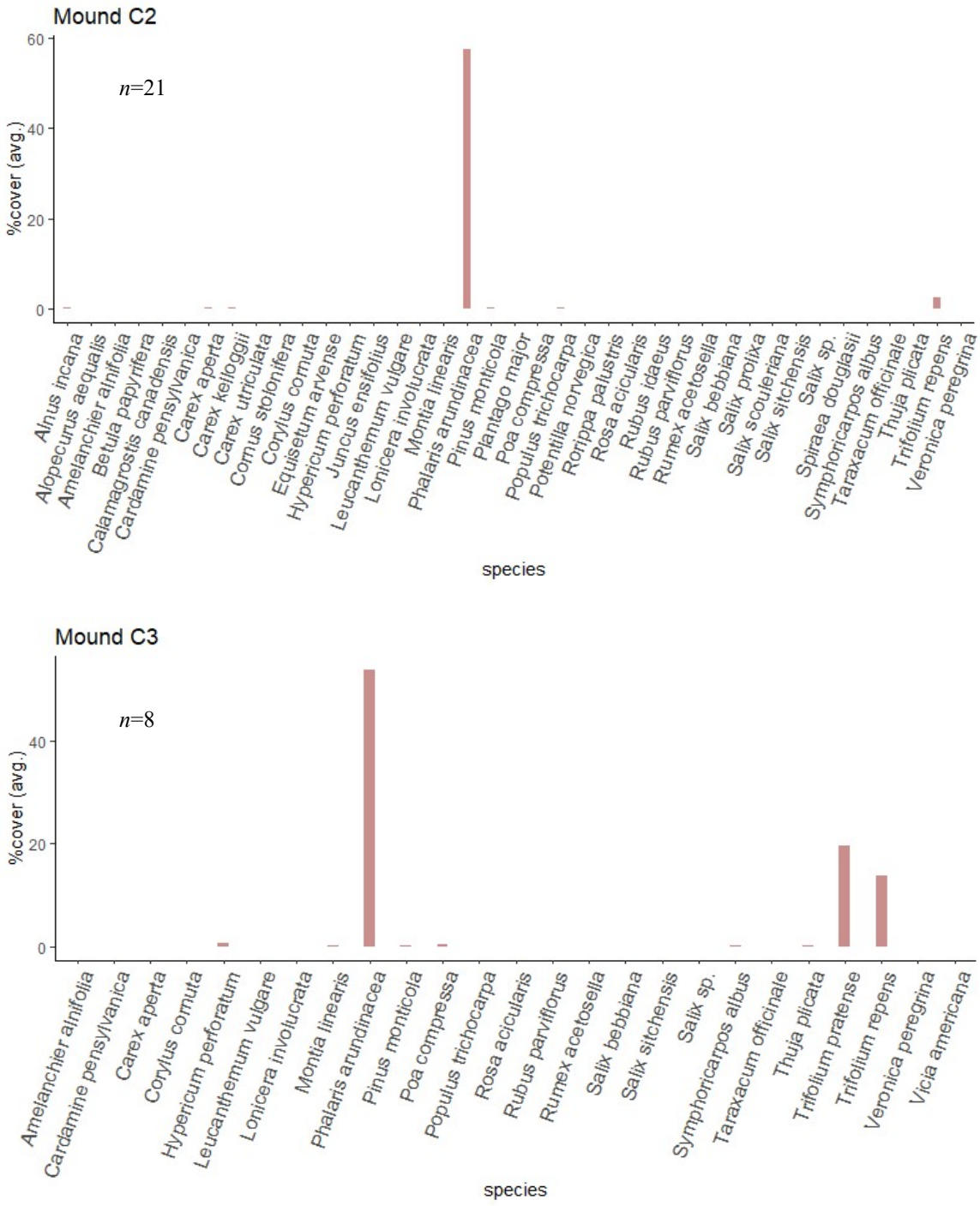


Figure 4-11. Average species covers recorded at Mounds C2 and C3 in May 2022. Species with nil covers indicated on the charts were in fact present, but only in trace amounts.

