Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoir Revegetation Management Plan

Implementation Year 7

Reference: CLBMON-12

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

Study Period: 2021

Okanagan Nation Alliance, Westbank, BC
and
LGL Limited environmental research associates, Sidney, BC

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CLBMON-12 Revegetation Effectiveness Monitoring of Burton Flats Wildlife Enhancement Project (CLBWORKS-30B, Phase 1)




Summary Report (Final)

2021

Prepared for

BC Hydro

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 2021 (Year 2 of post-construction monitoring under CLBMON-12).

Two revegetation effectiveness assessments were conducted at Burton Flats in 2021: one in May prior to summer inundation, and one in September following inundation. The spring survey found that surviving densities for most species planted in 2019 compared favourably to the target densities identified in the Phase 1 prescriptions. The fall survey revealed that stem counts of certain species (primarily woody-stemmed species) declined notably over the summer of 2021, possibly in response to the year's summer "heat dome" event and associated drought that appeared to kill off many shrubs and trees before they could become properly established. Both old (Phase 1) and new (Phase 2) plantings were also being subjected to heavy competitive pressure from reed canarygrass which had overgrown many of the smaller-statured plants. Reservoir inundation also produced moderate to high stem die-off in several woody species.

Despite these limiting factors, revegetation prescriptions implemented under CLBWORKS-30B have effectively 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. In total, over 70 different plant species were recorded in 2021 on the project site at Burton Flats, representing a striking change from the largely "bare earth" conditions that prevailed following completion of the Phase 1 wetland and mound construction in the fall of 2019. Further monitoring is needed to determine if the species and vegetation structure contributed by the planting will continue over time to influence the successional trajectory of this site. Effectiveness monitoring under CLBMON-12 is scheduled to continue in 2022 (Year 3), 2023 (Year 4), and 2024 (Year 5), and will help to address these questions.

With Phase 2 physical works now completed, no further planting work is currently planned for the CLBWORKS-30B site at Burton Flats. Nevertheless, some supplementary weeding work has been recently scheduled for 2022 with the primary aim of reducing the cover/ingrowth of reed canarygrass cover from around the recently planted seedlings. This thinning will be accomplished mechanically using hand clippers and a weed eater and will likely be limited to the most densely infested microsites. This previously unplanned treatment could provide an opportunity for added learning under CLBMON-12 during later (post-2022) implementation years.

ACKNOWLEDGEMENTS

Mark Sherrington administered this monitoring project for BC Hydro, and David Derosa administered the project for ONA. Darryl Thomas (ONA) provided field assistance on the May field survey, and Sterling Peterson (ONA) provided field assistance on the September survey. Carrie Nadeau (SME) and Alexis Hall provided (SME) helpful review comments.

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. Phase 1 occurred in the fall of 2019 (Miller and Hawkes 2020c). Phase 2 occurred in the spring and fall of 2021 (Miller and Hawkes 2021). The condition (survival and vigor) of the Phase 1 plantings in spring of 2020 (after one winter and prior to summer inundation) and fall of 2020 (following the first summer inundation event) was described by Miller and Hawkes (2020d). Phase 2 involved the expansion of some Phase 1 ponds along with the construction of several additional pond and/or mound features, and revegetation of those features, as well as some targeted restocking of Phase 1 features (Figure 1-1).

As part of ongoing effectiveness monitoring under CLBMON-12, vegetation status was reassessed in the spring of 2021 (prior to inundation) and again in the fall of 2021 (post-inundation). The results of those assessments are summarized in this report.

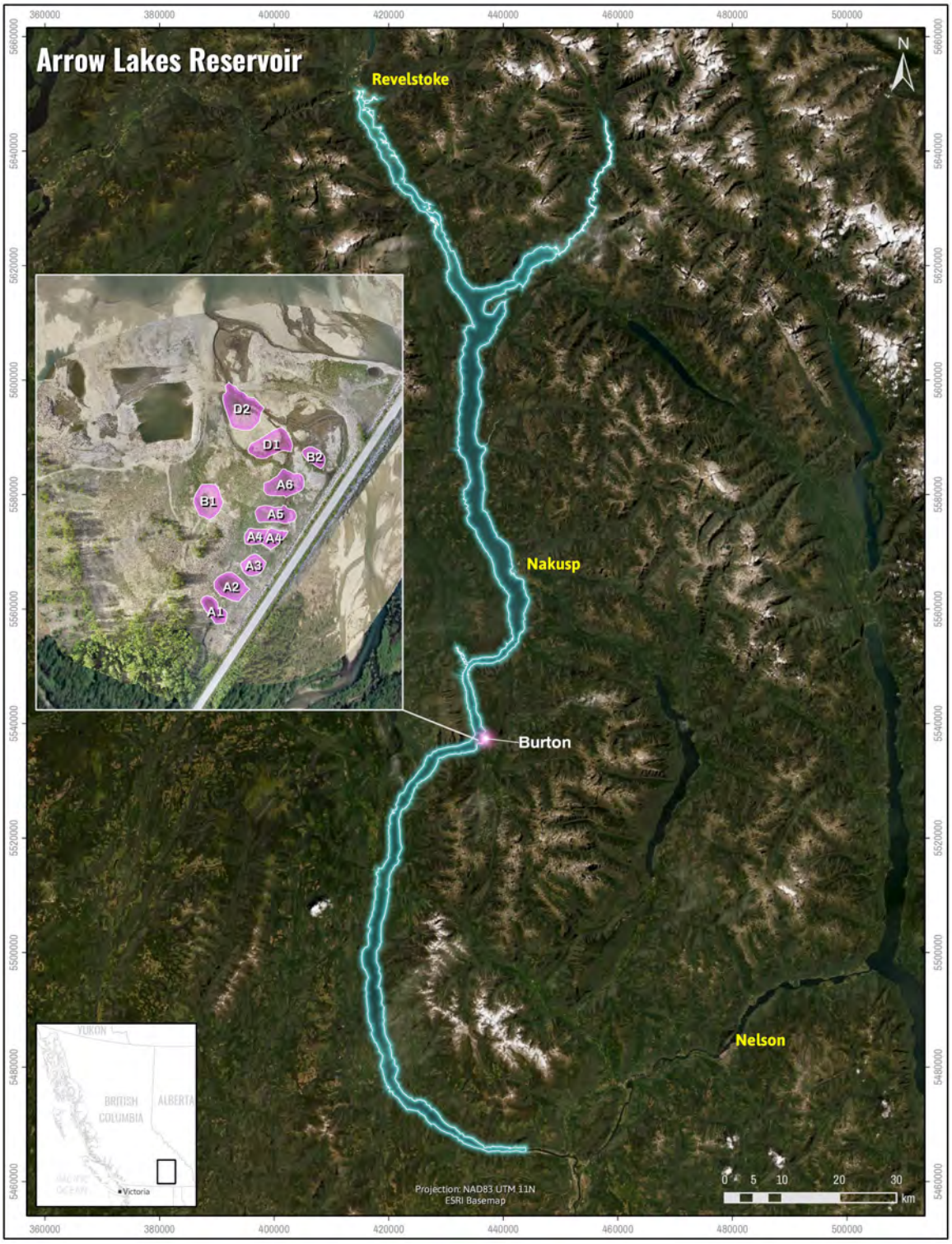


Figure 1-1. Burton Wetland Enhancement Project Location, Arrow Lakes Reservoir (KWL 2021). Inset shows the spatial orientation of constructed pond features. Phase 1 constructions: A1, A2, A3, A4, B1. Phase 2 constructions: A2 (deepening), A3 (deepening), A4 (expansion), A5, A6, B2.

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 program was completed in the fall of 2019, while Phase 2 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 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 described in detail 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 from the pond excavations) (Figures 2-1 to 2-3).

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

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.

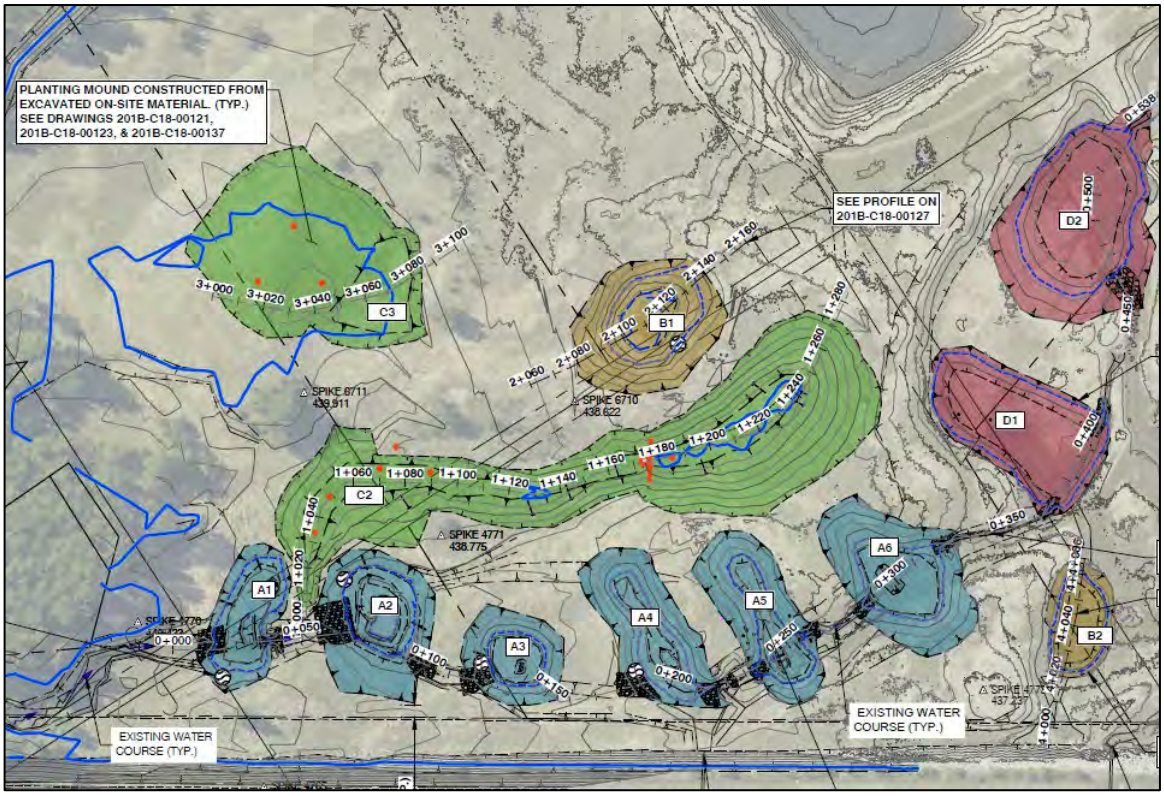


Figure 2-1. Burton Flats Wetland Enhancement Project Design Components (from: KWL Phase 2 Detailed Design 2021). Features A1-A6 (shallow pond wetland complex) are shown in blue; B1 and B2 (isolated ponds) in beige; C2 and C3 (elevated mounds) in green; and D1 and D2 (deep low-elevation waterfowl ponds) 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) intended to enhance an 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 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 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, 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 ponds (up to 1.2 m deep with shallow fringes) created from existing depressions at the lower end of the tiered wetlands (watercourse terminus). 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.

