Columbia River Project Water Use Plan

Arrow Lakes Reservoir Wildlife Management Plan

Arrow Lakes Reservoir Wildlife Enhancement Program – Physical Works

Implementation Year 2

Reference: CLBWORKS-30B (Phase 2)

CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program

Burton Flats Planting Project (Phase 2)

Study Period: 2021

LGL Limited environmental research associates
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Burton Flats Planting Project (Phase 1)




Final Report

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CELEBRATING 50 YEARS

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Cover photos

From left to right: Salvaging sedges from Pond A6 footprint, staging salvage material, planting salvaged sedges at Pond A5, planting cottonwood stakes. Photos © LGL Limited: Mike Miller.

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CLBWORKS-30B planting crew, 2021. Left to right: Dalton Godtmark, Stewart MacMillan, Isabelle Bergeron, Scott Harzan, and Melissa Zeleznik. Missing: Damond Ripper.

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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 (as per 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 development of wildlife physical works prescriptions for Arrow Lakes Reservoir was accomplished through an assessment of wildlife data collected for CLBMON-11B1 as well as an evaluation of where physical works projects could feasibly be implemented. In 2010, a meeting occurred with various stakeholders including BC Hydro, the Fish & Wildlife Compensation Program–Columbia Region, and the British Columbia Ministry of Environment to discuss several potential wildlife physical works projects, some of which (including Burton Flats) were identified for prescription development. The initial prescription for wetland construction at Burton Flats was provided by Hawkes and Howard (2012) as part of their follow-up study of wildlife physical works opportunities on the middle to lower Arrow Reservoir (*CLBWORKS-29B: Arrow Lakes Reservoir: Study of High-Value Wildlife Habitat for Potential Enhancement and Protection*).

That study simultaneously developed prescriptions for, and considered the merits of, two additional proposed physical works projects (at Lower Inonoaklin Road and Edgewood South), both of which, if implemented, had the potential to increase the amount of shallow wetland habitat available in the drawdown zone of mid- and lower Arrow Lakes Reservoir. Feasibility assessments for each site included an evaluation of topography, elevation, hydrology, substrate, disturbance potential, existing wildlife use, site ownership, and access (Hawkes and Howard 2012). In 2016, a further prioritization of these three locations was provided in an updated CLBWORKS-29B report (Hawkes and Tuttle 2016). The final prescription for Burton Flats was developed and formalized into the current project by BC Hydro, LGL Limited, and Kerr Wood Leidal Associates (KWL) in 2018 (KWL 2018).

Prior to construction (Figure 1-1), the project area at Burton Flats consisted of a shallowly undulating (nearly flat) expanse of annually inundated drawdown zone. The terrain supported sparse to dense graminoid cover (consisting primarily of non-native reed canarygrass intermixed with native sedges), interspersed with some small stands of black cottonwood on higher ground (Figure 1-2). The site is bounded to the east by Highway 6, to the south (above full pool) by a mixedwood forest, to the north by Burton Creek, and to the west by the reservoir. From the height of land at the northeast corner, the site slopes gently towards the creek and reservoir, with some old gravel borrow pits creating additional depressions at low elevations. An existing watercourse flows north along the site parallel to Highway 6, fed by shallow subsurface flow from Burton Creek. In the upper part of the reservoir drawdown zone, this drainage supported a shallow wetland/wet meadow dominated by emergent grasses and sedges (e.g., bluejoint reedgrass [*Calamagrostis canadensis*], small-flowered bulrush [*Scirpus microcarpus*], and beaked sedge [*Carex utriculata*]) with a minor component of wetland forbs (e.g., marsh cinquefoil [*Comarum palustre*]; Figure 1-2).