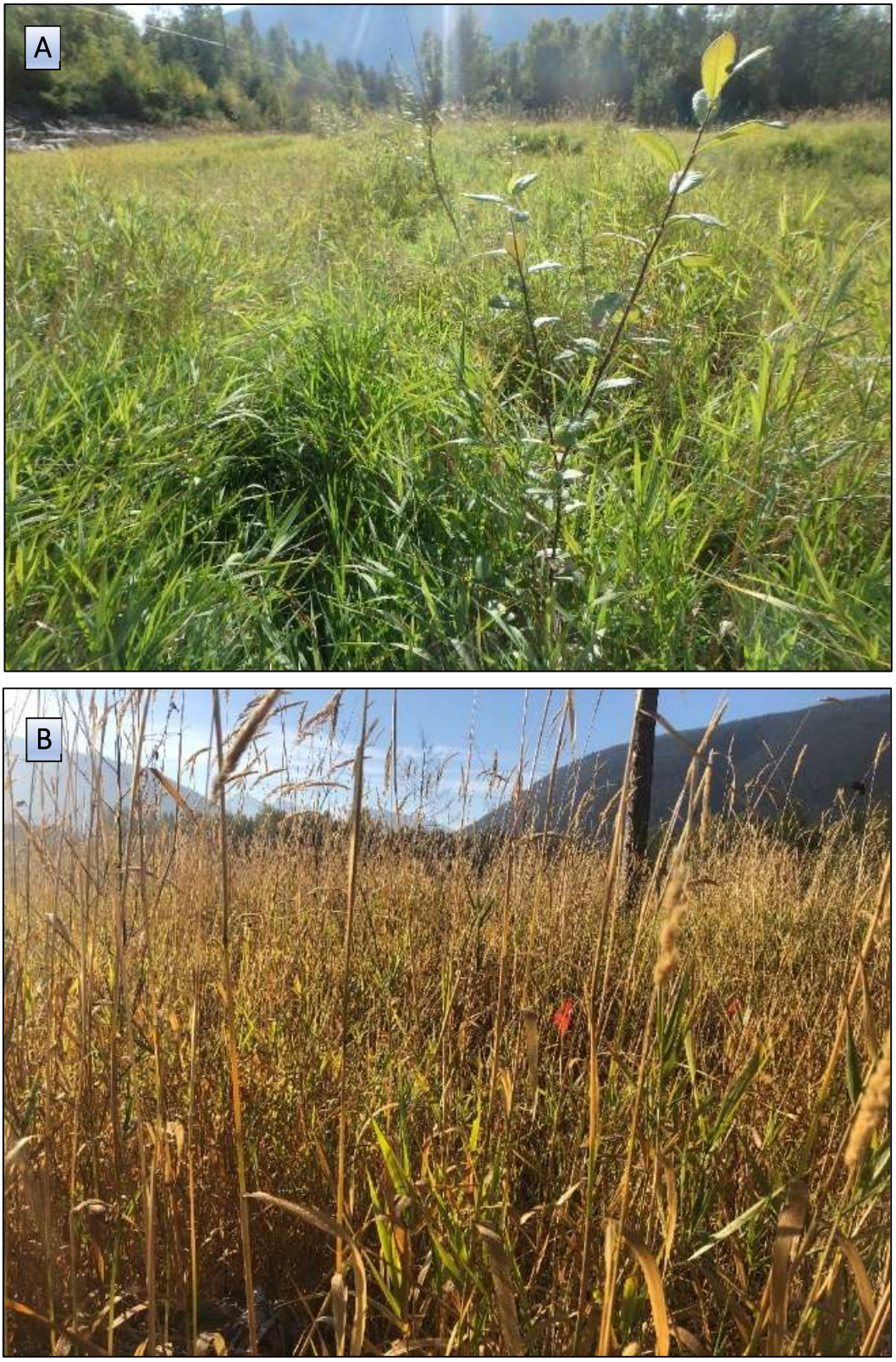


Figure 4-12. Dense September ground cover of *Phalaris arundincaea* (reed canarygrass). A: Pond A3 monitoring plot. B: Mound C2 monitoring plot. Photos: M. Miller.

5.0 Factors Limiting Vegetation Establishment

5.1 Inundation

Between the time of the May 2022 monitoring work, Phase 1 (2019) plantings had been exposed to two complete reservoir inundation cycles and portion of Phase 2 plantings (those installed in the spring of 2021) had been exposed to one full inundation cycle. Between 2020 and 2022, the summer reservoir maxima ranged from 438.7 to 439.7 mASL (Figure 5-1), resulting in the inundation of all ponds to varying degrees each year, depending on their elevation. For example, pond A6 was inundated for 87 percent of days, and Pond A1 for 23 percent of days, in June 2020 (Figure 5-2). Pond A3 was inundated for 0.26 of the time in June 2022 and for the entire month of July, whereas pond A1 remained inundation-free in 2022 (Figure 5-2). These events allow for some preliminary conclusions to be drawn around reservoir impacts on establishment success.

Nearly all the plant taxa used in non-mound prescriptions (i.e., for microsites within the inundation zone) have shown the ability to withstand some extended inundation, although to varying degrees. Three of the four primary graminoid species (Kellogg's sedge, Columbia sedge, beaked sedge) appeared generally unaffected by the depth and duration of inundation in 2020 and 2021 and have established vigorously at every elevation where they were introduced. The overall performance of the fourth graminoid planted, bluejoint, is uncertain due to challenges with enumeration (see Results), but this species is also showing early signs of being able to establish within the zone of inundation.