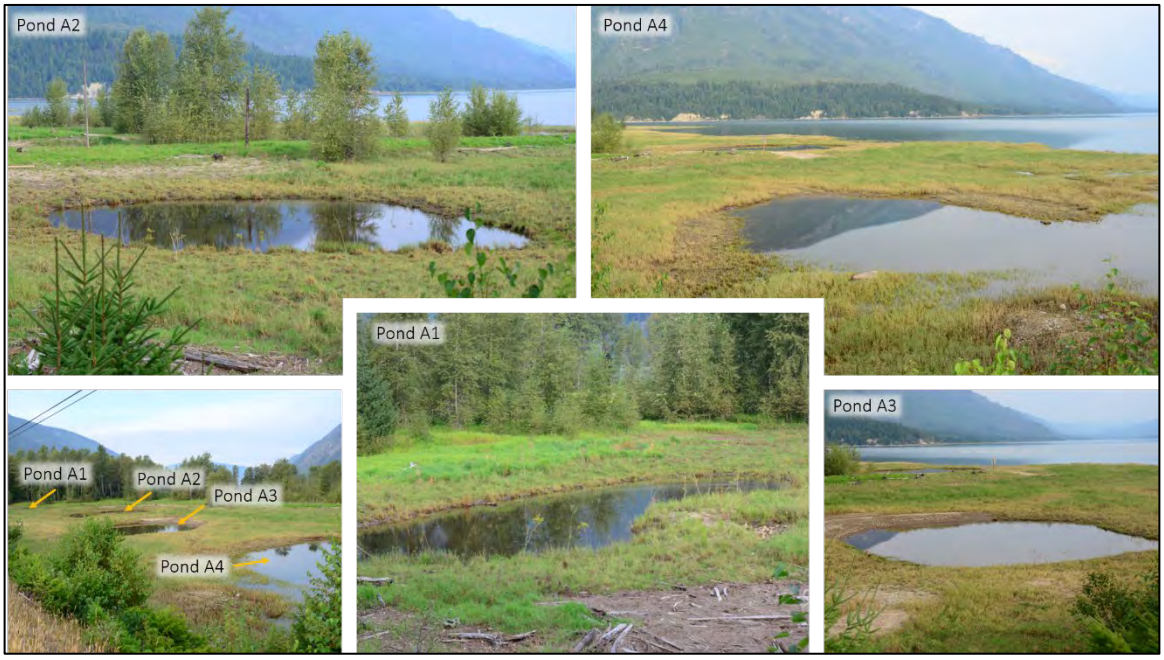


Figure 2-2. **Photographs of Ponds A1 through A4 taken 20 August 2020 showing the orientation and shape of each (Phase 1) constructed pond in the drawdown zone of Arrow Lakes Reservoir at Burton Flats.** Photos: G. Davidson.

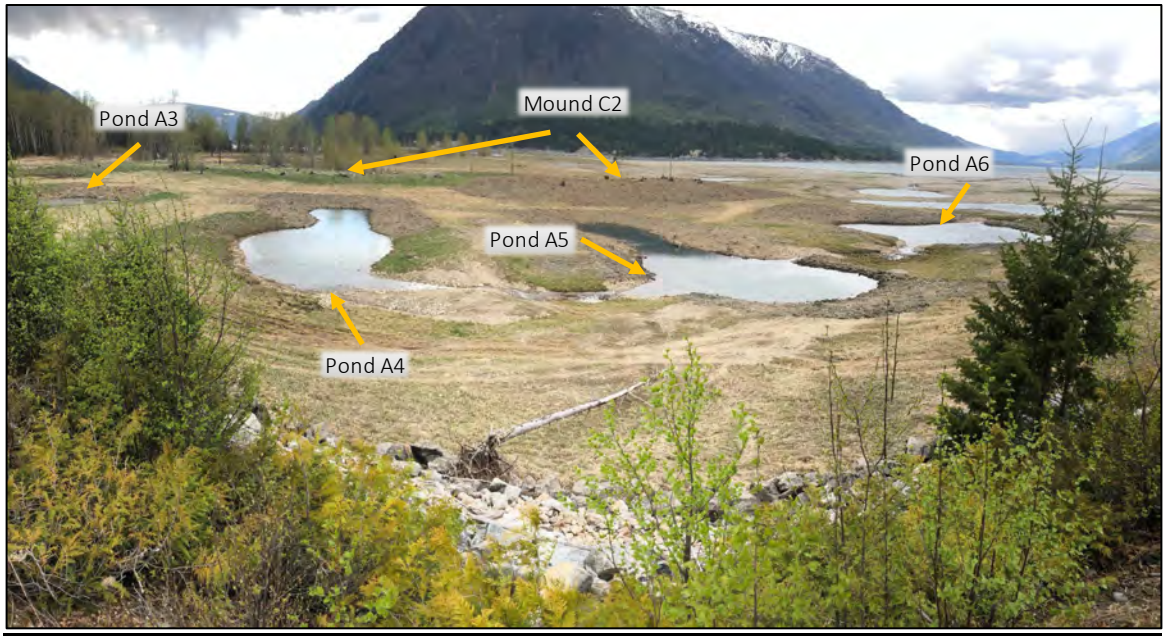


Figure 2-3. Lower ponds at Burton flats, proceeding from upper left with pond A3 (just visible at edge of the frame), the Phase 2 expansion of pond A4, and the two new Phase 2 ponds A5 and A6. Mound C2, including the newly constructed Phase 2 portion, is behind A4 and A5. The two Phase 2 deep-water ponds (D1 and D2) are visible at the far upper right. Ponds A1, A2, B1, and B2 are not visible in the frame. Photographed 22 April 2021 shortly after construction. Photo: M. Miller

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.

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 2-2) 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 2-2).

The spatial layout of the various planting prescriptions were 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).
3: Terrestrial Sedges (upper)	High elevation terrestrial prescription that can include species to encourage nesting. Variable density stocking with salvaged sedges (Kellogg's and Columbia sedge), and stakes of three species (black cottonwood, red-osier dogwood, Sitka willow) stocked to a density target. Restock microsites in future where survivorship is observed.
4: Terrestrial Sedges (lower)	Low elevation 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.
5: Terrestrial Mix (general)	These polygons span elevations and will be planted with PP3 or PP4, depending on site elevations.
6: Mound Mix	Moderate density and high diversity terrestrial vegetation mix (e.g., soopalallie, paper birch, white pine, hazelnut, 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.

Table 2-2. **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 will be 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 will be 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 will be 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 will be 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 will be 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 will be 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	3b: 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 will be 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 will be 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.

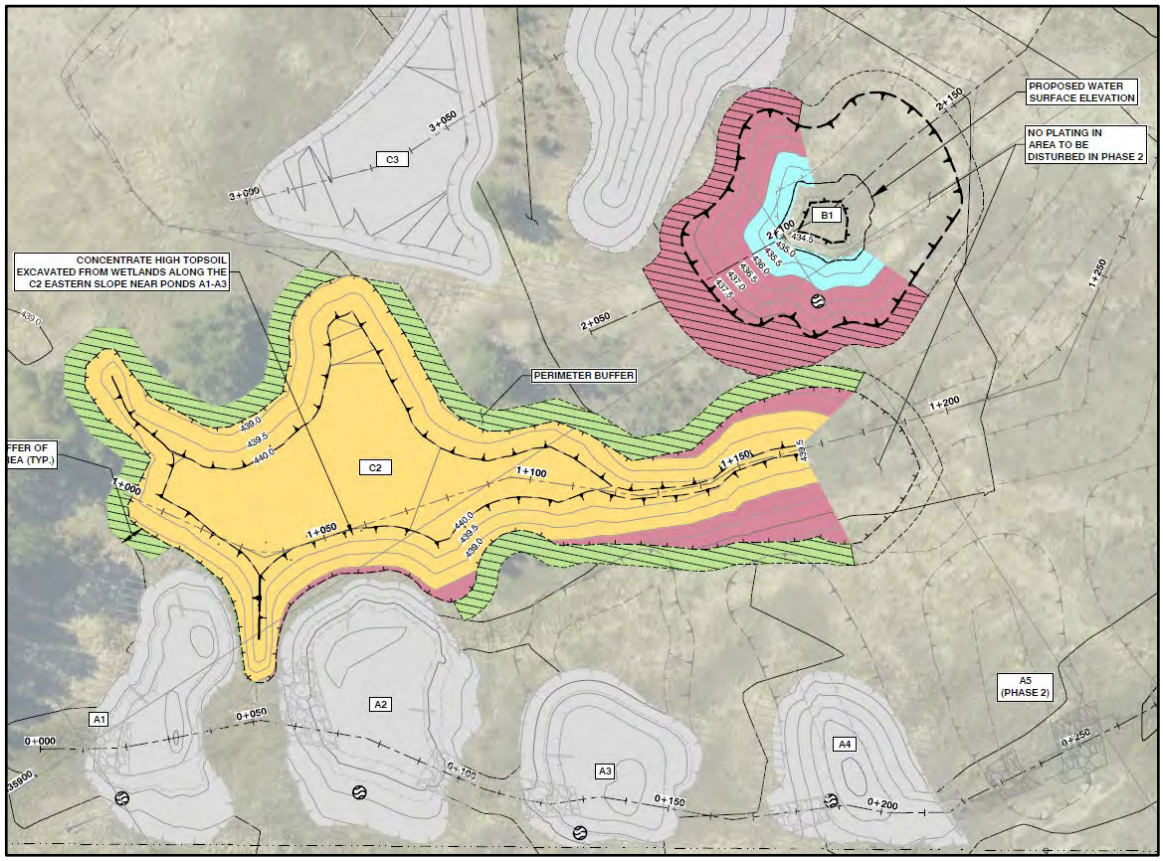
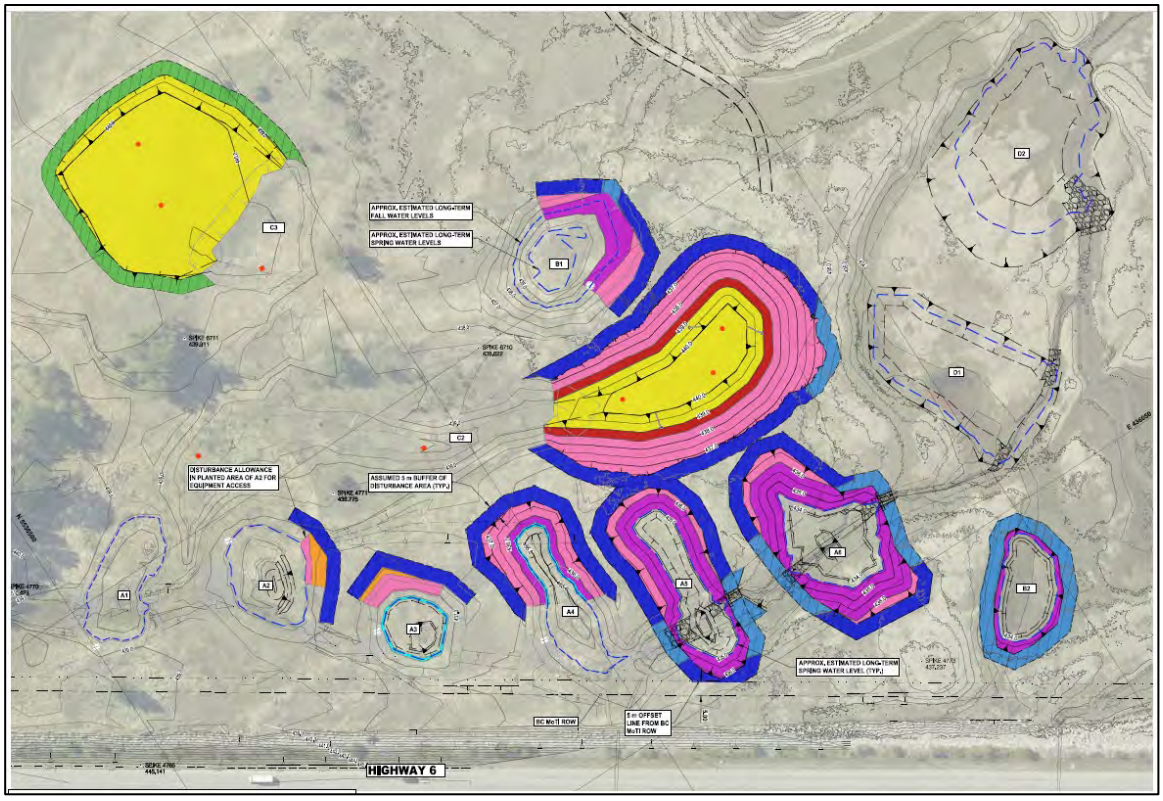


Figure 2-4. Sample schematic of planting prescription (PP) spatial layouts at Burton Flats. The colour-coded configurations for Pond B1 and Mound C2 are displayed. Turquoise = PP 4 (Terrestrial Sedges – lower), pink = PP 3 (Terrestrial Sedges – upper), green = PP 5 (Terrestrial Mix – general), yellow = 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 2021 to assess the performance of Phase 1 revegetation treatments in the second year following planting. Survey 1 took place on 19-25 May (after the Phase 2 spring planting work was completed and before summer reservoir inundation). Survey 2 occurred on 22-23 September, following summer inundation and reservoir recession.