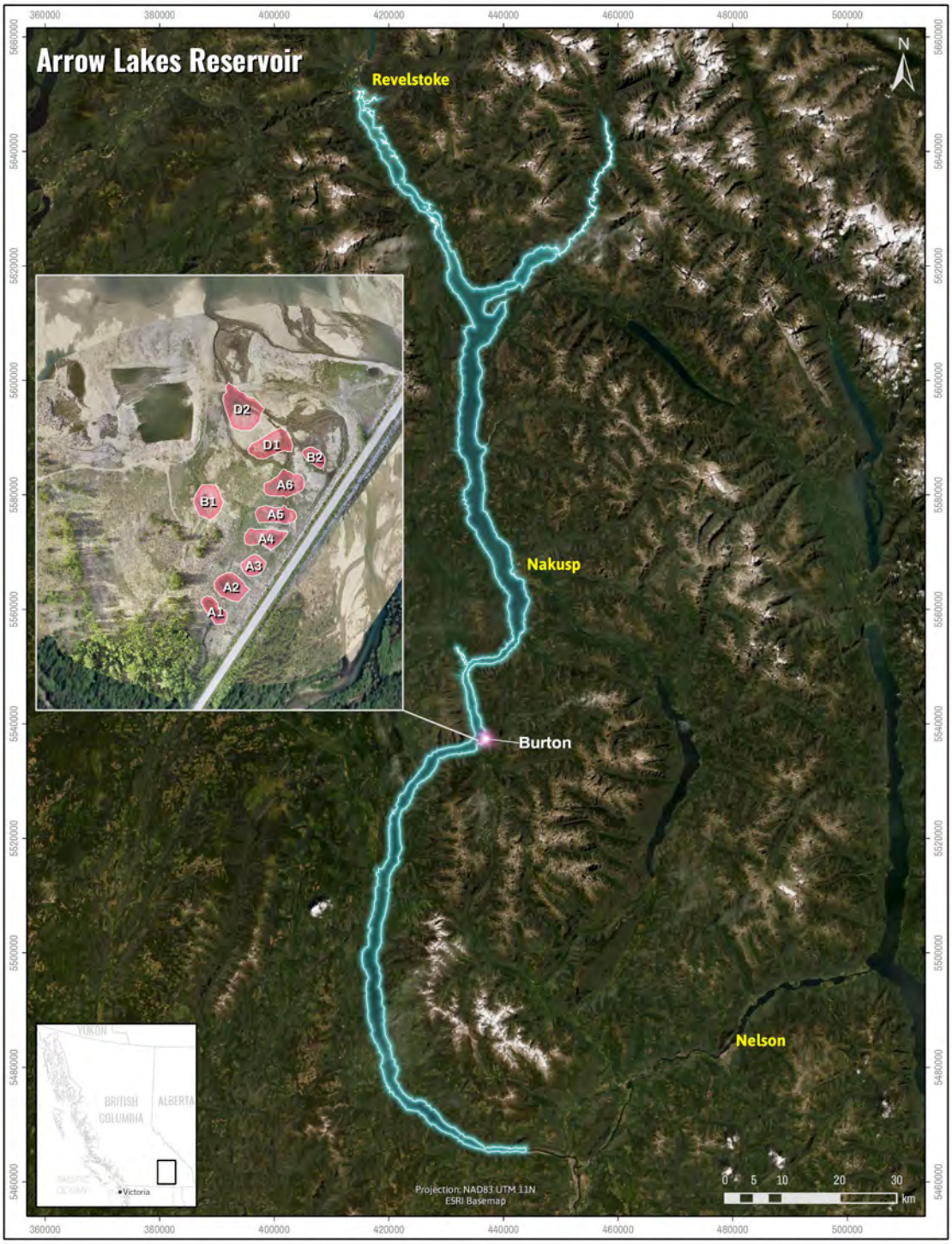


Figure 1-1. Burton Wetland Enhancement Project Location, Arrow Lakes Reservoir (KWL 2021). Inset shows the spatial orientation of constructed pond features. Phase 1 constructions: A1, A2, A3, A4, B1. Phase 2 constructions: A2 (deepening), A3 (deepening), A4 (expansion), A5, A6, B2.

Figure 1-2. Burton Flats project site (pre-enhancement). Clockwise from top: northern portion of site, looking northeast towards highway and Burton Creek bridge; existing shallow wetland (future pond A1/A2 feature) at southeast corner of site; overview of site during initial stripping; representatives of BC Hydro, KWL, and Landmark Solutions inspecting the site of a planned low-elevation pond along existing stream course. Photos: M. Miller.

Sedge plug, fertilization, and cottonwood planting trials were undertaken between 2008 and 2011 in areas adjacent to the project footprint by BC Hydro under CLBWORKS-2, and the success of these treatments was monitored under CLBMON-12 (*Arrow Lakes Reservoir Monitoring of Revegetation Effectiveness and Vegetation Composition Analysis*). This prior revegetation effort produced slightly higher sedge covers for the area but resulted in minimal increases in shrub cover (Keefer Ecological Services 2010, Miller *et al.* 2018b).

The specific aim of the CLBWORKS-30B project was 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 pools between elevations 434 masl (metres above sea level) and 438.1 masl and enhancing riparian and wetland vegetation on the banks of the pond features via a planting program. The wetland design includes shallow and deep pool configurations as well as pools 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 habitat at higher elevations (>438 masl) are also incorporated into the design for continued learning about habitat enhancement within, and adjacent to, the drawdown zone (KWL 2018).

(2020a). Phase 2, involving the expansion of some Phase 1 ponds along with the construction of additional pond and mound features, and planting of those features, occurred in 2021 (KWL 2021). The Phase 2 planting program is the subject of this report.

2.0 Revegetation goals and approach[1]

The goal of the planting program was 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). Specific objectives included augmenting the existing (naturally occurring) emergent vegetation community at high elevation ponds and establishing a riparian habitat consisting of graminoids, shrubs, and trees along the wetland edges and on top of constructed mounds. At the same time, 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.

Key features of the planting program were as follows:

1. Site-specific revegetation prescriptions were developed for each constructed feature (ponds and mounds) and for the various elevation zones spanned by each feature. A total of six different planting prescriptions (PPs) were developed to reflect the differing site priorities and elevational requirements.
2. The program 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.
3. 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.
4. 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.
5. 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.
6. 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 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). 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

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

corresponding goals for revegetation, are briefly summarized below. A more detailed description of the planting prescriptions for different features and elevations appears in Section 2.2.3.

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

- A1, A2, A3, A4, A5, and A6 (Figure 1-1) 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 (Figure 1-1), 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 (Figure 1-1) 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 purpose of these ponds is to increase waterfowl habitat.
- Due to their low position in the drawdown zone (the bottom elevation of D1 is ~432.8 masl, that of D2 is ~431.4 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 revegetation plan prioritized the establishment of native species with high wildlife habitat value in and around the wetlands. The planting composition was also designed to support development of a vegetation community that approaches, in richness and complexity, what might establish along a natural (unregulated) riparian course at this location. At the same time, it was recognized that because the drawdown zone is a highly modified habitat with an unnatural

hydroperiod, such an ideal community state is unlikely to be achieved and a more realistic expectation is for the eventual development of a less complex, and more specialized, reservoir-adapted community. The nearest unregulated riparian area (and a potential basis for comparison) is the riparian zone of Burton Creek upstream of the reservoir full pool elevation (east of the highway bridge). However, a more realistic, intermediate reference point may be that provided by the riparian community that has established over decades around the margins of Cartier Bay, a reservoir-affected wetland located ~100 km to the north in Revelstoke Reach.

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; and
5. the suitability of conditions for transplanted species at each microsite.

2.2.1 Valued plants for wildlife

During revegetation, attention was paid to the types of plants that would be of most benefit to wildlife, in particular to shrub species most likely to be utilized by nesting birds. Baseline bird use of the Burton Flats area had been previously assessed in 2018 as part of CLBMON-11B1 (Hentze *et al.* 2019). Six songbird species were recorded in the wildlife physical works area at Burton Flats: American Robin, Common Yellowthroat, Dusky Flycatcher, Lazuli Bunting, Rufous Hummingbird, and Yellow Warbler. Both the Common Yellowthroat and Yellow Warbler are marsh and riparian species. However, evidence of local nesting was low with only four nests of an unknown species observed. The current lack of shrub and tree species at Burton Flats may be contributing to the low density of nests observed in the drawdown zone here.

Based on results of previous nesting research conducted as part of CLBMON-36 in Revelstoke Reach (Craig *et al.* 2018), species prioritized for planting at Burton Flats included *Alnus incana* (mountain alder), *Spiraea douglasii* (hardhack), *Betula papyrifera* (paper birch), *Thuja plicata* (western redcedar), *Cornus sericea* (red-osier dogwood), *Corylus cornuta* (beaked hazelnut), *Pinus monticola* (western white pine), *Rosa acicularis* (prickly rose), *Symphoricarpos albus* (snowberry), *Lonicera involucrata* (black twinberry), *Populus trichocarpa* (black cottonwood), and *Salix* (willow). Hardhack and mountain alder are not widely distributed in the drawdown zone and likely have relatively low tolerance to inundation; however, where they persist they are favoured for nesting by a wide variety of species including Common Yellowthroat, Song Sparrow, Chipping Sparrow, Willow Flycatcher, Alder Flycatcher, Cedar Waxwing and Yellow Warbler. On the other hand, willow (primarily *Salix sitchensis* but including other *Salix* spp.) is relatively tolerant of inundation and is widely used by the same species recorded using alder (Craig *et al.* 2018).

