Environment and Climate Change Canada

Canada Nature Fund: Community-Nominated Priority Places for Species at Risk

Kootenay Connect: 5CW Columbia Wetlands:

Hydrology and Beavers: Wetlands on the Western Upland Bench of the Columbia Valley

March 31, 2024. Final Report: Year 5

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Executive Summary:

Global concerns are rising regarding the current state of the world's wetlands. A recent review of 189 reports found that 54-57% of the global wetland area has been lost, with rates increasing during the 20th and 21st centuries (Davidson, 2014). The risks posed to various wetland types differ based on their ecology, location, and commonly associated human impacts. Valley-bottom floodplain wetlands are vulnerable to human development (e.g., hydroelectric dams, agriculture), but upland wetlands with smaller catchment areas dependent on precipitation or ground water supply are at a higher risk of drought (Winter, 2007; Hupp *et al.,* 2009). Small (globally averaging 3.9 ha) non-floodplain wetlands comprise approximately 53% of globally identified wetlands and contribute important ecosystem services and to landscape resilience - including actions such as buffering aquifer dynamics and base stream flow (McLaughlin *et al.,* 2014; Lane *et al.,* 2023).

The western upland bench of the Columbia Valley provides a suitable landscape for many small wetland features where minimal investigative work has been completed. The Freshwater Atlas of BC (FWA), an open-source database that maps provincial freshwater attributes, identifies 349 lake and 479 wetland polygons on the bench between Canal Flats and Spillimacheen. In 2023, we visited 371 of the 828 (45%) mapped polygons either via drone or in-person to generate a summary of wetland status and identify potential restoration sites. To assess wetland status, we recorded the presence/absence of vegetation communities (e.g., open water, wetland vegetation, shrub, conifer) and noted the dominant and subdominant community for 94% (350 out of 371) of the visited wetland and lake polygons.

Our drone imagery analysis found that 21% (n = 45) of the assessed FWA wetland polygons on the western upland bench are receiving adequate water supply to maintain open water or wetland vegetation. The other 79% of wetlands (n= 169) showed some evidence (e.g., encroachment of shrub and conifers) of drying or appear dry from the drone. For example, 24% (n = 51) of the assessed polygons did not have any detectable signs of water and are either dryer wetland types with conifer overstory (e.g., bogs) or are now dry features on the landscape. Lastly, 55% of the assessed wetlands are in an intermediate stage of succession and are a mix of dryer vegetation types but still maintain evidence of some water and wetland vegetation. Of the three geomorphic wetland types identified (i.e., lake-edge, isolated, stream channel), stream channel wetlands exhibited the most signs of drying (e.g., 63% dominated by hydrophobic vegetation communities). In 2024, field visits classifying wetland characteristics will be useful to document the current state of these wetland categories.

Our project goal is to restore 5 - 10 hectares of wetlands on the upland bench of the Columbia Valley using Beaver Dam Analogues – in 2023, we identified 22 potential sites that are suitable for restoration with this method. We focused on collecting detailed information for permit applications and effectiveness monitoring at nine of these sites, which would allow us to flood 13 ha within the FWA mapped boundaries. These measurements include stream flow and water quality, the size of the remnant beaver dam gap needing repair, estimated flood area, bathymetry, vegetation community mapping, vegetation plots, and orthomosaic drone imagery. In early 2024, we submitted permit applications for two of these sites and are currently waiting for feedback from the provincial government. If we restore these 2 sites this year (pending permits) we will accomplish our project goal and flood approximately 6.3 hectares of wetland. In our intensive surveys of potential restoration sites we found 56 plant species. Lastly, we used the Conservation Data Centre to identify 21 wildlife species at risk/red listed species that may occur within our study area - some of which we may monitor in 2024.

Section 1: Overview of Wetlands on the West Upland Bench of Columbia Valley

In May of 2023, we identified our study area on the western bench of the Columbia Valley from the edge of the valley bottom to the base of the Purcell Mountains, between Canal Flats and Spillimacheen. To guide our analysis, we used the Freshwater Atlas of British Columbia (FWA), an open-source dataset created from provincial topographic maps that identifies and maps hydrological features such as watershed boundaries, stream networks, waterbodies, and obstructions (Caslys Consulting, 2010). Within our study area, the FWA has mapped 479 wetland and 349 lake polygons, most of which are less than 3 ha in size (Figure 1). Many, if not most, of these small lakes contain water that is less than 2 meters deep and are therefore considered open water wetlands in the Canadian Wetland Classification System (National Wetlands Working Group, 1997).