3.1 Pre-inundation (Spring) Survey

Sets of permanent 5-m x 5-m (25 m^2) monitoring plots were established and sampled within different prescription areas (PPs) at each constructed feature (pond and mound; Figure 3-1). A total of 65 plots were established. Plot corners and centres were marked with pins (long nails) and the centre pin labeled using an aluminum tag. Sample sets at each feature ranged in size from *n*=2 to *n*=18, depending on the size and heterogeneity of the feature. The identity and percent covers of all species (both intentionally planted and naturally established) was recorded. The number of (apparent) live and (apparent) dead stems of each planted species was then recorded for each plot, along with 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.

Monitoring plots were established and sampled in both the Phase 1 and the recently-completed Phase 2 areas. This was done even though the latter areas were still in the process of being planted (fall planting of these treatments had not yet occurred). The primary objective of sampling within the Phase 2 areas in 2021 was to establish a set of baseline conditions for future evaluation and also to identify any notable within-year (May-Sept.) trends in survivorship. For this purpose, a subsample of the spring-sampled plots was re-enumerated in the fall, and the results compared between the two time periods.

3.2 Post-inundation (Fall) Survey

During the second survey, a subset of 28 plots from the 65 plots established in May 2021 was selected for a rapid resurvey. The rapid resurvey consisted of stem counts only; cover data were not recorded as many herbaceous species had already entered seasonal dormancy by the time of the second survey. 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 shorter 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 2020 summer inundation event and other factors, such as the extreme summer “heat dome” event of 2021.

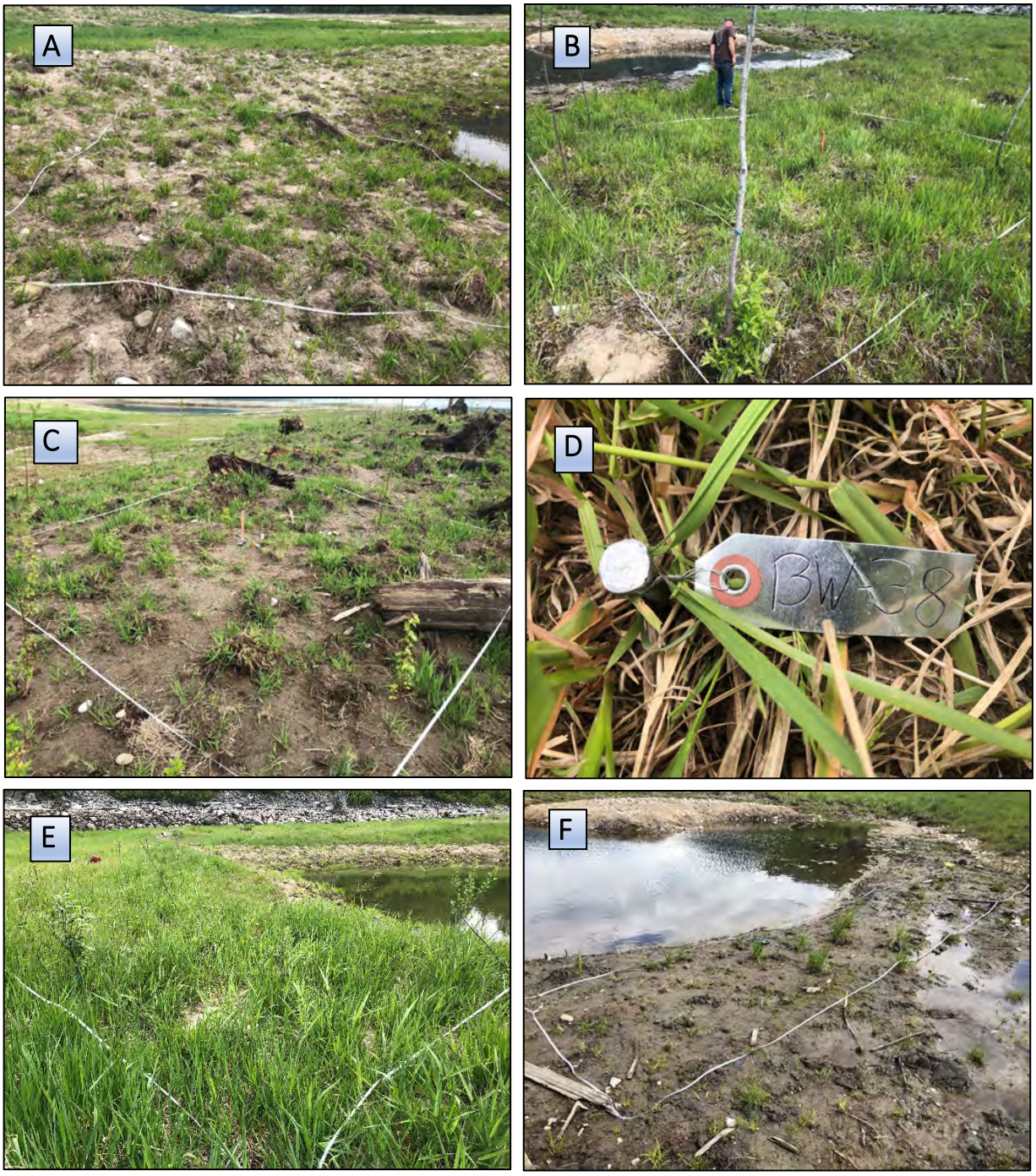


Figure 3-1. **Monitoring plots established in May 2021 for purposes of tracking status of plantings and overall vegetation percent cover.** A: pond A5 (Phase 2). B: pond A2 (Phase 1). C: mound C2 (Phase 2). D: plot centre label. E: pond A3 (Phase 1). pond A2 emergent zone (Phase 1). Photo: M. Miller.

4.0 Results

4.1 Revegetation performance

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

- *Salix sitchensis* (Sitka willow) (reflecting in part a nursery supply deficit in 2019)
- *Cornus stolonifera* (red-osier dogwood) (which experienced relatively poor establishment success overall)
- *Betula papyrifera* (paper birch) and *Spiraea douglasii* (hardhack) planted on mounds
- *Pinus monticola* (western white pine) planted at lower elevation
- *Rosa acicularis* (prickly rose)
- *Symphoricarpos albus* (snowberry)
- *Scirpus microcarpus* (small-flowered bulrush) (emergent prescription)
- *Shepherdia canadensis* (soopolallie)

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

- *Alnus incana* (mountain alder) (riparian prescription),
- *Amelanchier alnifolia* (saskatoon) (mound prescription)
- *Calamagrosits canadensis* (bluejoint) (emergent prescription)
- *Carex kelloggii* and *C. aperta* (Kellogg's and Columbia sedge) (various prescriptions)
- *Carex utriculata* (beaked sedge) (emergent prescription)
- *Corylus cornuta* (beaked hazelnut) (mound prescription)
- *Lonicera involucrata* (black twinberry)
- *Populus trichocarpa* (black cottonwood) (various prescriptions)
- *Salix bebbiana* (Bebb's willow) (various prescriptions)
- other non-prescribed willows, such as Pacific willow (*S. lucida*) and Mackenzie willow (*S. prolixa*) (various prescriptions)
- hardhack (riparian prescription)

Note that, although there appeared to be an absence of surviving bluejoint in certain treatments (e.g., PP6; Figure 4-1), 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 and September, 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 lower-elevation prescriptions (PP2, PP3) such as mountain alder, paper birch, black twinberry, Bebb's willow, and hardhack. For example, mountain alder stem counts declined by ~75% (Figure 4-2).

Table 4-1. Density of surviving plantings per m^2 (versus the prescribed target density in parenthesis) of each species at Phase 1 treatment sites in May 2021, 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 (Miller and Hawkes 2020).

Species	Planting Prescription (PP)						
	1 (*n*=5)	**2** (*n*=15)	**3a/5b** (*n*=3)	**3b/5c** (*n*=0)	**4/5a** (*n*=3)	**5** (*n*=0)	**6** (*n*=10)
Alnus incana (mountain alder)		0.04 (0.01)					0.004 (0.01)
Amelanchier alnifolia (saskatoon)							0.09 (0.03)
Betula papyrifera (paper birch)		0.006 (0.002)					0.02 (0.05)
Calamagrostis canadensis (bluejoint)	0.5 (0)	0.02 (0.2)	n/a (0.05)	n/a (0.05)		n/a (0.2)	n/a (0.1)
Carex aperta (Columbia sedge)**	0.1 (0)	0.12 (0.02)	0.13 (0.02)	n/a (0.02)	0.2 (0)	n/a (0.01)	n/a (0.01)
Carex kelloggii (Kellogg's sedge)**	0.44 (0)	0.38 (0.05)	0.16 (0.05)	n/a (0.05)	0.35 (0.05)	n/a (0.05)	n/a (0.01)
Carex utriculata (beaked sedge)*	0.58 (0.2)						
Carex aquatilis, C. rostrata, C. stipata (mixed water sedges)	? (0)						
Cornus stolonifera (red-osier dogwood)		0.006 (0.2)	0.01 (0)	n/a (0.1)			0 (0.05)
Corylus cornuta (beaked hazelnut)							0.03 (0.01)
Lonicera involucrata (black twinberry)		0.03 (0.01)					0.04 (0.02)
Pinus monticola (western white pine)		0 (0.002)					0.03 (0.01)
Populus trichocarpa (black cottonwood)***		0.03 (0)	0.07 (0.1)	n/a (0.1)		n/a (0.05)	0.004 (0.002)
Rosa acicularis (prickly rose)							0.004 (0.01)

Salix bebbiana (Bebb's willow)		0.02 (0)	0.01 (0)	n/a (0)			0.05 (0.05)
Salix sitchensis (Sitka willow)***		0.02 (0.2)	0.09 (0)	n/a (0.04)			0.01 (0.05)
Salix spp. (willows) bare root containers		0.02 (0)					0.01 (0)
Scirpus microcarpus (small-flowered bulrush)*	0 (0.2)						
Shepherdia canadensis (soopalallie)							0.01 (0.05)
Spiraea douglasii (hardhack)		0.09 (0.02)					0 (0.01)
Symphoricarpos albus (snowberry)		0.006 (0)					0.01 (0.03)

*Salvaged material
**Mix of nursery plugs and salvage material
***Mix of nursery containers and locally harvested stakes

Stem counts of several woody species also decreased markedly for the mound prescription (PP6). On the newly constructed (Phase 2) portion of mound C3, almost none of the plantings from the spring of 2021 appeared to have survived through the summer. Woody plantings on mound C2 generally performed better (Figure 4-3). Mountain alder, saskatoon, paper birch, red-osier dogwood, beaked hazelnut, black twinberry, and soopolallie were among those with relatively lower presence than in the second survey, while western white pine, certain willows, and hardhack showed less overall decline (Figure 4-2). Note that stem counts for a given species may have been lower in the fall due to various factors aside from attrition, such as a temporary stem diebacks, seasonal dormancy, or reduced detectability due to over-summer ingrowth of reed canarygrass. For example, willow plantings will commonly lose their stem foliage under stress, giving the appearance of having died, but then resprout later from the stem base. Reduced detectability may have been a factor in particular for the smaller-statured woody plantings such as saskatoon and soopolallie.