2.2.2 Nest flooding

Within a reservoir, the ecological benefit of revegetating the drawdown zone as nesting habitat is reduced by the risk of nests flooding due to reservoir operations. Low elevation habitats have higher flooding risk and so the net benefit to birds is maximal at high elevations. Based on experience and findings from the CLBMON-36 monitoring program, it was determined that creating high quality nesting habitat should only be attempted at elevations greater than 438.5 masl (1.5 m below the full pool elevation; see also Hawkes and Tuttle 2016). It is recognized that this is an

estimate, and in truth the reality depends on species, plant morphology, and annual variability in reservoir operations. Below this elevation, the focus should be on establishing vegetation communities that are not commonly associated with high nests densities in the reservoir (e.g., Kellogg's sedge). Observations suggest that black cottonwood can also be used safely below 438.5 masl as this species does not typically provide suitable nesting habitat within 1.5 m of the ground.

2.2.3 Plant tolerance for inundation

The operation of Arrow Lakes Reservoir has created vegetation bands stratified by elevation, reflecting differing tolerance for inundation among plant species. The distribution of these vegetation communities is also affected by other factors including substrate type and morphology, hydrology, and influence of reservoir operations on seed germination and establishment (Miller *et al.* 2018a). The complex interaction between local site conditions, reservoir operations, and plant habitat preferences create some uncertainty around the local responses of particular plant species and the outcome of revegetation efforts. For example, previous work in Arrow Lakes and Kinbasket Reservoirs (Hawkes and Gibeau 2017, Hawkes *et al.* 2018, Miller *et al.* 2018a, Miller and Hawkes 2019) indicates that two terrestrial sedge species, Kellogg's sedge and Columbia sedge, both of which naturally occur in the drawdown zone, are amenable to transplantation and are also relatively tolerant of fluctuating water levels—as long as the site is topographically sheltered and the substrate is stable (not subject to frequent erosion), not overly coarse or fine, contains sufficient nutrients, and remains appropriately saturated through the growing season. Not surprisingly, given these requirements, field observations of revegetated areas indicate that the success of individual plantings has been highly variable: some areas have seen good establishment from seedling plugs, while others have failed completely (Hawkes *et al.* 2018).

Similarly, work has shown that willows and black cottonwood are relatively inundation-tolerant (compared to other woody species), but that instances of successful establishment decline sharply with decreasing elevation in the drawdown zone (and, by extension, with increased depth and duration of inundation). These species also have low drought tolerance and require saturated or periodically inundated soils. Thus, their utility for revegetation is generally restricted to upper portions of the drawdown zone on sites with a shallow water table and/or moisture-retaining substrates (Hawkes *et al.* 2018).

The approach taken in this project was that initial stocking effort should: (1) be experimental; and (2) reflect confidence in success, with higher stocking densities applied in high-confidence settings. Given their demonstrated tolerances for inundation, sedges, willows, and black cottonwood were emphasized in the Phase 1 and Phase 2 planting prescriptions for lower elevations. Wetland sedges and grasses already thriving at site (e.g., small-flowered bulrush, beaked sedge, bluejoint reedgrass) have the capacity to spread and populate the enhanced pond margins that will be created. Stocking of these species was done using locally salvaged plants and distributed evenly throughout new shorelines. In other instances, a lower stocking effort was used to experimentally learn where different riparian and upland species can be successfully planted. By testing inundation and substrate tolerances for a wide diversity of species and monitoring interim survival during Phase 1 (Miller and Hawkes 2020), the project was positioned to undertake strategic restocking of successful species at specific sites and elevations under an updated planting plan in Phase 2 (LGL Limited 2020).

2.2.4 Invasive weeds

The existing reservoir drawdown zone plant communities are a combination of native and non-native species arrayed by habitat preferences and by competitive tolerances. On many open terrestrial substrates, reed canarygrass (*Phalaris arundinaceae*, henceforth RCG) is a dominant invasive species where it out-competes most other herbaceous plants, and likely suppresses establishment of many other species. Much of the planting for this project occurred in fresh overturned topsoil, in theory providing woody shrubs a chance to become established prior to RCG reinvasion. The eventual development of an overhead canopy will, it is expected, reduce the competitive edge of RCG and allow other herbaceous species to become established. Aside from promoting a canopy of native shrubs and trees, no further effort is being made to control invasive plant species via stocking; however, the Environmental Management Plan for the project had explicit control measures to prevent the spread of noxious weeds (e.g., ensuring that all machinery is cleaned of dirt, debris, and plant parts; minimizing ground disturbance; and reseeding with an appropriate native seed mix following disturbance).

2.2.5 Planting prescriptions

The existing wetland/watercourse at the site supports emergent sedges and mountain alder. Above full pool, the wetland is shaded by forest canopy. The drawdown zone has limited potential to be shaded by a forest canopy even after habitat enhancement. A preferred vegetation community—one that extends the naturally existing wetland into a non-shaded opening—is a ponded complex supporting emergent and terrestrial sedges; shrubs such as hardhack and mountain alder; and nearby conifers and birch growing sporadically on hummocks, with occasional dead conifers (e.g., western redcedar, western white pine) acting as coarse woody debris. This describes the basic vision for the upper elevation riparian zones (Ponds A1-A2 and associated matrix habitat/banks).

The two mound features (C2 and C3) present a novel situation for revegetation attempts in Arrow Lakes Reservoir and pose a specific set of challenges. Over the course of a growing season, these microsites will alternate between being well-drained and hot, versus heavily saturated, due to the highly variable water table controlled by the reservoir. The approach here was to experiment with a diversity of upland species; especially those which can potentially tolerated drought and periodically raised water tables. The revegetation aim was to establish a diverse and dense multi-storied vegetation community, but the target species assemblage was not strictly defined.

At lower elevations (those <~438.5 masl), species that are conducive to bird nesting near the ground (e.g., most shrubs other than cottonwood) were avoided. The focus at these elevations was on establishing an initial ground cover of sedges.

A total of six different planting prescriptions (PPs) were developed to reflect these differing site priorities and elevational requirements (Table 2-1): (1) Emergent Sedges; (2) Riparian; (3) Terrestrial Sedges (upper) including two variants (3a, 3b); (4) Terrestrial Sedges (lower); (5) Terrestrial Mix (general), including three variants (5a, 5b, 5c); and (6) Mound Mix. The development of these prescriptions was informed by results coming out CLBMON-12 and CLBMON-33 as summarized in the CLBMON-35 Prescription Catalogue for Arrow Lakes Reservoir (Hawkes *et al.* 2018, Miller and Hawkes 2020).