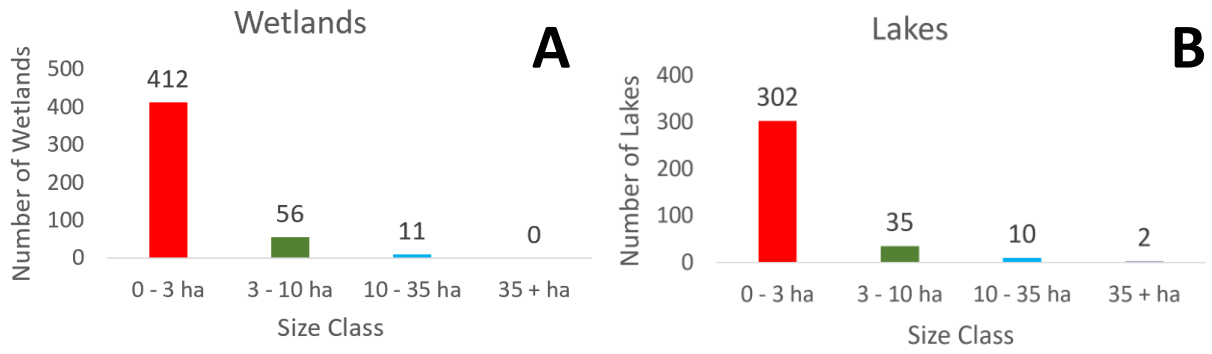


Figure 1. The size of wetlands (A) and lakes (B) mapped by Freshwater Atlas (FWA) that occur on the western upland bench of the Columbia River Valley between Canal Flats and Spillimacheen.

Between May and September 2023, we visited 227 wetland (47%) and 144 lake (41%) FWA polygons via drone or in person to assess their potential for restoration sites and general status; thus we assessed 371 of the 828 (45%) mapped polygons (Figure 2). We used a combination of geographic information system (GIS) resources, in-person observations, and photographic imagery to assess potential sources of water, wildlife values, location of wetlands in the region, and dominant vegetation types.