Despite the over-summer attrition due to heat and drought, many examples of vigorous shrub growth and flowering were noted in both surveys, both on riparian banks and on the elevated portions of mounds (Figure 4-4). 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. Some of this material appeared to have begun to spread vegetatively and also appeared to be providing habitat cover for amphibians and macroinvertebrates (Figure 4-5).

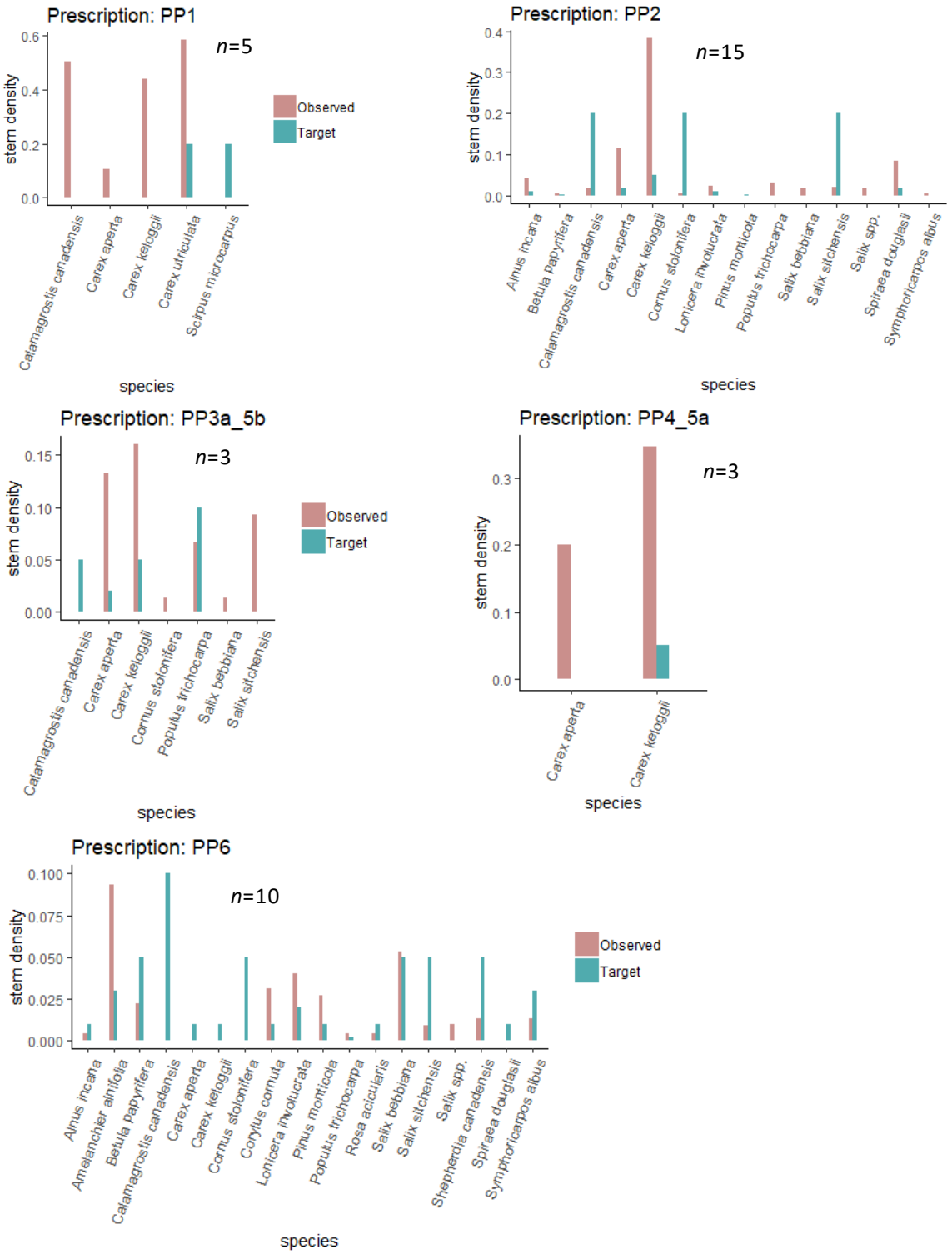


Figure 4-1. **Achieved stem densities (per 1-m²) as of May 2021 in Phase 1 treatment areas compared to prescribed target densities, by planting prescription.** Samples were taken prior to Phase 2

infill planting of the same features and hence may not be reflective of current conditions.

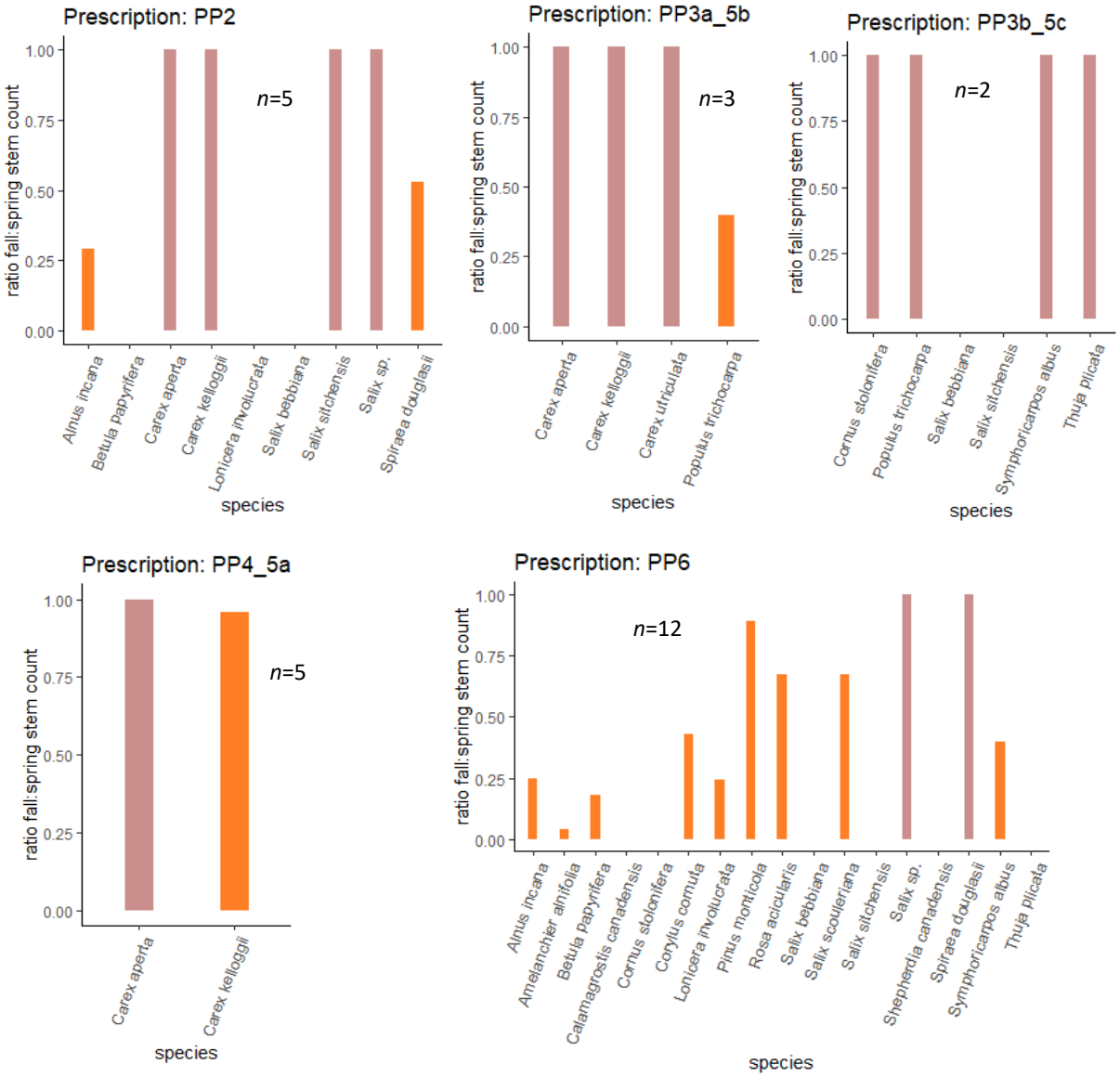


Figure 4-2. **Number of surviving planted stems counted in September 2021 compared to the number counted in May in the same sample plots, expressed as a proportion for each planting prescription.** Orange bars: ratios <1 (indicating counts declined between May and September).

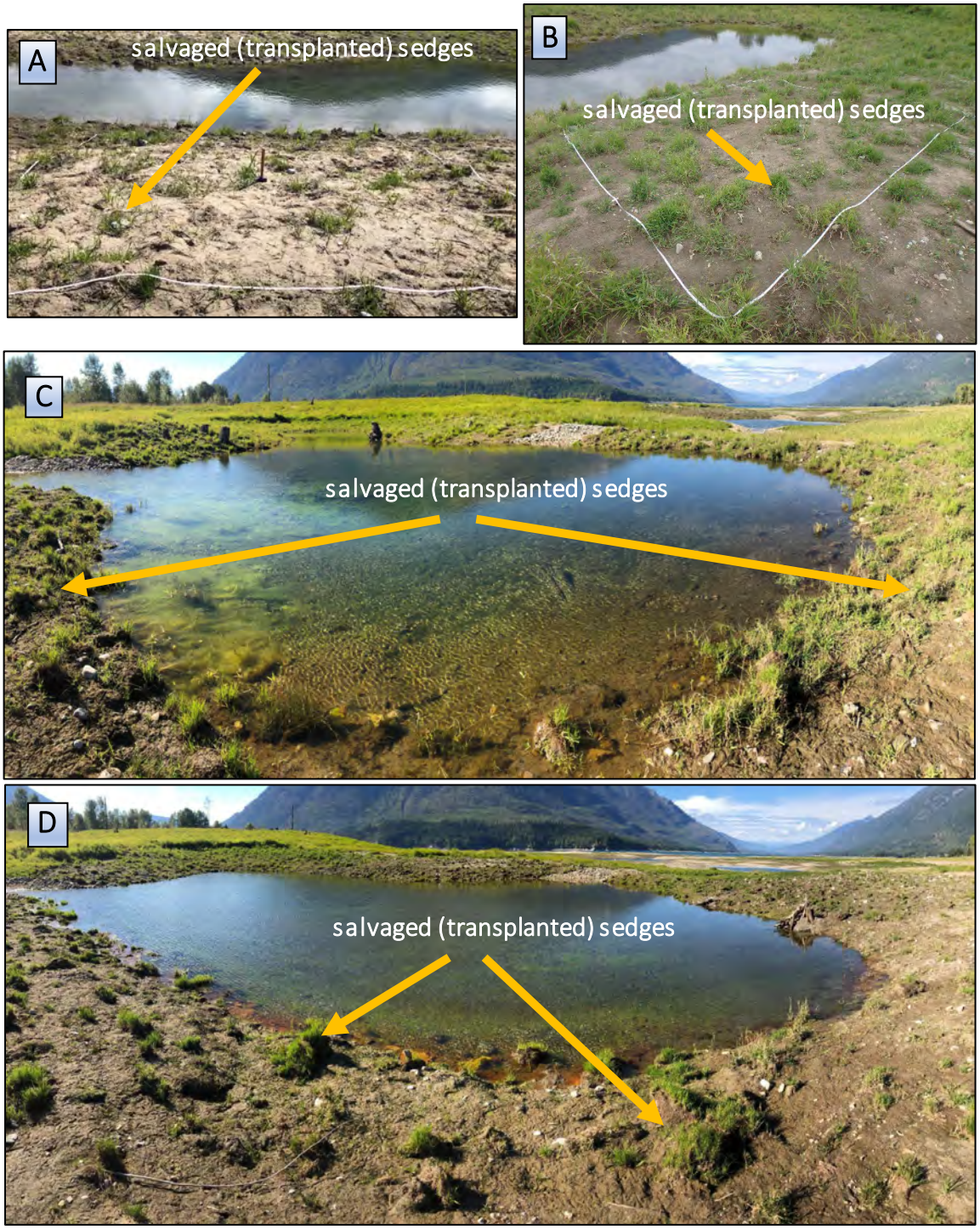


Figure 4-3. **Low elevation transplants of salvaged Kellogg's and Columbia sedge did not appear to be negatively affected by the 2021 summer inundation and "heat dome" events.** Photo (A) shows a monitoring plot at pond A5 in May 2021, shortly after it had been stocked. Photo (B) shows the same plot in September, five months later. C: Overview of pond A5 plantings in September. D: Overview of pond A6 plantings in September. Photos: M. Miller.