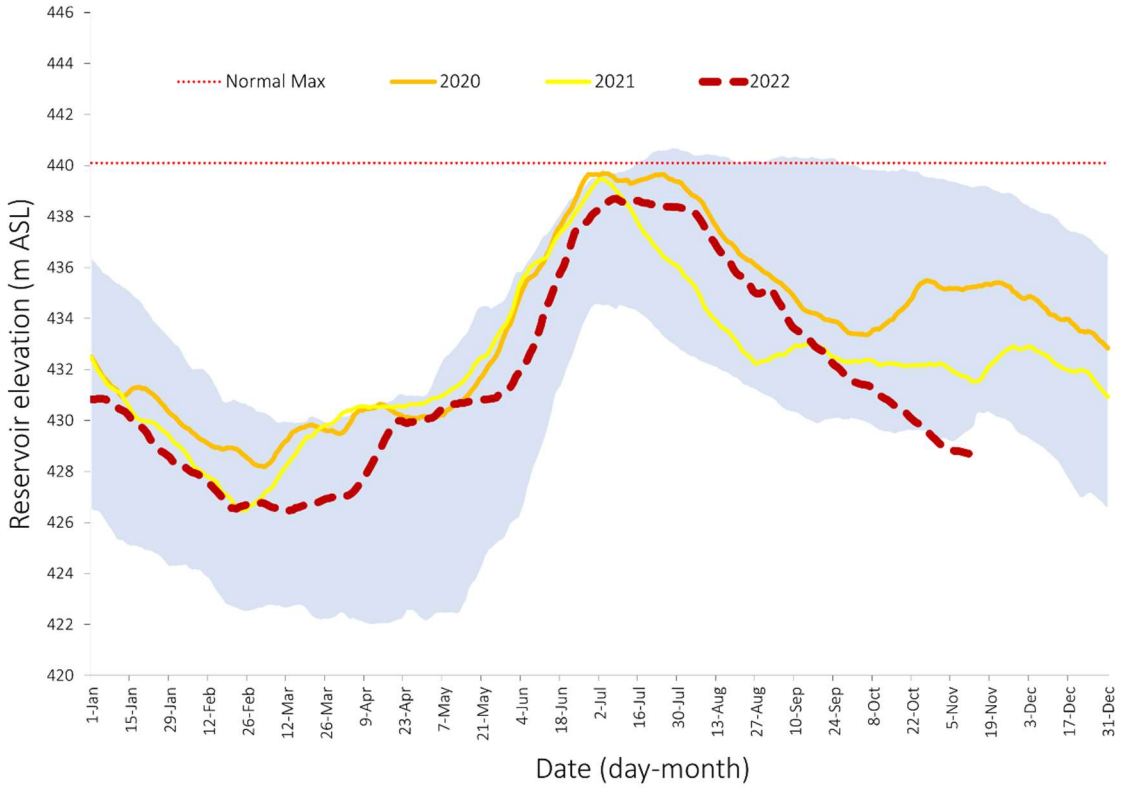


Figure 5-1. Daily water levels in Arrow Lakes Reservoir shown by year for 2020–2022. Shading represents range of operations (10th and 90th percentile) between 1969 and 2022.

		Month (2020)											
Pond	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	438.75	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.16	0.00	0.00	0.00	0.00
A2	438.24	0.00	0.00	0.00	0.00	0.00	0.29	1.00	0.29	0.00	0.00	0.00	0.00
A3	437.25	0.00	0.00	0.00	0.00	0.00	0.48	1.00	0.45	0.00	0.00	0.00	0.00
B1	436.31	0.00	0.00	0.00	0.00	0.00	0.58	1.00	0.74	0.00	0.00	0.00	0.00
A4	435.86	0.00	0.00	0.00	0.00	0.00	0.68	1.00	0.94	0.00	0.00	0.00	0.00
A5	435.39	0.00	0.00	0.00	0.00	0.00	0.81	1.00	1.00	0.13	0.16	0.06	0.00
A6	434.85	0.00	0.00	0.00	0.00	0.00	0.87	1.00	1.00	0.29	0.29	0.94	0.03
B2	434.33	0.00	0.00	0.00	0.00	0.00	0.94	1.00	1.00	0.42	0.42	0.97	0.29
D1	433.54	0.00	0.00	0.00	0.00	0.06	0.97	1.00	1.00	0.90	0.77	0.97	0.65
D2	432.52	0.00	0.00	0.00	0.00	0.19	0.97	1.00	1.00	0.97	1.00	0.97	1.00

		Month (2021)											
Pond	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	438.75	0.00	0.00	0.00	0.00	0.00	0.10	0.29	0.00	0.00	0.00	0.00	0.00
A2	438.24	0.00	0.00	0.00	0.00	0.00	0.23	0.42	0.00	0.00	0.00	0.00	0.00
A3	437.25	0.00	0.00	0.00	0.00	0.00	0.42	0.58	0.00	0.00	0.00	0.00	0.00
B1	436.31	0.00	0.00	0.00	0.00	0.00	0.61	0.84	0.00	0.00	0.00	0.00	0.00
A4	435.86	0.00	0.00	0.00	0.00	0.00	0.77	1.00	0.00	0.00	0.00	0.00	0.00
A5	435.39	0.00	0.00	0.00	0.00	0.00	0.87	1.00	0.13	0.00	0.00	0.00	0.00
A6	434.85	0.00	0.00	0.00	0.00	0.00	0.90	1.00	0.23	0.00	0.00	0.00	0.00
B2	434.33	0.00	0.00	0.00	0.00	0.00	0.97	1.00	0.29	0.00	0.00	0.00	0.00
D1	433.54	0.00	0.00	0.00	0.00	0.13	0.97	1.00	0.52	0.00	0.00	0.00	0.00
D2	432.52	0.00	0.00	0.00	0.00	0.32	0.97	1.00	0.77	0.68	0.00	0.26	0.29

		Month (2022)											
Pond	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	438.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2	438.24	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.10	0.00	0.00	0.00	0.00
A3	437.25	0.00	0.00	0.00	0.00	0.00	0.26	1.00	0.32	0.00	0.00	0.00	0.00
B1	436.31	0.00	0.00	0.00	0.00	0.00	0.35	1.00	0.52	0.00	0.00	0.00	0.00
A4	435.86	0.00	0.00	0.00	0.00	0.00	0.39	1.00	0.61	0.00	0.00	0.00	0.00
A5	435.39	0.00	0.00	0.00	0.00	0.00	0.45	1.00	0.77	0.00	0.00	0.00	0.00
A6	434.85	0.00	0.00	0.00	0.00	0.00	0.52	1.00	1.00	0.10	0.00	0.00	0.00
B2	434.33	0.00	0.00	0.00	0.00	0.00	0.58	1.00	1.00	0.16	0.00	0.00	0.00
D1	433.54	0.00	0.00	0.00	0.00	0.00	0.65	1.00	1.00	0.32	0.00	0.00	0.00
D2	432.52	0.00	0.00	0.00	0.00	0.00	0.77	1.00	1.00	0.68	0.00	0.00	0.00

Figure 5-2. Timing and duration of inundation of physical works features at Burton Flats from 2020-2022. Shown are the approximate constructed elevations of each pond feature and the proportion of each month that this elevation was exceeded by the reservoir (i.e. pond innundation, shaded in blue). (Note that ponds A5, A6, B2, D1, and D2 were not actually inundated by the reservoir in 2020 because they had not been constructed yet.)