A second, detailed table (Table 2-2) specifies how, and in what combinations, the prescriptions were to be applied at each of the constructed Phase 2 features. For example, Pond A3 was prescribed to receive a combination of infill planting plus new applications of PPs 1 and 3; the newly added section of Mound C3 was prescribed to receive a combination of PPs 3, 5, and 6 (Table 2-2).

The spatial and elevational distributions of the various Phase 2 planting prescriptions are shown in Figure 2-1. Target stem densities for species in each PP were similar to those for Phase 1 (Miller and Hawkes 2020) and are shown in Table 2-3.

Table 2-1. Overview of Phase 1 and Phase 2 planting prescriptions applied to constructed ponds and mounds at Burton Flats.

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.

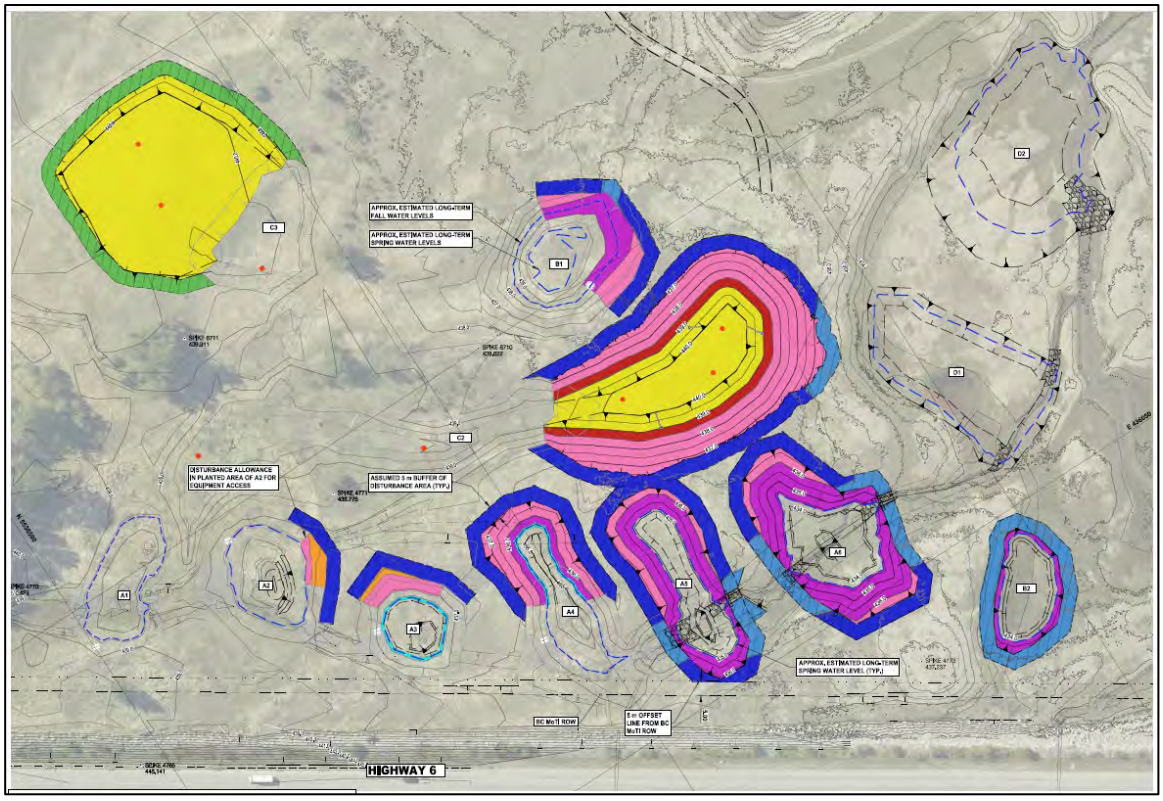
Table 2-2. **Phase 2 feature- and elevation-specific planting prescriptions for constructed ponds and mounds at Burton flats.** Where two values are shown under **Area**, the first value refers to the Phase 1 area, the second to the Phase 2 area. TOB = top of bank.

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.
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 (as per 3b)	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.
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 (as per 3a)	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.
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 (as per 3a)	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 (as per 3a)	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 (as per 3a)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	261	5a: Terrestrial Mix (as per 4)	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 (as per 3a)	On new perimeter disturbance allowance, low density stocking of Kellogg's sedge, Columbia sedge, and cottonwood.
Perimeter Disturbance Allowance (<436)	391	5a: Terrestrial Mix (as per 4)	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 (as per 4/3a)	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 (as per 4)	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.
Perimeter Disturbance Allowance (<438)	~2217 + 1323	5a/5b: Terrestrial Mix (as per 4/3a)	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 (as per 3b)	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.



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 2-1. Schematic of Phase 2 planting prescription (PP) spatial layouts at Burton Flats. Phase 1 works have been grayed out; restocking of Phase 1 treatments was determined in the field. Map prepared by Kerr Wood Leidal (KWL) for BC Hydro and LGL Limited, 2021.

Table 2-3. Stocking targets (density/ha) for each species, by prescription category. Realized stocking densities were influenced by the availability of nursery stock and salvaged material.

Species	Type	Planting Prescription						Source
		1	2	3	4	5	6	
Carex aquatilis (water sedge)	plug	1000	0	0	0	0	0	Nursery
Carex aperta (Columbia sedge)	plug	0	200	1000	0	500	500	Salvage/ Nursery
Carex kelloggii (Kellogg's sedge)	plug	0	500	1000	1000	100	100	Salvage/ Nursery
Calamagrostis canadensis (bluejoint)	plug	0	2000	500	0	2000	1000	Nursery
Spiraea douglasii (hardhack)	rooted stock	0	200	0	0	0	200	Nursery
Lonicera involucrata (black twinberry)	rooted stock	0	100	0	0	0	200	Nursery
Alnus incana (mountain alder)	rooted stock	0	100	0	0	0	200	Nursery
Populus trichocarpa (black cottonwood)	live stakes and rooted stock	0	100	1000	0	500	20	Harvest/ Nursery
Shepherdia canadensis (soopolallie)	rooted stock	0	100	0	0	0	400	Nursery
Betula papyrifera (paper birch)	rooted stock	0	20	0	0	0	300	Nursery
Pinus monticola (western white pine)	rooted stock	0	20	0	0	0	50	Nursery
Thuja plicata (western red cedar)	rooted stock	0	20	0	0	0	50	Nursery
Salix sitchensis (Sitka willow)	rooted stock	0	2000	1000	0	0	0	Nursery
Salix bebbiana (Bebb's willow)	rooted stock	0	0	0	0	0	500	Nursery
Amelanchier alnifolia (saskatoon)	rooted stock	0	0	0	0	0	300	Nursery
Symphoricarpos alba (snowberry)	rooted stock	0	0	0	0	0	200	Nursery
Corylus cornuta (beaked hazelnut)	rooted stock	0	0	0	0	0	200	Nursery
Rosa acicularis (prickly rose)	rooted stock	0	0	0	0	0	100	Nursery