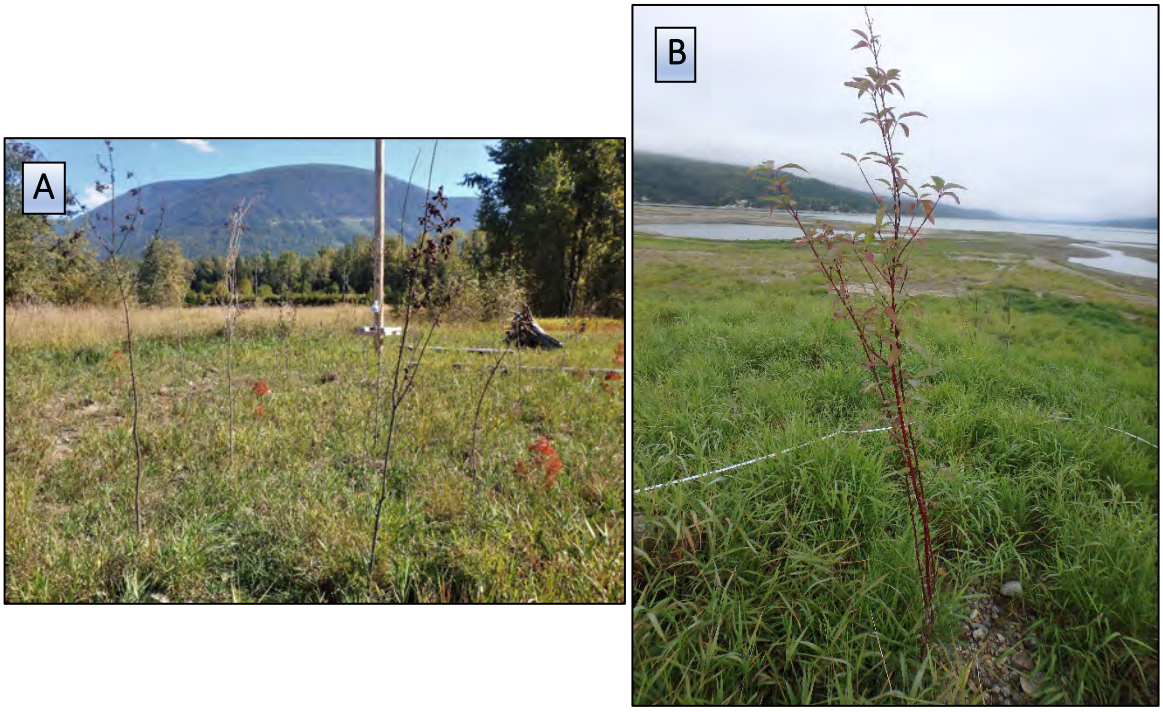


Figure 4-4. Examples of within-year (over-summer) planting attrition and survival. A: Failed willow and western white pine stems at mound C3 (the reddish needle clusters in the image are dead pine). B: Surviving red-osier dogwood at mound C2. Photographed September 2021. Photos: M. Miller.

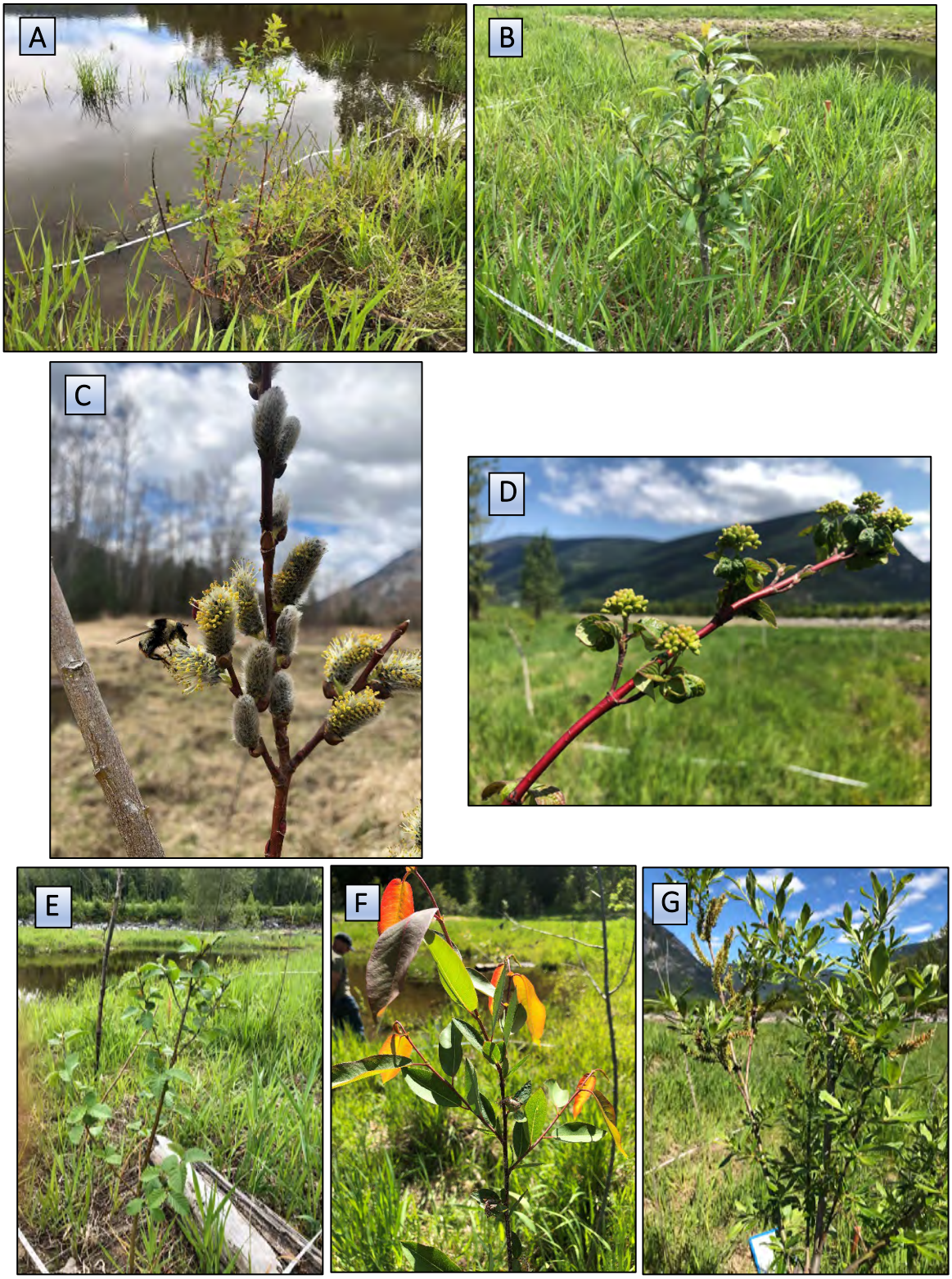


Figure 4-5. Examples of promising Phase 1 shrub growth, 1.5 years post-planting. A: hardhack. B: black cottonwood. C: bee mimic on flowering Bebb's willow catkin, early spring. D: blossoming red-osier dogwood. E: mountain alder. F: Mackenzie willow. G: maturing catkins on Bebb's willow. Photos: M. Miller.

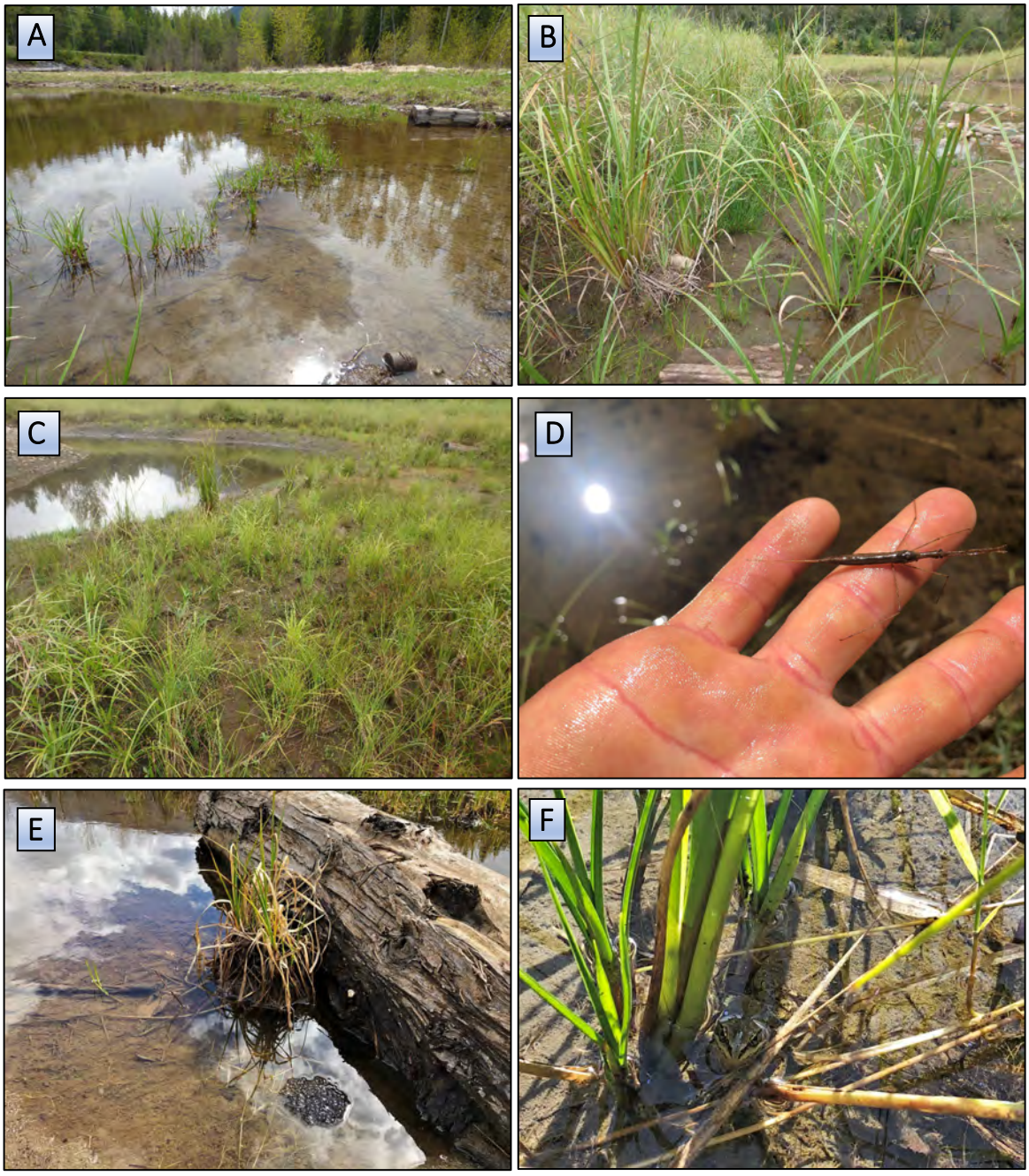


Figure 4-6. Emergent planted graminoids and associated wildlife at ponds A1 and A2. A-B: Beaked sedge. C: Mixed graminoids. D: Water stick (*Ranatra* sp.). E: Amphibian egg mass next to beaked sedge transplant. F: Columbia spotted frog in beaked sedge transplant. Photos: M. Miller.