Amongst woody-stemmed plants, species such as red-osier dogwood and paper birch appeared relatively more sensitive to summer flooding (and associated anoxia) than others (e.g., black cottonwood, willows, hardhack), as stock planted at lower elevations (e.g., around the upper ponds) often did not survive. Mountain alder showed a moderate tolerance for inundation, while western white pine showed very limited tolerance. However, even the two most tolerant species, black cottonwood and Sitka willow, exhibited some water stress with a substantial portion of stems

undergoing dieback. A subsequent round of planting in the fall of 2021 (Phase 2 project) has, for the moment, restored these species to their original planted densities. It is not yet known yet how these latter plantings (locally harvested live stakes in the case of cottonwood; nursery-raised bare-root cuttings in the case of Sitka willow) will ultimately respond to submergence because they have not yet undergone inundation (2022 being a relatively low water year). Initial indications are that the cottonwood live stakes survived their first, inundation-free year well but that the Sitka willow cuttings (which were shorter in stature) have been completely overgrown and likely eliminated by RCG.

5.2 Woody debris

Aside from anoxia (drowning), another inundation-associated factor that could impede vegetation establishment is the deposition of floating coarse and/or fine woody debris following annual reservoir recession. For example, some Phase 1 plantings on the eastern bank of pond A1 were partially to completely buried by wood debris when the reservoir receded in 2020 (Figure 5-3). A similar impact was previously noted by Miller and Hawkes (2020d) with reference to the upper banks of mound C2 (Figure 5-3). These woody depositions were concentrated in relatively small catchment areas, and no new woody debris depositions were noted in relation to either of the two subsequent inundation cycles (2021, 2022).

That said, woody debris deposition poses a potential long-term threat to the physical integrity of the ponds and to riparian plantings and for this reason merits further monitoring. If significant wood deposits do settle into the ponds, they will be difficult to clear via mechanical means without causing undo compaction or damage to the existing vegetation. One possible preventative action would be to install a log-boom in a strategic location at the north end of the project area to prevent floating wood from entering the ponded zone. A similar approach has been trialled to good effect in Kinbasket Reservoir at both Bush Arm and Canoe Reach (Miller and Hawkes 2020a). The elevated eastern bank of mound C2 affords a potential attachment point for one end of the boom, with the highway embankment providing a logical second attachment point. Since mound C2 only extends northward past a portion of the pond complex (Figure 3-1), the lowermost ponds (D1, D2, B2, and possibly A6) would not likely benefit from this approach. However, protecting ponds A5 to A1 with this method should be relatively straightforward. The benefits of doing so would need to be weighed against the risk of retaining the current open design (presently unknown, but possibly minor), the cost incurred to install and maintain an exclusionary device over time, and the possible negative visual impact of such a device.

5.3 Other Reservoir Effects

Erosion, sedimentation, and wave action, three other reservoir-associated process that have been cited as limiting revegetation success elsewhere in Arrow Lakes and Kinbasket Reservoirs (Miller et al. 2018, Miller and Hawkes 2020a, Miller and Hawkes 2020b), do not so far appear to be major influences at the Burton Flats wetland.