3.0 Methods

3.1 Sourcing of planting stock

3.1.1 Nursery plugs and rooted stock

To ensure the required nursery stock would be available in time for the planting program, BC Hydro submitted pre-orders to two separate suppliers for graminoid plugs and rooted shrubs/trees in the winter of 2020/2021. CLBWORKS-1 contributed funding to the purchase of plants. The plant suppliers were: Spiral Farm and Nursery (Winlaw, B.C.); and Sagebrush Nursery (Oliver, B.C.). A total of 18 species were ordered, including 4 graminoid species and 14 woody species. Orders were delivered to the site in late April (spring planting session) and again in September and early October (fall planting session), in time for the commencement of planting. The delivered inventory generally matched the original orders in terms of species and numbers, with some minor deviations (Table

3-1). For example, the *Shepherdia canadensis* (soopolallie) stock had not matured sufficiently enough to be out-planted by the time of project implementation and was instead replaced with *Betula occidentalis* (water birch), *Salix sitchensis* (Sitka willow), *S. bebbiana* (Bebb's willow), black cottonwood, and expanded orders of some other species such as saskatoon, western white pine, and western redcedar. One new species, *Populus tremuloides* (trembling aspen), was also added to the fall planting order (Table 3-1).

The delivered stock was stored in a staging area and periodically watered until it was required for planting, at which time it was transported to the planting area with the aid of a pick-up (Figure 3-1).

3.1.2 Plant salvage

In early April 2021, two species of sedge (Kellogg's and Columbia) were hand-salvaged from the footprints of ponds A5 and A6 prior to construction (Figure 3-2). Salvaged plugs were set aside (Figure 3-2) and later replanted around the banks of the new ponds (including B2), and on the newly modified banks of ponds A2, A3, A4, and B1 (Figure 3-3).

Table 3-1. BC Hydro nursery stock order, including the number of each species ordered and the number delivered.

Item	Type	Supplier	No. ordered	No. delivered (spring)	No. delivered (fall)	Total delivered
Alnus incana (mountain alder)	1 gal.	Spiral	240	235		235
Amelanchier alnifolia (saskatoon)	1 gal.	Sagebrush	320	320	100	420
Betula occidentalis (water birch)	2 gal.	Sagebrush	0	0	50	50
Betula papyrifera (paper birch)	1 gal.	Sagebrush	320	250		250
Calamagrostis canadensis (bluejoint)	plug	Sagebrush	1700	1000	700	1700
Carex aperta (Columbia sedge)	plug	Sagebrush	1000	275	725	1000
Carex aquatilis (water sedge)	plug	Sagebrush	100		100	100
Carex kelloggii (Kellogg's sedge)	plug	Sagebrush	700		700	700
Cornus sericea (red-osier dogwood)	1 gal.	Spiral	100	100		100
Corylus cornuta (beaked hazelnut)	1 gal.	Sagebrush	230	230		230
Lonicera involucrata (black twinberry)	1 gal.	Sagebrush	240	140	100	240
Pinus monticola (western white pine)	1 gal.	Sagebrush	90	90	35	125
Populus trichocarpa (black cottonwood)	2 gal.	Spiral	100	100		100
Populus trichocarpa (black cottonwood)	1 gal.	Sagebrush	0		200	200
Populus tremuloides (trembling aspen)	1 gal.	Sagebrush	0		100	100
Rosa acicularis (prickly rose)	1 gal.	Sagebrush	130	130		130
Salix spp. (mixed willows)	2 gal.	Spiral	320	265		265
Salix sitchensis (Sitka willow)	plug	Sagebrush	0		200	200
Salix bebbiana (Bebb's willow)	1 gal.	Sagebrush	0		50	50
Shepherdia canadensis (soopolallie)	1 gal.	Sagebrush	400			0
Spiraea douglasii (hardhack)	1 gal.	Sagebrush	240	140	100	240
Symphoricarpos alba (snowberry)	1 gal.	Sagebrush	230	230		230
Thuja plicata (western red cedar)	1 gal.	Sagebrush	90	60	130	190

Figure 3-1. Stored nursery stock at staging areas and in transport to planting area (right). Photos: M. Miller.

Figure 3-2. Native plant salvage. Left: stripping of sedge material from the footprint of pond A6. Right: off-loading salvaged plugs at stage area. Photos: M. Miller.

Figure 3-3. Planting salvaged Kellogg's and Columbia sedge clumps on bank of newly expanded portion of pond A4. Photo: M. Miller.

3.1.3 Planting of plugs and rooted stock

The Phase 2 spring planting session occurred over seven days between Apr. 19 and 27. The Phase 2 fall planting session occurred over seven days between Sept. 29 and Oct. 7. To enable spring planting to be completed prior to the reservoir filling, this work occurred concurrently with the construction operation. Plant stock was distributed among microsites in a pattern that followed as closely as practical (while accounting for stock availability and various microsite constraints) the six elevation-specific planting prescriptions that had been mapped out for each constructed feature (Table 2-2, Figure 2-1). Planting operations were directed by the onsite vegetation specialist (Dr. M. Miller, LGL Limited).

Hole spacing for graminoids was ~0.3 m, and for potted shrubs ~1 m. Salvaged sedge plugs were dug in by hand, while receptor holes for nursery-raised plugs of sedge and grass, which had considerably less root depth than salvaged material, were rapidly made using a specialized plugging tool (ProPlugger™; Figure 3-4). Initially, planting of shrubs was also accomplished by hand. However, in places the dense consistency of the Phase 1 planting substrate made it impracticable to carry out infill planting by hand. Therefore, for the fall planting session, a gas-powered earth auger was used to create holes for the 1- and 2-gallon potted stock (Figure 3-4). Due to the dense and tall cover of RCG that had established since 2019 on many of the Phase 1-treated sites, infill planting at these locations often also necessitated that the planting areas first be partly cleared using a gas-powered trimmer (Figure 3-4).