4.2 Overall vegetation composition and cover

In total, over 70 different plant species were recorded in 2021 on the project site at Burton Flats (Appendix: Table 9-1, Figure 4-6, Figure 4-7, Figure 4-8), representing a striking change from the largely "bare earth" conditions that prevailed following completion of the Phase 1 wetland and mound construction in the fall of 2019 (Miller and Hawkes 2020c). Of these species, 47 were natural "regen" (as opposed to planted), of which another 23 were native species and 24 were

exotic. Not surprisingly, given the higher positions in the drawdown zone, the highest numbers of species were recorded on the mounds (C2=38, and C3=33) and at the two upper ponds (A1=31, A2=37) (Appendix: Table 2-1).

Notable volunteer woody species on mounds and banks included *Rubus parviflorus* (thimbleberry), *Rubus idaeus* (red raspberry), and *Populus trichocarpa* (black cottonwood) (Figure 4-6). Establishing on exposed mud flats of the upper ponds were various graminoids not observed at the site prior to physical works including *Eleocharis obtusa* (blunt spike-rush), *Juncus ensifolius* (dagger-leaf rush), and *Carex crawfordii* (Crawford's sedge). Notable aquatics colonizing the new ponds, and also apparently new to the site, included *Ranunculus gmelinii* (small yellow water-buttercup) and *Callitriche palustris* (spring water-starwort) (Figure 4-7).

Despite the relatively high species diversity that was present on the constructed features, plant canopy cover was overwhelmingly being contributed by just one species: *Phalaris arundinacea* (reed canarygrass or RCG). This non-native grass ranged from ~15-30% cover when covers were assessed in sample plots in May (Figure 4-6, Figure 4-7, Figure 4-8). However, by the second (September) survey, RCG had grown substantially denser and higher, with a canopy approaching 100% cover in many locations (Figure 4-11).

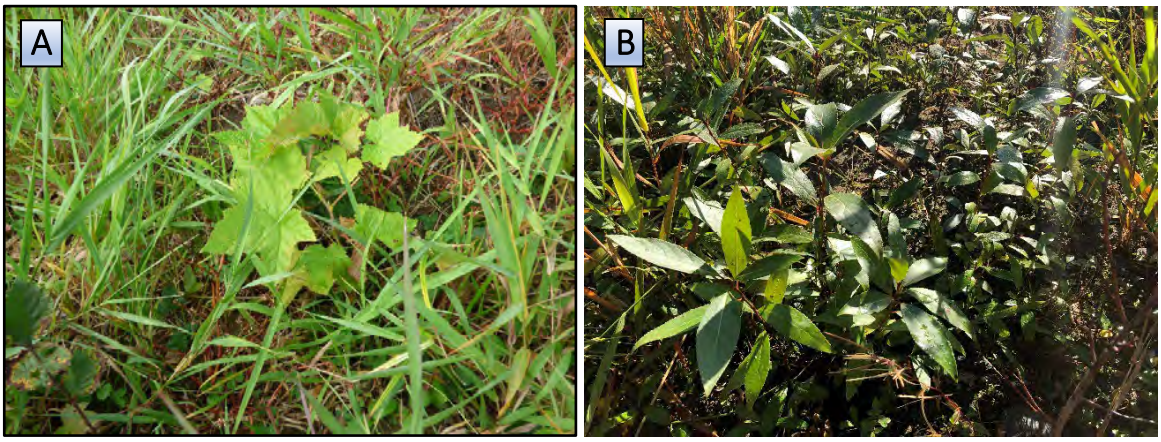


Figure 4-7. Volunteer woody establishment, mound C2. A: Thimbleberry (*Rubus parviflorus*). B: Black cottonwood. Photos: M. Miller.

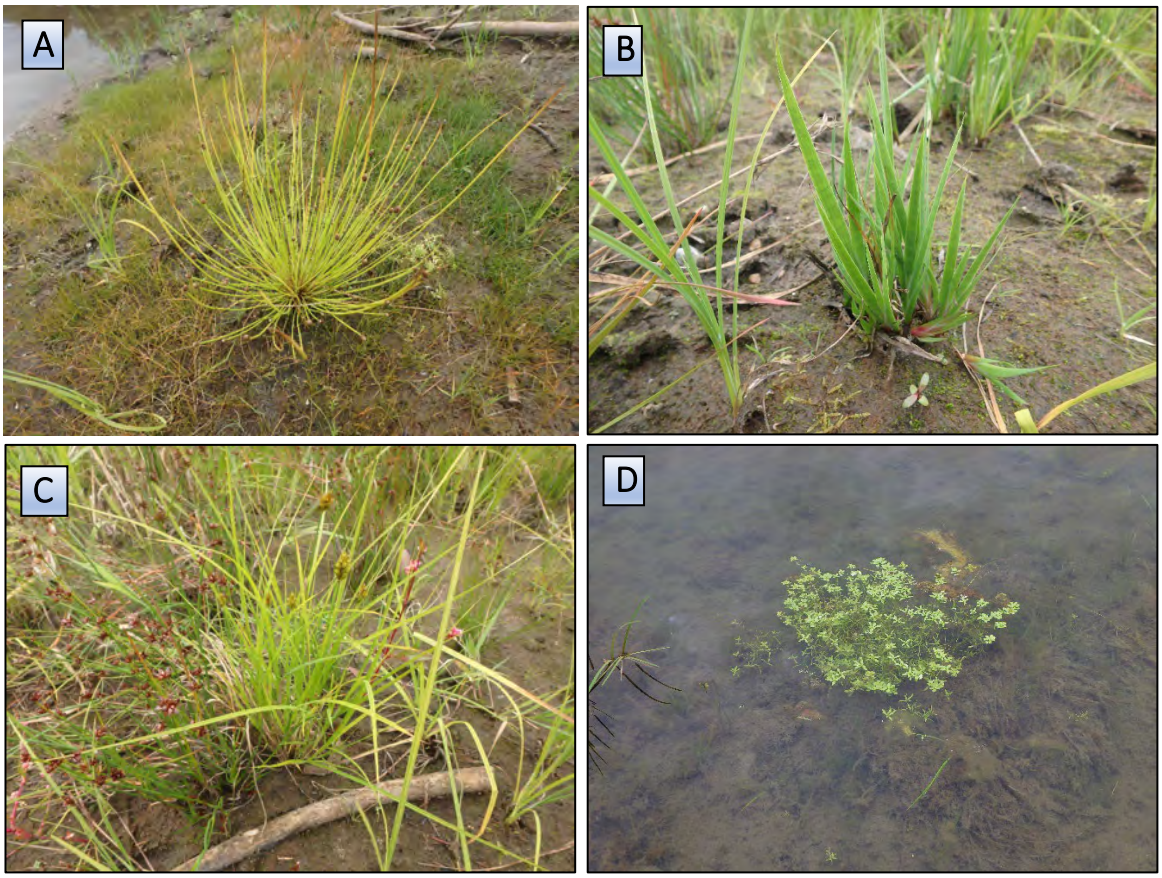


Figure 4-8. Volunteer colonizers of mud flats at ponds A1 and A2, and of aquatic habitat at pond A3. A: *Eleocharis obtusa* (blunt spike-rush). B: *Juncus ensifolius* (dagger-leaf rush). C: *Carex crawfordii* (Crawford's sedge). D: *Callitriche palustris* (spring water-starwort). Photos: M. Miller.

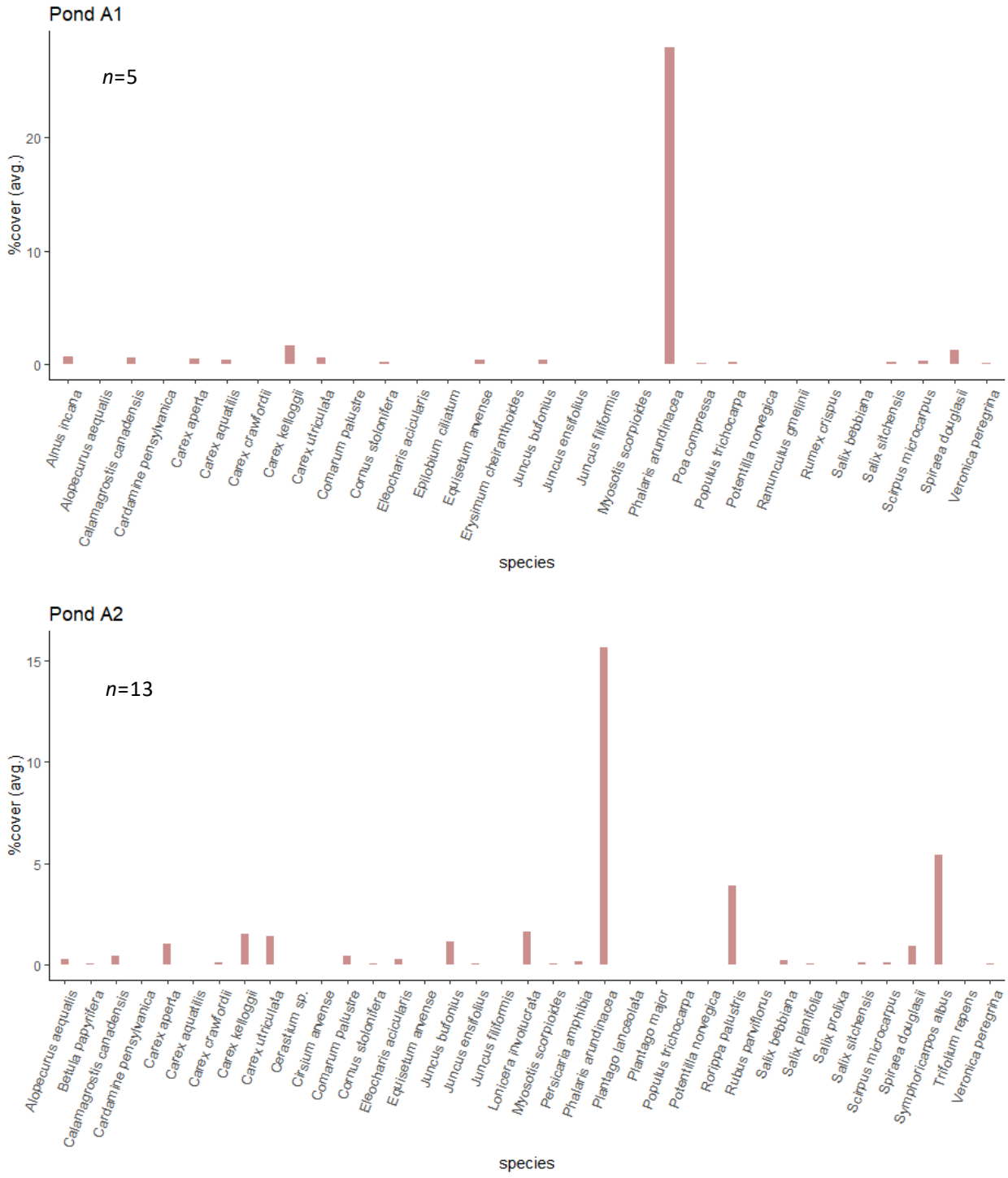


Figure 4-9. Average species covers recorded at Ponds A1 and A2 in May 2021.