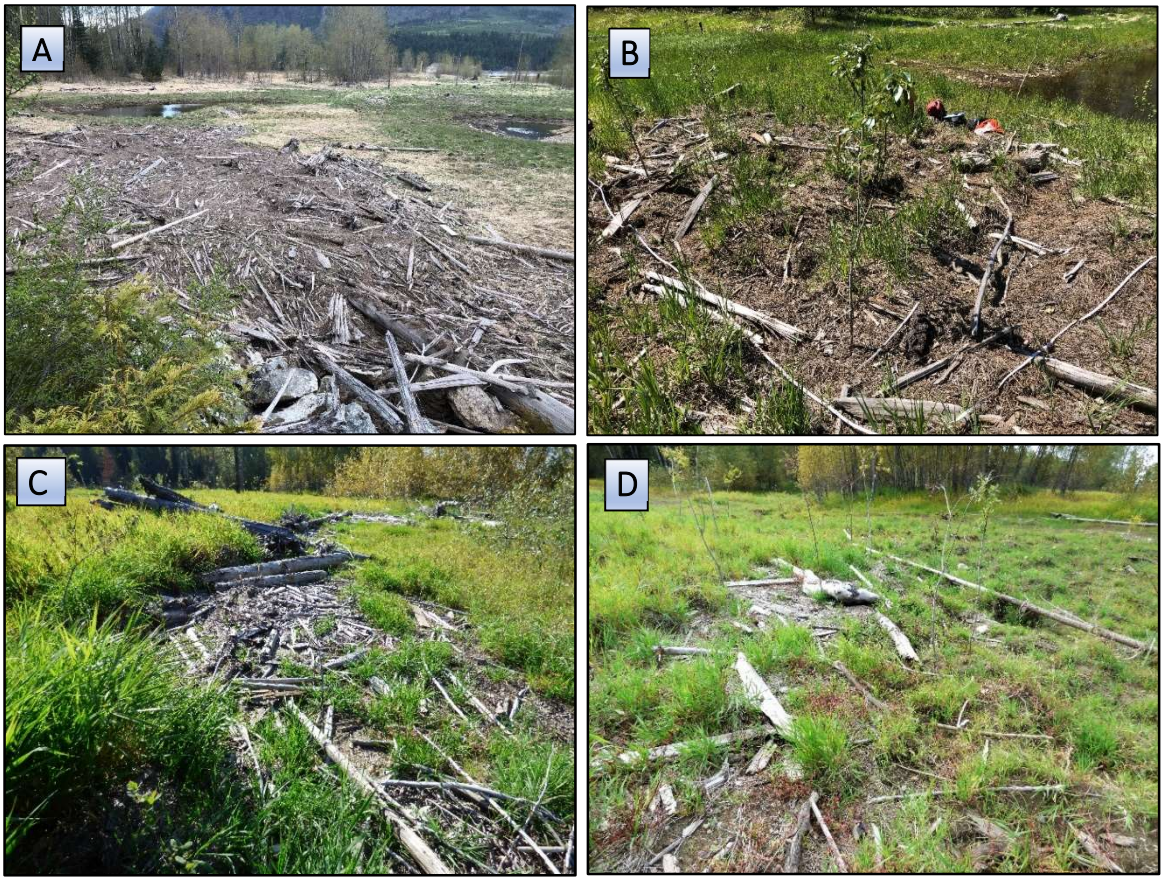


Figure 5-3. Woody debris depositions indicating the 2020 summer high-water mark. A: Debris above ponds A1 and A2. B: Black cottonwood plantings surrounded by debris in pond A1 monitoring plot. C: Debris deposition on the banks of mound C2. Some shrubs were knocked over or partially buried by this debris in 2020 (Miller and Hawkes 2020d). Photos: M. Miller.

5.4 Soil Moisture

As reported previously (Miller and Hawkes 2022), the "heat dome" event in late June and early July of 2021 exerted a heavy toll on mound plantings (particularly the freshly-installed Phase 2 mound plantings). Shrubs on mound C3 performed particularly poorly in 2021, due, it appears, to the combination of heat and drought stress associated with the heat dome. To mitigate for this high summer attrition, the tops of mounds C2 and C3 (Phase 2 portions) were extensively re-treated in the fall of 2021. In the case of C3, however, this second round of plantings had by and large also failed by the fall of 2022. The low water-holding capacity of the topsoil material at this location (consisting of coarse parent material provided by the pond D2 excavation) may account for much of the low survivorship of plantings here. Drought stress also appears to have affected, albeit to a lesser extent, the survivorship of plantings on the tops and sides of mound C2 (which also occur on rapidly-drained substrates). In retrospect, the revegetation program may have achieved higher establishment rates if supplemental irrigation had been provided to these high-elevation stock in the weeks/months following planting (a non-surprising observation given that one would likely not expect newly planted shrubs in a household garden to survive the summer if they were never watered).

5.5 Reed canarygrass

The second factor of note, already mentioned above, is the dense RCG cover that has re-established on many treatment areas (after just a single partial growing season in some cases). RCG is a dominant invasive species on many open terrestrial substrates in the Arrow Lakes Reservoir drawdown zone, where it has shown an ability to out-compete most other herbaceous plants and/or suppress their establishment. The added stress imposed by intense reed canarygrass competition could represent a physiological tipping point for many revegetated species that lack either the stem height or deep root depths required to harvest necessary light, moisture, and nutrient sources.

Under CLBWORKS-30B, LGL Limited carried out preliminary control work on RCG at Burton Flats, first in in May 2022 and again in September 2022 (coincidental with CLBMON-12 monitoring work). Control consisted of clipping grass to ground level around the bases of plantings using a gas-powered weed eater and hand clippers. Work focused on the revegetated areas of mound C2 and associated lower riparian banks, as well as on the shrub-stocked zones of ponds A2 and A3 (Figure 6-1). Care was taken to avoid inadvertently damaging planted vegetation during weeding. In densely overgrown areas, an initial wide pass through the grass was made with the weed eater, then remaining RCG was pulled from around the individual planted stock by hand.

It is recognized that, in the present context, bi-annual mechanical mowing and clipping of RCG is a stop-gap measure that temporarily reduces, but does not remove, ongoing competition with the planted stock. This management method is not expected to result in a permanent reduction in RCG cover at Burton Flats. Nevertheless, the results from this initial effort suggest that the approach can potentially serve to “buy” extra time for stock to become better established during the initial years post-planting, ideally to the point that the plantings can, in turn, begin to overtop and perhaps outcompete the invading grass. To help ensure the ongoing effectiveness of this adaptive management effort, a second (follow-up) round of targeted control work has been recommended for 2023. As in 2022, this round of control will ideally occur at least twice during the growing season: once during the spring exposure period, and again when the reservoir recedes following summer inundation.

6.0 Revegetation Effectiveness

After 2.5 years, revegetation prescriptions implemented under CLBWORKS-30B have increased species diversity, vertical structure, and canopy cover of the constructed wetland and associated mounds over that which would have developed in the absence of treatment. Around pond margins, terrestrial sedges and emergent plants are now providing shoreline stability as well as habitat cover for shorebirds, pond-breeding amphibians, and aquatic invertebrates. Above the emergent zone is a developing riparian community of shrubs (e.g., hardhack, cottonwood, willow, alder) and graminoids (sedges and grasses). On slopes and mounds above the ponds, planted shrubs are being used as bird perches (potentially facilitating dispersal of native seeds into the site) and as early season pollen sources by insects. On some mound tops, western white pine plugs are growing well and are up to about 1 m in height, representing the possible beginnings of a nascent upland forest structure.

Figure 6-1. **Under CLBWKS-30B, a gas-powered weed eater was used to reduce RCG (reed canarygrass) cover from around plantings in May and September 2022.** Photos: M. Miller.