When applying riparian and terrestrial sedge prescriptions (PP 2-4), such as around the banks of ponds, effort was made (as in Phase 1) to distribute individual species most densely within their inferred preferred elevation zone while also ensuring some representation across the full range of available elevation zones to maximize the likelihood of establishment in at least one zone. Around the riparian margins of the two upper ponds (A1 and A2), first planted in Phase 1, primary emphasis was given to restocking with hardhack, mountain alder, and Sitka willow—species with high nesting value that had shown promising establishment success in Phase 1 (Figure 3-5).

On mound tops, where dense regrowth of RCG on the Phase 1 treated areas had, by 2021, begun to overtop—and evidently outcompete—the grass and sedge plugs planted in 2019, there was less emphasis given in Phase 2 to the planting of graminoids and more emphasis placed on stocking sites with taller, more robust shrub saplings that could potentially compete with RCG for available resources during the establishment phase. As in Phase 1 (Miller and Hawkes 2020), the general strategy was to create clusters of shrubs comprised of a single species, with the aim of creating an array of different cover types and nesting options on each elevated feature. Woody species used for this purpose included Bebb's willow, prickly rose, saskatoon, snowberry, trembling aspen, water birch, and paper birch. Cottonwood was deployed around the mound aprons and tops of pond banks to provide habitat "curtains" between these features and the adjacent drawdown zone and/or highway embankment. Two conifer species (western white pine and western redcedar) were distributed in loose clusters at the tops and crests of mounds to provide supplementary large woody structure for nesting and perching (Figure 3-7).

Figure 3-4. Examples of planting methods. Clockwise from left: using earth auger to make 6-inch planting holes for shrubs; using ProPlugger™ to create small planting holes for sedge plugs; clearing reed canarygrass growth prior to planting. Photos: M. Miller.

Figure 3-5. Pond planting. Left: Installing graminoids across elevational gradient on new section of pond A3. Right: Infill planting at pond A1. Photos: M. Miller.

The newly-created island in the centre of pond A2 (a Phase 2 feature that was not covered by the original prescriptions) was lightly stocked with a mix of Kellogg's and Columbia sedge (Figure 3-6).

Figure 3-6. New (Phase 2) island feature, pond A2. Photographed in April 2021, shortly after construction, the island was planted in fall 2021 with nursery plugs of Kellogg's and Columbia sedge. Photo: M. Miller.

3.1.4 Live stake collection and planting

Live staking was carried out in the second week of October after other planting operations had been completed and as plants were entering dormancy. Stakes of inundation-adapted black cottonwood were harvested from the upper margin of the drawdown zone near the project site. Approximately 150 stakes were collected. Cuttings ranged in diameter from 1-3 cm. Following removal from the parent plants, the cuttings were pruned, taking care not to damage the bark of the stem, then trimmed to ~1.5 m lengths and soaked overnight in a pond prior to transplanting along the margins of ponds A1 and A2, and at the base of mound C2 above pond A3. A gas-powered earth auger was used to create the planting holes. After the stake was positioned in the hole, the hole was filled in and tamped down by hand (Figure 3-8).

Figure 3-7. Mound planting. Top two panels: newly installed stock, mound C3. Bottom four panels: newly installed stock, mound C2. Lower left: infill plantings, Phase 1 section of C2. Photos: M. Miller.

Figure 3-8. Live staking with black cottonwood. Left: Staking between mound C2 and pond A3. Right: installed stakes above pond A2. Photos: M. Miller.

4.0 Results

4.1 Completed planting

All the delivered nursery stock (totalling 3,555 woody and 3,500 herbaceous plants; Table 3-1) was successfully utilized in the planting. Another ~1,500 plugs of locally salvaged sedges (Kellogg's and Columbia sedge) were planted, along with ~150 live stakes (black cottonwood) for a planted total of ~8,700 plants (20+ species).

The achieved stocking numbers and species composition were in general agreement with the suggested targets for each constructed feature (Table 2-3). As per the general prescription guidance (Table 2-2), mounds C2 and C3 were planted with the highest diversity of species (Table 4-1), followed by the riparian zone around ponds A1 and A2. Lower elevation ponds received the fewest species (Table 4-1; Figure 4-1).

Figure 4-1. Completed planting. Left: saskatoon, a component of the high-diversity mound prescription PP6, on mound C2. Right: Dense application of a mix of salvaged and nursery sedge stock on pond A5. Photos: M. Miller.

Extensive attention was given in 2021 to infill planting of Phase 1 features, using a combination of salvaged sedges and nursery plants (Table 4-1). Three features—ponds A1 and A2, and mound C2—received most of the infill planting, in keeping with their higher elevation and expected relative

importance as amphibian and bird breeding areas. A1 and A2 were replanted with mountain alder, black cottonwood, Sitka willow, hardhack, bluejoint reedgrass, and water sedge, while A2 also received additional black twinberry and Columbia sedge (Figure 4-2). Some infill planting was also undertaken at Pond A3 (cottonwood live stakes) and mound C3 (western redcedar, saskatoon). At all the Phase 1 sites mentioned, and as noted previously, a dense cover of re-establishing RCG significantly hampered replanting efforts.

Figure 4-2. Infill planting, upper ponds. Left: installing additional graminoid plugs between the upper water line and the dense reed canarygrass fringe of pond A1. Right: the initial Phase 1 hardhack treatments at ponds A1 and A2 were densified through additional plantings in 2021. Photos: M. Miller.

The "heat dome" event in late June and early July of 2021, when temperatures reached unprecedented levels across British Columbia, exerted a heavy toll on the spring plantings, particularly on the tops of the newly constructed mounds. Shrub plantings on mound C3 had experienced particularly high mortality over the summer. (Lower-elevation prescriptions, which were inundated by the reservoir during this period, appeared to have been largely unaffected by the heat dome and associated drought.) To make up for this unexpected attrition, the tops of mounds C2 and C3 (Phase 2 portions) were extensively re-treated during the fall planting session. For this we used some of the Mound Mix (PP 6) stock that had been held back in the nursery (as contingency) from the spring planting session, along with supplementary stock from the fall nursery order.

Table 4-1. Number of each species planted per constructed pond and mound in 2021. Numbers represent a combination of salvaged material, nursery stock, and/or live stakes. Numbers in parentheses indicate infill plantings applied to Phase 1 features.