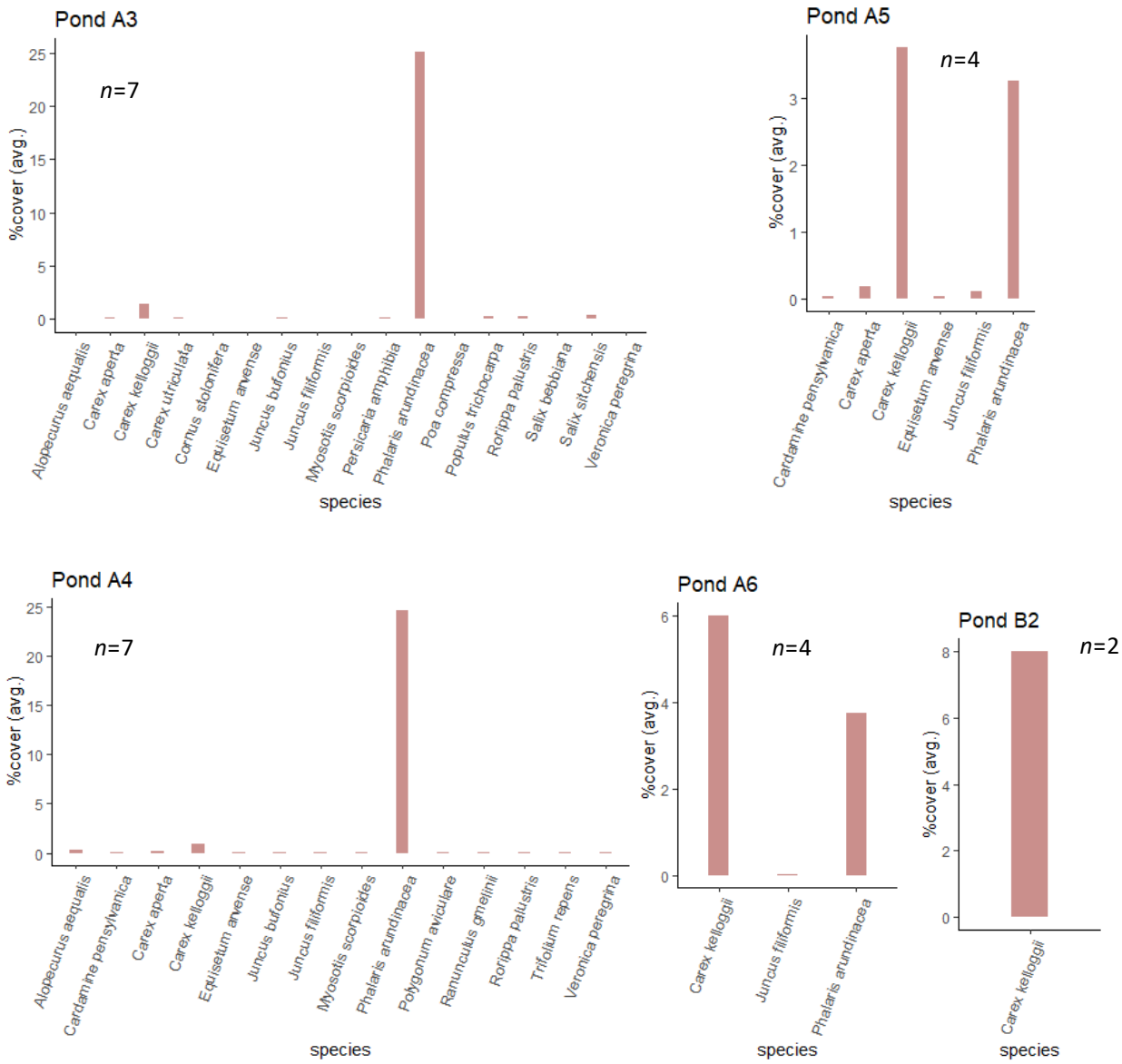


Figure 4-10. Average species covers recorded at ponds A3, A4, A5, A6, and B2 in May 2021. Species covers were not formally assessed at pond B1 in 2021.

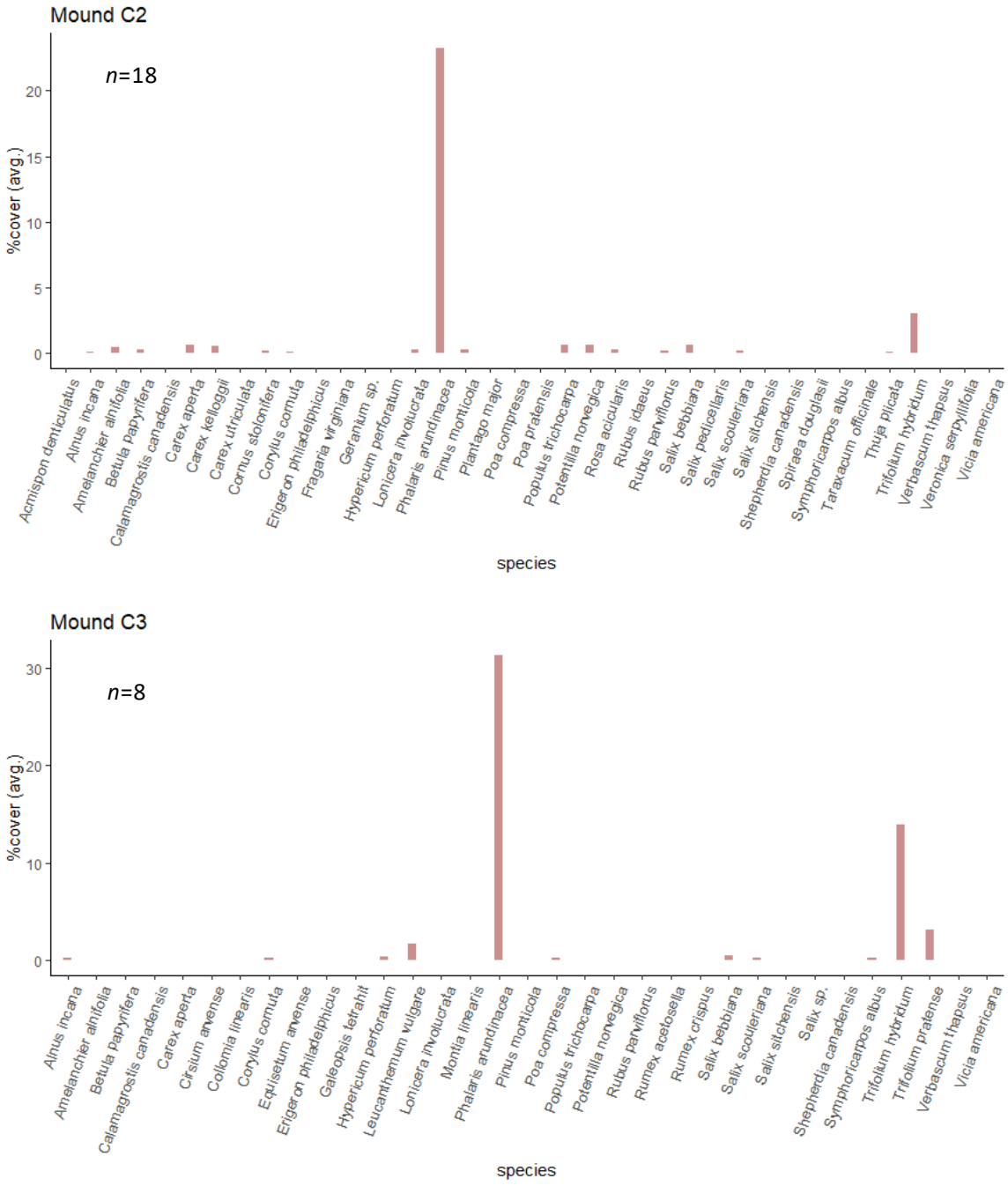


Figure 4-11. Average species covers recorded at Mounds C2 and C3 in May 2021.

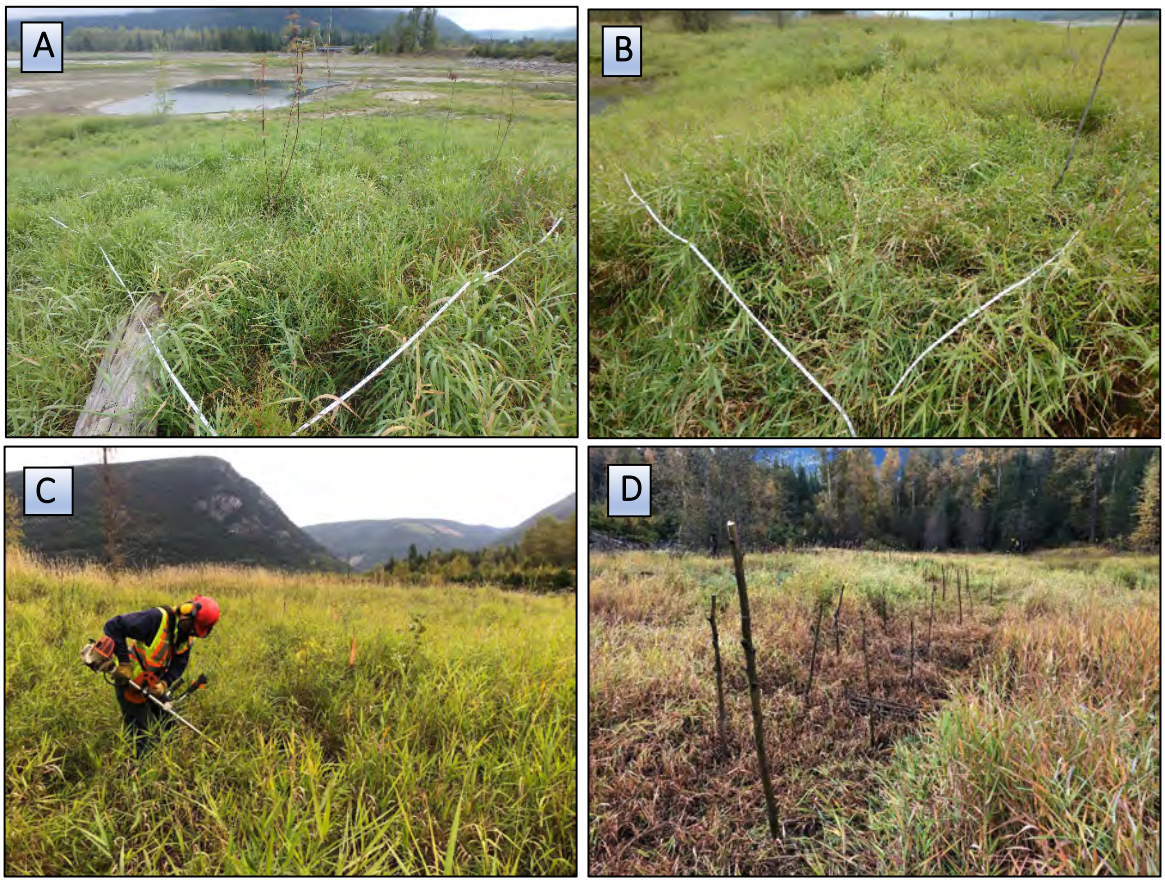


Figure 4-12. **Dense September ground cover of *Phalaris a rundincaea* (reed canarygrass).** A: Mound C2 monitoring plot. B: Pond A2 monitoring plot. C: Clearing openings in heavy RCG to facilitate fall planting. D: Newly-planted black cottonwood stakes in a cleared swath of RCG above pond A1. Photos: M. Miller.

5.0 Factors Limiting Vegetation Establishment

Between the time of their installation in the fall of 2019 and the May 2021 monitoring work, Phase 1 plantings had been exposed to one complete reservoir inundation cycle, allowing for some early conclusions to be drawn around reservoir impacts on establishment success. Some information on the short-term impacts of the 2021 summer inundation event (inundation cycle #2), which was relatively brief for most plantings and peaked at ~439.5 m in late June before subsiding in early July, was also obtained during the fall 2021 follow-up assessment.

Based on these early results, 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.