Early trends suggest that, even in the absence of any intentional planting, substantial vegetation establishment would have occurred naturally on most of the newly constructed features. Results also suggest that this vegetation likely would have included a component of native colonizers (e.g., thimbleberry) as well as various weedy species and the highly dominant RCG. That the site has begun to revegetate vigorously on its own can be regarded as an indication that the project's overall conceptual design (stepped ponds maintained by an inflowing creek and bordered by elevated mounds) was appropriate for this location. Further years of monitoring are needed to determine if the additional vegetational complexity ascribable to the various planting prescriptions will endure long enough to have a lasting impact on the community that eventually develops on this site. Effectiveness monitoring under CLBMON-12 is scheduled to continue in 2023 (Year 4) and 2024 (Year 5) and will help to address these questions.

Aside from reservoir inundation, competition from encroaching RCG remains the single greatest long-term impediment to successful revegetation establishment. The previously unplanned-for RCG control work being undertaken through CLBWORKS-30B provides an added opportunity for learning under CLMBON-12 in future implementation years.

7.0 Summary

Two revegetation effectiveness assessments were conducted at Burton Flats in 2022: one in May prior to summer inundation, and one in September after inundation. The surviving densities of planted species in the spring survey compared favourably to the densities targeted by the CLBWORKS-30B prescriptions (with some exceptions). However, by the fall of 2022, densities of several woody-stemmed species had declined notably. In some cases (e.g., on the Phase 2 section of mound C3), the die-off appeared to be induced by drought stress related to the limited water-holding capacity of the substrate; in other instances, to direct competition from, or overtopping by, reed canarygrass. The summer inundation event, which affected elevations up to 438.7 mASL, also appeared to produce some woody stem die-off in certain low to mid elevation planting prescriptions (PP2, PP3). Despite these limiting factors, the prescriptions implemented under CLBWORKS-30B have, to date, successfully increased the species diversity, vertical structure, and canopy cover of the constructed wetland and associated mounds over that which would have developed in the absence of treatment. Follow-up monitoring in subsequent years (2023-2024) will assist in determining if the species and vegetation structure contributed by the planting program continues to influence the successional trajectory of this site.

No new occurrences of woody debris deposition were observed in 2022. However, some settling of debris did occur in 2020 that resulted in localized impacts to vegetation. Mobile woody debris thus represents a potential source of disturbance that merits close monitoring. As a possible preventative measure, a log-boom installation that will exclude floating debris from the project area during high water, and protect stems from direct damage, should be considered.

8.0 Literature Cited

Kerr Wood Leidal 2018. Detailed Design Report. Wildlife Enhancement Program at Burton Flats. Final Report – Version 2. (KWL Project No.0478.203). 178 pp + appendices.

Miller, M.T., P. Gibeau, and V.C. Hawkes. 2018. CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Final Report – 2017. LGL Report EA3545C. Unpublished report by Okanagan Nation Alliance, Westbank, BC, and LGL Limited

environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Castlegar, BC. 50 pp + Appendices.

Miller, M.T. and V.C. Hawkes. 2020a. CLBMON-9 Kinbasket Reservoir monitoring of revegetation efforts and vegetation composition analysis: Final Report—2008-2019. Unpublished Report by LGL Limited, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 59 pp. + App.

Miller, M.T. and V.C. Hawkes. 2020b. CLBMON-35 Arrow Lakes and Kinbasket Reservoirs plant response to inundation. Year 2 – Final Report (2019). LGL Report EA3797. Prepared by LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 34 pp + Appendices.

Miller, M.T. and V.C. Hawkes. 2020c. CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 1). Final Report – 2019. LGL Report EA3957. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 38 pp.

Miller, M.T. and V.C. Hawkes. 2020d. CLBMON-12 Revegetation Effectiveness Monitoring of Burton Flats Wildlife Enhancement Project (CLBWORKS-30B, Phase 1). 2020 Summary Report. LGL Report EA4106. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 23 pp.

Miller, M.T. and V.C. Hawkes. 2021. CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 2). Draft Report – 2021. LGL Report EA4177. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 29 pp.

Miller, M.T. and V.C. Hawkes. 2022. CLBMON-12 Revegetation Effectiveness Monitoring of Burton Flats Wildlife Enhancement Project (CLBWORKS-30B). 2021 Summary Report. LGL Report EA4230. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 34 pp + Appendix.

9.0 Appendix 1

Table 9-1. Feature- and elevation- specific planting prescriptions for constructed ponds and mounds at Burton flats. mASL: metres above sea level. Adapted from Miller and Hawkes (2020c).

Elevation Range (mASL)	Area (m^2)	Planting Prescription	Description
A1 – Pond Feature			
Wetland Fringe	~199.5	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of permanent water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
438.4 to TOB (approx. 439)	~648	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasized. Establishment of hardhack with spaced alders is a primary aim.
Perimeter Disturbance Allowance (>438)	~702	5c: Terrestrial Mix (upper)	Infill planting as needed to achieve Phase 1 target densities (low density sedge, bluejoint, cottonwood, willow, red-osier dogwood).
A2 - Pond Feature			
Wetland Fringe	~152	1: Emergent Sedges	Phase 1 prescription was applied while new pond was filling and before location of new (realised) water line had been determined. Phase 2 treatment will use any additional emergent sedge (e.g., beaked sedge, small-flowered bulrush) salvaged during Phase 2 construction to extend the Phase 1 treatment so that it aligns with the realised wetland fringe (1 to 1.5 m pond edge of shallow water, < 25 cm deep). In lieu of available salvage, plug stock can possibly be used. Moderate density. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
Island	~20	3a: Terrestrial Sedges (upper, no nesting shrubs)	Low density stocking of the small, newly created gravel island in A2 using a mix of Kellogg's sedge and Columbia sedge.
438 to TOB (approx. 438.5)	~884 + 81	2: Riparian	Surrounding the ponds, the shorelines were infill planted as needed to achieve Phase 1 target densities within low density microsites. The objective is to achieve a dense irregular mix of riparian shrubs (e.g., hardhack, twinberry, Sitka willow, mountain alder, red-osier dogwood) intermixed with graminoids (e.g., Kellogg's sedge, Columbia sedge, bluejoint). Species from the Phase 1 trial showing promising initial establishment were emphasised. Establishment of hardhack with spaced alders is a primary aim.