Species	Feature									
	A1	A2	A3	A4	A5	A6	B1	B2	C2	C3
Alnus incana (mountain alder)	50	30							50 (55)	50
Amelanchier alnifolia (Saskatoon)									80 (120)	110 (110)
Betula occidentalis (water birch)									50	
Betula papyrifera (paper birch)									150 (80)	90
Calamagrostis canadensis (bluejoint reedgrass)	100	200			400	300			500	200
Carex aperta (Columbia sedge)		250+*		100	350	300	*	*		
Carex aquatilis (water sedge)	50	50								
Carex kelloggii (Kellogg's sedge)		25+*	*	50+*	*	375+*	*	250+*		
Cornus sericea (red-osier dogwood)									50	50
Corylus cornuta (hazelnut)									100	130
Lonicera involucrata (twinberry)		50							140	50
Pinus monticola (western white pine)									20	105
Populus tremuloides (trembling aspen)									30 (25)	30
Populus ssp. *trichocarpa* (black cottonwood)	*	*	(117)						180 (*)	50
Rosa acicularis (prickly rose)									58	80
Salix bebbiana (Bebb's willow) + mixed *Salix* spp.									120 (110)	85
Salix sitchensis (Sitka willow)	100	100								
Spiraea douglasii (hardhack)	140	200								
Symphoricarpos albus (snowberry)									100 (30)	100
Thuja plicata (western redcedar)									30 (30)	77 (53)
Total species	6	2 (7)	2 (1)	3	3	3	2	2	14 (9)	13 (2)
Total plants (excluding *)	440	275 (630)	100 (117)	250	750	975		250	1608 (500)	1007 (163)

*Salvaged plugs or live stakes; exact plant count not available.

4.2 Lessons learned

Reservoir drawdown zones presents particularly challenging conditions within which to establish plant communities through revegetation efforts (Miller *et al.* 2018b, Miller and Hawkes 2019). This is due to a combination of factors:

- the prolonged seasonal inundation of most of the zone, and attendant anoxic conditions;
- the counter-seasonal fluctuation of water levels, in which the reservoir is held at low water during the spring and then allowed to gradually increase throughout the summer (opposite of the spring freshet cycle to which most plants are adapted);
- summer moisture-deficits (prior to inundation);
- the powerful fetch and associated wave energy affecting exposed shorelines;
- shoreline freezing during winter drawdown as ice subsides onto the shore;
- high rates of erosion and deposition;
- the low nutrient availability in many of the soils due to the removal of the organic soil layer;
- the abundance of large woody debris that collects in some areas and precludes plant growth or scours existing vegetation; and
- competition from non-native species, especially densely-established RCG.

The long-term outcomes of Phase 1 and 2 planting will be formally evaluated through the multi-year effectiveness monitoring program CLBMON-12 (Miller and Hawkes 2020b). Nevertheless, experiences to date with the planting initiative allow for the provision of some initial "lessons learned."

Aside from the impacts of reservoir inundation, which will not be assessable until at least one year post-planting (i.e., 2022), two specific factors appeared likely to limit Phase 2 planting success in the first year. The first was the 2021 "heat dome" event and accompanying drought that caused the wilting—and likely death—of a large number of spring-planted transplants over the summer establishment period, especially on relatively exposed mound tops. Interestingly, salvaged sedge material and other stock introduced at lower elevations during the spring planting session appeared to have been largely unaffected by the weather conditions, presumably benefiting from a brief period of summer inundation that peaked at ~439.5 m in late June before subsiding in early July (coinciding precisely with the heat dome event).

The second factor of note was the dense canopy of RCG that covered many Phase 1 treatment areas and that had to be cleared away manually before infill planting of these features could be practically undertaken. Even some Phase 2 areas (such as the new section of mound C2) were found to support a substantial cover of RCG by September of 2021 after only one partial growing season. Many of the original graminoid plugs as well as smaller-statured shrubs planted on Phase 1 features in 2019 had since been overtopped and were no longer visible, suggesting that they had been, or would soon be, outcompeted 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. 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.

Following is a summary of lessons learned from the Phase 1 and Phase 2 planting programs:

- Planting of constructed features is easier to do when the upper planting substrate (topsoil) is made rough and loose, as it was for Phase 2, as opposed to smooth and partially compacted (the Phase 1 approach).
    - In Phase 1, a second machine (mini-excavator) had to be used to dig the receptor holes for larger potted stock because the substrate, which in most places consisted of a mantel of overturned RCG sod, was too compacted for efficient manual digging. In Phase 2, the planting surface was intentionally left looser during the

construction process; this made for easier subsequent digging using hand shovels.

- In lieu of a mini-excavator, two other methods for digging planting holes were trialed in Phase 2: the ProPlugger 5-IN-1 Planting Tool™, two of which were used to make small plug-sized holes suitable for grass and sedge plugs; and a rented gas-powered (Stihl™) earth auger for creating larger (6-inch) potting holes as well as deep, smaller-diameter holes for receiving live stakes.

  Both methods worked well and reduced considerably the amount of time and energy required for hole-digging (compared to manual shoveling). The ProPlugger was the tool of choice for speed-planting graminoid plugs on pond banks and mounds. The auger was used extensively for potted stock on all terrain but was especially useful for boring holes in compacted ground and through RCG thatch, without which it likely would have been impracticable to carry out infill planting of mounds C2/C3 and ponds A1/A2.

- The one-man earth auger's configuration and weight rendered it somewhat awkward (and tiring) for a single person to carry over the rough, uneven, and extensive terrain. Furthermore, during operation, significant torque was applied to the operator's arms and shoulders. These factors resulted in some complaints of sore muscles and joints following extended use (including from the lead author).

  For future projects, consideration should be given to trialing a two-man auger which, though heavier to carry than the one-man auger and needing two people to operate, could be ergonomically preferable. Alternatively, if the terrain permits use of wheeled equipment, portable one-man hydraulic augers are available for rent and could also be trialed.

- Both spring and fall planting regimes were trialed during this project. Phase 1 entailed only fall planting, whereas Phase 2 used a combination of spring and fall planting. The fall planting regime in Phase 1 resulted in quite good (>50%) initial over-winter survivorship for most planted species. Outcomes of the Phase 2 fall planting are not yet known. However, possible *advantages* of delaying planting until the fall include:

  - Live stakes are best harvested when the plant is dormant, generally in the late fall through early spring before bud break.
  - Fall planting should afford live stake roots, as well as those of potted nursery stock, more time to establish and develop prior to being inundated by the reservoir in May or June of the following year.
  - Fall planting can help prevent moisture stress in higher elevation transplants that might not otherwise get irrigated by reservoir inundation immediately after planting (or ever, in the case of elevated mound summits). This is because (a) plants transpire less as they approach dormancy, and (b) precipitation tends to increase in the fall, so less supplemental water is needed.
  - If it is not done too late in the year, fall planting allows plants to develop root systems before the ground freezes, preparing them for vigorous growth in the spring.
  - Fall planting potentially provides for an extra season of nursery growth, meaning that nursery plants will be larger and more robust at the time they are transplanted.