Amongst woody-stemmed plants, species such as red-osier dogwood, and paper birch appeared relatively more sensitive to 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, experienced substantial declines after one year with about half of stems exhibiting dieback. These results underscore the importance of attempting to initially stock species at densities higher than the final targets to allow for attrition over time.

Aside from anoxia (drowning), another inundation-associated factor that may be limiting establishment in some portions of the site is the deposition of 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 5-1). A similar impact was previously noted by Miller and Hawkes (2020d) with reference to the upper banks of mound C2 (Figure 5-1). However, so far most woody deposition appears to be concentrated within few relatively small catchment areas around the site. No significant woody debris depositions were observed in relation to the most recent (2021) inundation.

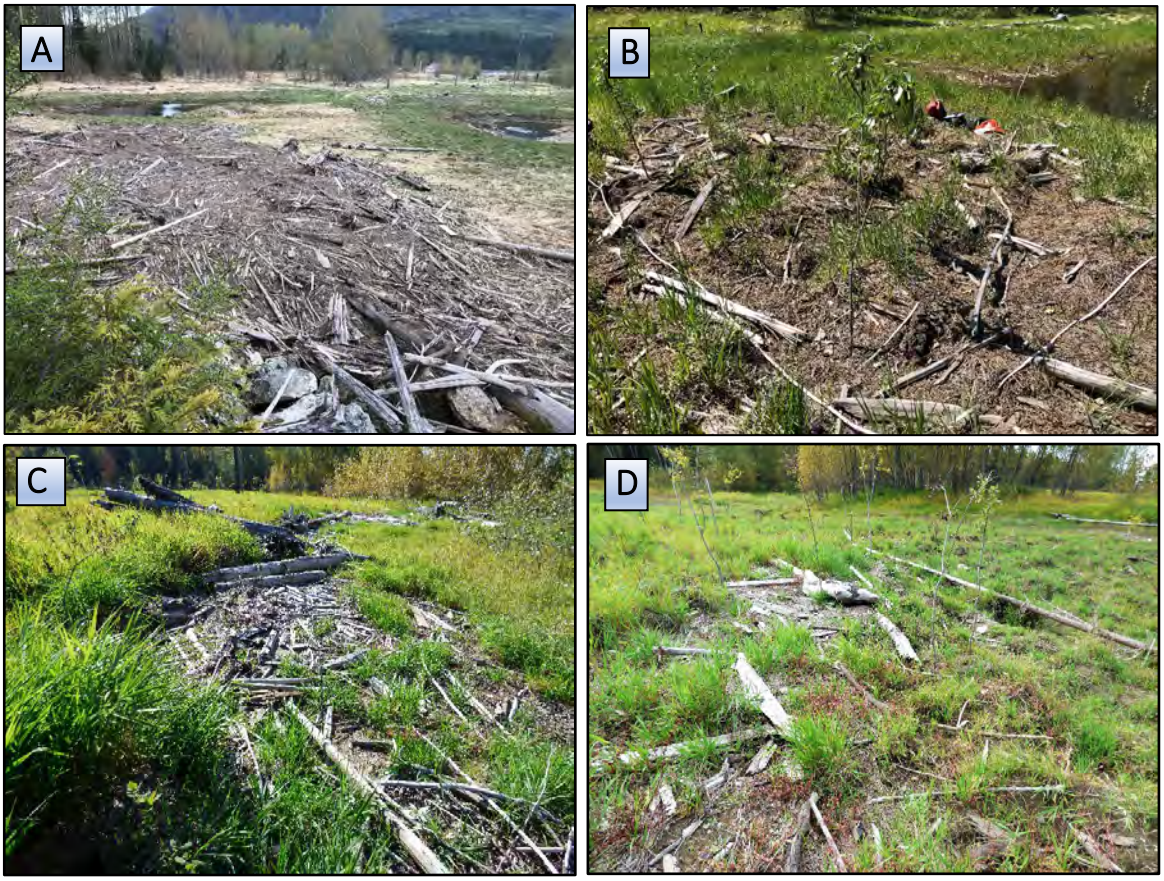


Figure 5-1. Woody debris depositions indicating the 2020 summer high-water mark. A: Debris above ponds A1 and A2. B: Black cottonwood plantings surrounded by debris in pond A1 monitoring plot. C: Debris deposition on the banks of mound C2. Some shrubs were knocked over or partially buried by this debris in 2020 (Miller and Hawkes 2020d). Photos: M. Miller.

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 2020b), do not so far appear to be major influences at the Burton Flats wetland.

With respect to non-reservoir impacts, the "heat dome" event in late June and early July of 2021, when temperatures reached unprecedented levels across British Columbia, [2] exerted a heavy toll on the spring plantings, particularly on the tops of the newly constructed mounds. Shrub plantings on mound C3 experienced particularly high mortality over the summer. This mound is situated further inland that mound C2 and is less exposed to breeze from Arrow Lake, which could result in higher summer heat loads and also higher desiccation rates. The underlying fill for the two mounds originated from different sources as well (for C3 the source was primarily the deep-water pond D2), potentially leading to a difference in the moisture-holding capacity. (Interestingly, lower-elevation prescriptions, which happened to be inundated by the reservoir during this period, were largely unaffected by the heat dome and associated drought). To make up for this unexpected summer attrition, the tops of mounds C2 and C3 (Phase 2 portions) were extensively re-treated during the fall planting session. Because this follow-up planting was completed in October after the CLBMON-12 surveys for 2021 had already taken place, an evaluation of its effectiveness will have to wait until the next CLBMON-12 implementation year (2023).

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. At Burton Flats, many of the original graminoid plugs as well as smaller-statured shrubs planted during Phase 1 are now being completely overtopped by late summer, suggesting that they are being, or eventually will be, excluded by this grass. Moving forward, a question of interest will be whether the strategy adopted in 2021 of restocking RCG-dominated areas with (primarily) taller shrub saplings will help promote the short-term survivorship of these plantings (Miller and Hawkes 2021). However, it seems likely that some follow-up weeding of RCG may be needed to ensure a reasonable rate of establishment in the most affected areas. On the other hand, it is unclear if merely reducing the above ground foliage via clipping can produce the intended competitive release given that much of the competitive interaction is likely to take place belowground, at the root level (Miller and Hawkes 2021).

6.0 Revegetation Effectiveness

After 1.5 years, revegetation prescriptions implemented under CLBWORKS-30B have effectively 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. In connection with this, introduced emergent plants are now providing habitat cover for pond-breeding amphibians and aquatic invertebrates. On slopes 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.

Based on early trends, it is apparent that substantial vegetation establishment would have occurred naturally on most of the newly constructed features even in the absence of any supplemental

[2] The average maximum daily temperature at Burton between June 28 and July 1 was 39.3°c, with a high of 41°c reached on June 30.

planting. 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 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 2022 (Year 3), 2023 (Year 4), and 2024 (Year 5), and will help to address these questions.

With Phase 2 physical works now completed, no further planting work is currently planned for the CLBWORKS-30B site at Burton Flats. Nevertheless, some supplementary weeding work has been recently scheduled for 2022 with the primary aim of reducing the cover/ingrowth of RCG cover from around the recently planted seedlings (T. Joyce, BC Hydro, pers. comm.). This thinning will be accomplished mechanically using hand clippers and a weed eater and will likely be limited to the most densely infested microsites. This previously unplanned treatment could provide an opportunity for added learning under CLMBON-12 during later (post-2022) implementation years.

7.0 Summary

Two revegetation effectiveness assessments were conducted at Burton Flats in 2021: one in May prior to summer inundation, and one in September following inundation. The spring survey found that surviving densities for most species planted in 2019 compared favourably to the target densities identified in the Phase 1 prescriptions. The fall survey revealed that stem counts of certain species (primarily woody-stemmed species) declined notably over the summer of 2021, possibly in response to the year's summer "heat dome" event and associated drought that appeared to kill off many shrubs and trees before they could become properly established. Both old (Phase 1) and new (Phase 2) plantings were also being subjected to heavy competitive pressure from reed canarygrass which had overgrown many of the smaller-statured plants. Reservoir inundation also produced moderate to high stem die-off in several woody species. Despite these limiting factors, revegetation prescriptions implemented under CLBWORKS-30B have effectively 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 (2022-2024) will assist in determining if the species and vegetation structure contributed by the planting continues to influence the successional trajectory of this site.

8.0 Literature Cited

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9.0 Appendix 1

Table 9-1. Complete vascular plant species list for plots sampled in 2021, 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	Naturally established	Native	Wetland feature									
			C2	C3	A1	A2	A3	A4	A5	A6	B1	B2
Acmispon denticulatus	X		X									
Alnus incana		X	X	X	X							
Alopecurus aequalis	X	X			X	X	X	X				
Amelanchier alnifolia		X	X	X								
Betula papyrifera		X	X	X		X						
Calamagrostis canadensis		X	X	X	X	X						
Cardamine pensylvanica	X	X			X	X		X	X			
Carex aperta		X	X	X	X	X	X	X	X		X	
Carex aquatilis		X			X	X						
Carex crawfordii	X	X			X	X						
Carex kelloggii		X	X		X	X	X	X	X	X	X	X
Carex utriculata		X	X		X	X	X				X	
Cerastium sp.	X					X						
Cirsium arvense	X			X		X						
Collomia linearis	X	X		X								
Comarum palustre	X	X			X	X						
Cornus stolonifera		X	X		X	X	X				X	
Corylus cornuta		X	X	X								
Eleocharis acicularis	X	X			X	X						
Eleocharis palustris	X				X							
Epilobium ciliatum	X	X			X							
Equisetum arvense	X	X		X	X	X	X	X	X			
Erigeron philadelphicus	X	X	X	X								
Erysimum cheiranthoides	X				X							
Fragaria virginiana	X	X	X									
Galeopsis tetrahit	X			X								
Geranium sp.	X		X									
Hypericum perforatum	X		X	X								
Juncus bufonius	X	X			X	X	X	X				
Juncus ensifolius	X	X			X	X						
Juncus filiformis	X	X			X	X	X	X	X	X		
Juncus alpinoarticulatus	X	X			X							

Leucanthemum vulgare	X			X								
Lonicera involucrata		X	X	X		X						
Montia linearis	X	X		X								
Myosotis scorpioides	X				X	X	X	X				
Persicaria amphibia	X	X				X	X					
Phalaris arundinacea	X		X	X	X	X	X	X	X	X	X	
Pinus monticola		X	X	X								
Plantago lanceolata	X					X						
Plantago major	X		X			X						
Poa compressa	X		X	X	X		X					
Poa pratensis	X	X	X									
Polygonum aviculare	X							X				
Populus trichocarpa		X	X	X	X	X	X				X	
Potentilla norvegica	X	X	X	X	X	X						
Ranunculus gmelinii	X	X			X			X				
Rorippa palustris	X	X				X	X	X				
Rosa acicularis		X	X									
Rubus idaeus	X	X	X									
Rubus parviflorus	X	X	X	X		X						
Rumex acetosella	X			X								
Rumex crispus	X			X	X							
Salix bebbiana		X	X	X	X	X	X				X	
Salix pedicellaris		X	X									
Salix planifolia		X				X						
Salix prolixa		X				X						
Salix scouleriana		X	X	X								
Salix sitchensis		X	X	X	X	X	X				X	
Salix sp.		X		X							X	
Scirpus microcarpus		X			X	X						
Shepherdia canadensis		X	X	X								
Spiraea douglasii		X	X		X	X						
Symphoricarpos albus		X	X	X		X						
Taraxacum officinale	X		X									
Thuja plicata		X	X									
Trifolium hybridum	X		X	X								
Trifolium pratense	X			X								
Trifolium repens	X					X		X				
Verbascum thapsus	X		X	X								
Veronica peregrina	X				X	X	X	X				
Veronica serpyllifolia	X		X									
Vicia americana	X		X	X								