<438	n/a + 36	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~705 + 226	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A3 - Pond Feature			
Wetland Fringe	~71.1 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation, or too far removed from the permanent water/seepage course, for these species to flourish. Added structural feature: Logs (anchored into the bank and extending into the pond) to provide habitat structure and heterogeneity.
436.9 to TOB (approx. 437.5)	~339 + 190	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
Perimeter Disturbance Allowance (>436<438)	~390 + 260	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A4 - Pond Feature			
Wetland Fringe	~90.7 + 70	1: Emergent Sedges	Low density stocking with salvaged emergent sedge (beaked sedge, small-flowered bulrush), if available. Infill stocking of Phase 1 planted area, and new stocking of Phase 2 constructed wetland fringe. Phase 1 prescription was applied before location of new (realised) water line had been determined; therefore, an objective of infill planting was to extend the Phase 1 treatment so that it aligns with the realised wetland fringe. In lieu of available salvage, plug stock can possibly be used. This area might be at too low elevation for these species to flourish.

436 to TOB	n/a + 486	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	~390 + 149	4: Terrestrial Sedges (lower)	Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (>436<438)	~387 + 547	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, bluejoint, and cottonwood. Infill planting as needed to achieve Phase 1 target densities.
A5 - Pond Feature			
436 to TOB	247	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	734	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	647	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	261	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
A6 - Pond Feature			
436 to TOB	241	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge) and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood (to prevent unwanted nesting habitat).
<436	1063	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (>436<438)	625	5b: Terrestrial Mix (mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	391	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
B1 - Pond Feature			

436 to TOB (approx. 437.5)	~1480 + 220	3a: Terrestrial Sedges (upper, no nesting shrubs)	Infill planting of Phase 1 treatment area to meet target densities of sedge plugs (Kellogg's/Columbia sedge), bluejoint, and cottonwood stakes within low density microsites. Both sedge species can be salvaged and/or stocked with plugs. Reapplication of bluejoint plugs if initial trials appear successful. On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Experimental bluejoint reedgrass plugs and cottonwood staking. Avoid planting any shrub species other than cottonwood below 438.5 m (to prevent unwanted nesting habitat).
<436	~690 + 377	4: Terrestrial Sedges (lower)	Completion of planting on section not completed in Phase 1. Infill planting of Phase 1 treatment area to meet target densities of Kellogg's sedge plugs within low density microsites. On newly constructed banks, low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking.
Perimeter Disturbance Allowance (<438)	1268 + 398	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
B2 - Pond Feature			
<436 to TOB	205	4: Terrestrial Sedges (lower)	Low density stocking of Kellogg's sedge plugs. This species can survive inundation at this band of the drawdown zone, but success depends on substrate. Experimental stocking using salvaged material from the A5/A6 footprints.
Perimeter Disturbance Allowance (<436)	643	5a: Terrestrial Mix (lower)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge.
C2 - Mound			
438.5 to Toe (approx. 436)	~848 + 2890	3: Terrestrial Sedges (upper) 3a: Terrestrial Sedges (upper, no nesting shrubs)	On newly constructed banks, low density stocking with a mix of Kellogg's and Columbia sedge, with the mix either evenly weighted or weighted in favour of the most promising species based on Phase 1 results. Both sedge species can be salvaged and/or stocked with plugs. Shrubs (cottonwood, Sitka willow, and red-osier dogwood) can be stakes (locally harvested) or nursery stock. Infill planting of Phase 1 treatment area to meet target densities of sedge and shrubs within low density microsites. Reapplication of bluejoint reedgrass plugs if initial trials appear successful.
>438.5	~5847 + TBD	6: Mound Mix	The summit of this mound is a high priority for attempting to foster a diverse upland community of multi-layer vegetation suitable for nesting birds, roosting bats, and other terrestrial wildlife. Infill planting as needed to achieve Phase 1 target densities within low density microsites. On newly constructed sections, moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Experimental staking, but at a relatively high density, and a diversity of stocked plants. Species from the Phase 1 trial showing promising initial establishment were emphasised. Infill planting as needed to achieve Phase 1 target densities within low density microsites. A priority site for augmentation with the best available soils. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.

Perimeter Disturbance Allowance (<438)	~2217 + 1323	5a/5b: Terrestrial Mix (lower/mid)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood (Kellogg's sedge only <436 m). Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
C3 - Mound			
Perimeter Disturbance Allowance	~2149 + 960	5c: Terrestrial Mix (upper)	On new perimeter disturbance allowance, low density stocking of willow, red-osier dogwood, cottonwood, Kellogg's and Columbia sedge, and bluejoint with reduced diversity at low elevations. Species mix weighted in favour of the most promising species based on Phase 1 results at other comparable microsites. Infill planting of Phase 1 treatment area to meet target densities within low density microsites.
>438.5	~2445 + 3689	6: Mound Mix	The objective for this mound is moderate density and high diversity terrestrial vegetation mix (e.g., graminoids, soapberry, trembling aspen, paper and water birch, western white pine, black twinberry, various willows, saskatoon, snowberry, cottonwood, red-osier dogwood, and prickly rose). Species from the Phase 1 trial showing promising initial establishment were emphasised. Experimental staking. Infill planting as needed to achieve Phase 1 target densities within low density microsites. Added structural features: Snags (cedar with branches) inserted upright into top of mound, and logs, stumps, and other large woody debris (LWD) incorporated into surface of mounds to provide habitat structure and heterogeneity.