  Possible *disadvantages* of fall planting include:

- Increased post-planting disturbance by wildlife. For example, shortly following the 2019 fall planting we observed evidence of ungulate (elk) browse on recently planted shrubs, especially on mound C2 and the banks of ponds A1 and A2. Signs of early morning/overnight activity ranged from track imprints, to grazed stems and stripped leaves, to the uprooting of entire plants. Of note, by far the most frequently targeted species was black twinberry, with roughly 80% of the newly planted stock browsed by mid October of that year. As it is presently unclear to what extent that browsing activity was directly seasonally influenced, this should be regarded for now as a purely anecdotal observation.
- If planting is not properly timed, there may be insufficient time for root system development prior to ground freeze.
- Cold temperatures may make the ground difficult to work (this became a slight factor for the crew towards the end of the Phase 1 fall planting session).
- In some years, reservoir levels remain high well into the fall, precluding the possibility of planting within the drawdown zone.

- The Phase 2 spring planting regime yielded mixed results. Low elevation plantings of cottonwood and salvaged sedge material, which were briefly inundated by the reservoir in late June and early July, did well. However, a number of higher-elevation plantings succumbed to the summer heat and drought, particularly on mound C3. Given that the summer of 2021 was exceptionally hot, the outcome may have been different in another year. Nonetheless, the 2021 result suggests that for future projects employing spring planting, the planting plan should include a provision for providing supplemental water to new plants during the spring and summer months until they have become established or until temperatures have cooled.

- The decision to go with two temporally separate planting sessions (spring and fall) for the Phase 2 project appears to have been beneficial in at least two respects. First, it allowed for planting-related risks to be spread between seasons. As it happened, if all planting had been undertaken in the spring concurrent with wetland construction, there would have been minimal opportunity to adjust later for the impact of the heat dome event (e.g., by conducting follow-up fall planting on the mounds).

  Second, the split seasonal effort, when combined with current reservoir forecasts, allowed us to plan in advance for within-year inundation cycles to improve the likelihood of a positive planting outcome. For example, because we had prior warning that that elevations below ~439 m were likely to be inundated briefly during the summer then left exposed for the fall period, a decision was made well in advance to limit spring infill planting of the two upper ponds and lower mound banks to relatively hydrophytic species (e.g., sedges, cottonwood) while postponing the reintroduction of less flood-tolerant species (e.g., hardhack, willows) until the fall planting session. By doing so, we were able to avoid exposing these species to the risk of anoxia (i.e., drowning) during their first year. The rationale was that by providing more time for root establishment over the fall and subsequent spring, the new transplants will be better equipped to withstand their first inundation event (presumably in 2022).

- It was recognized early on in prescription development that RCG was an engrained component of the Burton Flats flora and, as such, was unlikely to be eliminated from the project area through any of the control methods presently available. The incorporation of

topsoil stripped from the project footprint—composed as this was largely of RCG-dominated sod—into the capping material for mounds and ponds more or less ensured that RCG would remain a prevalent component of the post-construction plant community.

Nevertheless, the speed and aggressiveness with which RCG has re-established and come to dominate on newly-constructed mounds and riparian banks was somewhat surprising. The presumption (or hope) had been that there would be a time lag in RCG re-establishment that would provide a sufficient window of opportunity for the new transplants to become established. For many portions of the project site, this presumption is now in question. Future monitoring will confirm if that is the case, but as things currently stand it appears that targeted weeding/clipping of RCG, carried out one or two times per year, may be needed to prevent a large proportion of new transplants from being overtopped and/or outcompeted during the first years of establishment.

Due to the size of the area and the sensitive nature of the task—any weeding/clipping would need to be accomplished in such a way that it does not cause excessive collateral damage to desired vegetation—this could be a logistically challenging undertaking. Moreover, simply reducing the aboveground foliage via clipping may not produce the intended competitive release given that much of the competitive interaction is likely to take place belowground, at the root level. Nevertheless, some aboveground reductions of RCG biomass are likely the most that can be realistically achieved in this situation.

- For Phase 1 work we employed a skid steer to transport plant stock from the staging area to the work site, to haul tools, and to pound holes for stakes. A similar approach was planned for Phase 2; however, early in the Phase 2 process the rented skid steer developed a minor leak issue and had to be removed to avoid contamination of the site. In its place, a light pickup truck was deployed, which proved nearly as practical for transporting plants and materials. This method did entail more foot trips by the crew to get material to where it needed to go, on account of the inability of the pickup to access all areas. However, we found that the truck was less prone to causing compaction and rutting in soft ground compared to the wheeled skid steer. It also presented fewer objective safety hazards to the crew. If a skid steer is employed again for similar work in the future, a tracked machine, which potentially results in less compaction, should be considered.
- In general, larger, older plugs and shrubs will transplant better than smaller, younger plants. Thus, the more time young plants are given in the nursery before being out-planted, often the better. Some species also take longer to raise up to size than others. In 2021, the soopolallie order had not matured sufficiently in time to be used for the fall planting, and other species had to be substituted in lieu. For these reasons, nursery orders should be submitted as far in advance as is practicable, and in the lead-up to delivery the nursery should be asked to confirm all stock condition and also to reserve for delivery the largest individuals that it has on hand at the time.

5.0 Summary

As part of Phase 2 of the CLBWORKS-30B physical works program to enhance wetland and riparian habitat in the drawdown zone at Burton Flats, approximately 3.9 ha of constructed terrain (8 ponds and 2 mounds) were successfully stocked (or restocked) at varying densities in April, September, and October of 2021. Planted terrain included pond margins, riparian banks below and above full pool, mound tops and banks, and disturbance allowances. Revegetation species consisted of a mix

of locally salvaged material (sedge), harvested live stakes, and nursery stock. A total of 20+ species (~8,700 individuals) were translocated during the project.

Some notable challenges encountered during the implementation of the planting program in 2021 were the summer heat dome event and associated drought, which exerted a heavy toll on the spring plantings; and the rapid re-incursion of reed canarygrass into the project area post-Phase 1 construction, which hampered infill (re-entry) planting efforts on several Phase 1 features.

Using two separate planting sessions (spring and fall) for the Phase 2 project appears to have been beneficial as it allowed for planting-related risks to be spread between seasons. In this case, if all the planting had been undertaken in the spring concurrent with wetland construction, there would have been minimal opportunity to adjust later for the impact of the extreme summer weather (e.g., by conducting follow-up fall planting on the mounds). Various other takeaway lessons following from the implementation of this project are also provided.

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