Table 9-2. **Complete vascular plant species list for plots sampled in 2022, indicating the constructed wetland features where each species was found, the nativity of the species, and whether it is a naturally establishing (versus a planted) species.** *: Species present in 2021 and 2022. **: Species recorded in 2021 only. ±: Species first recorded in 2022

Species	Naturally established	Native	Wetland feature										
			C2	C3	A1	A2	A3	A4	A5	A6	B1	B2	A2 Island
Acmispon denticulatus	X		**										
Alnus incana		X	*	**	*								
Alopecurus aequalis	X	X	*	*	**	*	*	*	±	±			±
Amelanchier alnifolia		X	*	*		*							
Betula papyrifera		X	*	*	*	**	*						
Calamagrostis canadensis		X	*	**	*	*	*	*	±				
Callitriche palustris	X	X			*	*	*	*					
Cardamine pensylvanica	X	X	±	±	*	*	±	*	*	±		±	
Carex aperta		X	*	*	*	*	*	*	*	±	*		±
Carex aquatilis		X			*	*							
Carex crawfordii	X	X			**	*							
Carex kelloggii		X	*		*	*	*	*	*	*	*	*	±
Carex utriculata		X	*		*	*	*	*			?		
Cerastium nutans	X		±			**			*	±			
Cirsium arvense	X			**		**							
Cirsium vulgare	X		±										
Collomia linearis	X	X		**									
Comarum palustre	X	X			*	*							
Cornus stolonifera		X	*	*	*	**	*				* *		
Corylus cornuta		X	*	*									
Draba sp.	X	X	±										
Eleocharis acicularis	X	X			**	**							
Eleocharis obtusata	X				*								
Epilobium ciliatum	X	X	*		**								
Epilobium sp.	X	X	±										
Equisetum arvense	X	X		**	*	*	*	*	*				
Erigeron philadelphicus	X	X	**	**									
Erysimum cheiranthoides	X				**								
Fragaria virginiana	X	X	**										
Galeopsis tetrahit	X			**									
Galium triflorum	X	X			±								
Geranium sp.	X		**										

Species	Naturally established	Native	Wetland feature										
			C2	C3	A1	A2	A3	A4	A5	A6	B1	B2	A2 Island
Hypericum perforatum	X		*	*									
Juncus alpinoarticulatus	X	X			*	*	*	*					
Juncus ensifolius	X	X			*	*							
Juncus filiformis	X	X			*	*	*	*	*	*		±	
Juncus tenuis	X	X				±	±	±					
Leucanthemum vulgare	X		±	*								±	
Lonicera involucrata		X	*	*	*	*							
Matricaria discoides	X			±									
Montia linearis	X	X	±	*				±					
Myosotis scorpioides	X				**	**	*	*					
Myosotis stricta	X		±	±									
Persicaria amphibia	X	X				*	**						
Phalaris arundinacea	X		*	*	*	*	*	*	*	*	*		
Pinus monticola		X	*	*									
Plantago lanceolata	X					**							
Plantago major	X		*			**							
Poa compressa	X		*	*	**	*	*	*	*	*			
Poa pratensis	X	X	*										
Polygonum aviculare	X							**					
Populus tremuloides		X	±	±									±
Populus trichocarpa		X	*	*	*	*	*				*		
Potentilla norvegica	X	X	*	**	*	**							
Potentilla rivalis	X	X	±	±				±	±	±		±	
Ranunculus gmelinii	X	X			*			*					
Potentilla rivalis	X	X				±			±				
Rorippa curvipes	X	X	±			±		±	±	±			±
Rorippa palustris	X	X	±		±	*	*	*		±		±	±
Rosa acicularis		X	±	±									
Rubus idaeus	X	X	*										
Rubus parviflorus	X	X	*	*		**							
Rumex acetosella	X		±	*	±								
Rumex crispus	X			**	*	±							
Salix bebbiana		X	*	*	*	*	*				*		
Salix farriae	X	X	±										
Salix lasiandra	X	X					±	±					
Salix pedicellaris		X	**										
Salix planifolia		X		±	±	*							
Salix prolixa		X	±			**							

Species	Naturally established	Native	Wetland feature										
			C2	C3	A1	A2	A3	A4	A5	A6	B1	B2	A2 Island
Salix scouleriana		X	*	**									
Salix sitchensis		X	*	*	*	*	*				*		
Salix sp.		X	±	*		±	±				*		
Scirpus microcarpus		X			*	*							
Senecio sp.	X		±										
Shepherdia canadensis		X	**	**									
Spergularia rubra	X		±										
Spiraea douglasii		X	*		*	*	*						
Symphoricarpos albus		X	*	*		*							
Taraxacum officinale	X		*	*									
Thuja plicata		X	*	*									
Trifolium hybridum	X		X	±									
Trifolium pratense	X		±	**									
Trifolium repens	X		±	±	±	**		**					
Unknown garden intro	X									±			
Verbascum thapsus	X		**	**									
Veronica peregrina	X		±	±	**	*	*	*					
Veronica serpyllifolia	X		**										
Vicia americana	X		**	*									