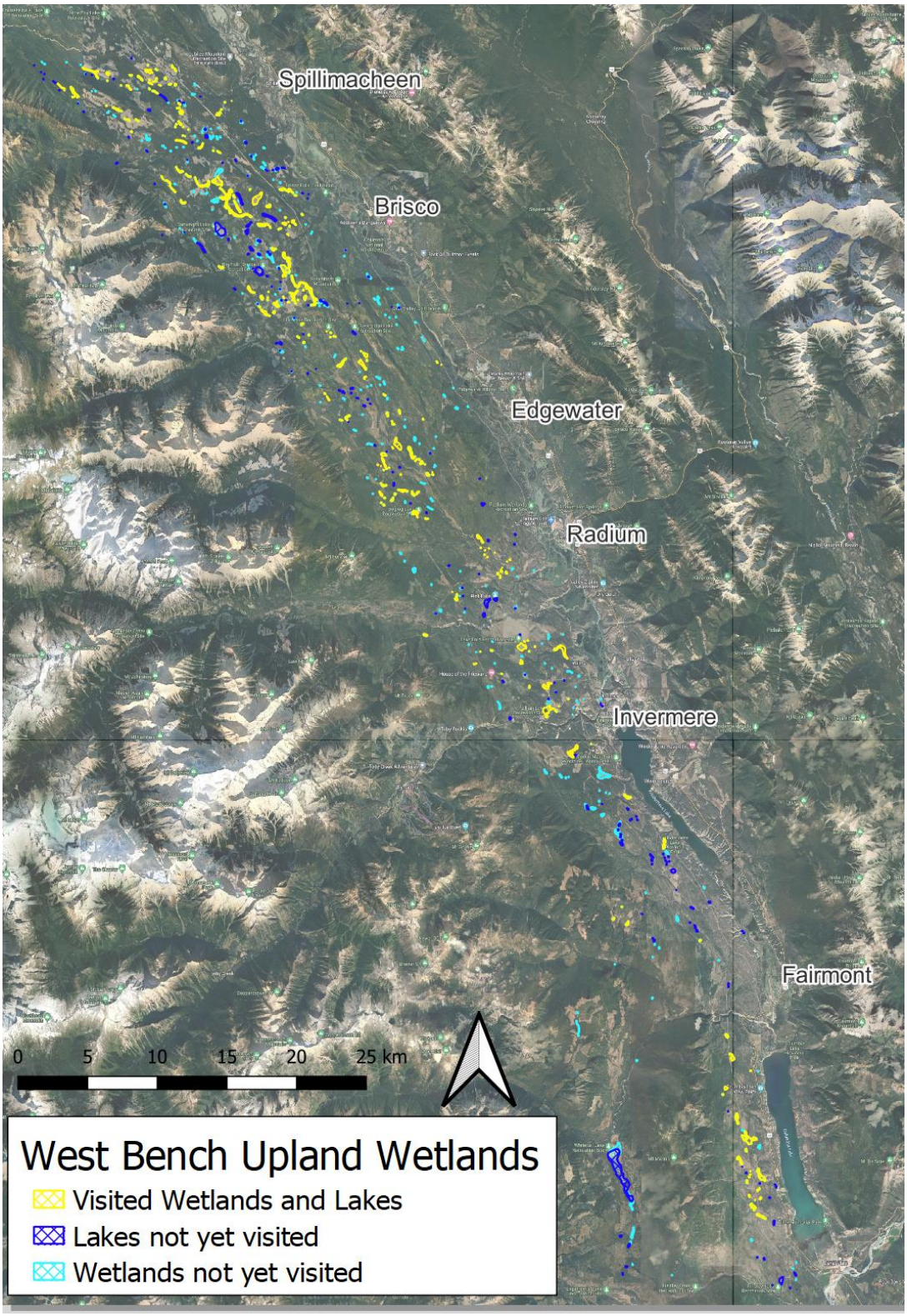


Figure 2. The distribution of Freshwater Atlas lake and wetland polygons, and those that we visited during the 2023 field season, on the western upland bench of the Columbia Valley between Spillimacheen and Canal Flats.

Section 1.1: Analysis of Vegetation as an Indicator of Water Availability to Wetlands

One goal of the project was to determine the vulnerability of wetlands on the western upland bench of the Columbia Valley and to use this information to identify potential restoration sites (Objectives 2.2 and 2.3). The Wetlands of British Columbia Guidebook's (2004) definition of a wetland includes the requirement of a relative abundance of hydrophytes (a plant that grows partly or totally submerged in water or in waterlogged soil) in the vegetation community. Vegetation community and composition is a wide-spread and useful indicator of biotic integrity as it is one of the three main elements of a wetland ecosystem, along with water and soil, and is relatively easy data to collect and classify (Behn *et al.,* 2018; Wu *et al.,* 2018).

In February 2024, we revisited our drone photograph inventory to broadly classify the vegetation communities present in each FWA polygon. Due to photograph quality, we were only able to classify vegetation communities for 94% (350 out of 371) of the originally assessed wetland and lake polygons. Thus, we examined vegetation in 214 FWA Wetlands and 136 FWA Lakes. We recorded the presence/absence of open water, wetland vegetation (e.g., bulrush, cattail, horsetail), shrubs, deciduous trees, coniferous trees, mudflat, and dryland vegetation (e.g., fields and dry open spaces). In addition, we recorded the dominant and subdominant community for each polygon. This analysis was completed to help inform whether this region's wetlands are healthy and continue to receive sufficient water to maintain hydrophytic vegetation. Our overview classification is based solely on vegetation communities observed in drone imagery (collected in summer of 2023) as an indicator of water availability in the wetland basin. We are unable to determine if other factors (e.g. drainage, pollution, disease) might be negatively affecting wetland health in this dataset.

It is also important to note that some wetland types are characterized by forested vegetation cover (e.g., bogs and swamps), while the encroaching growth of coniferous, deciduous, or shrub species in other wetland types (e.g., marshes) would indicate drying. In addition, wetlands are dynamic environments where different wetland types represent stages of ecological succession of one another - for example an unhealthy drying marsh may later become a healthy bog (MacKenzie and Moran, 2004), although this is unlikely due to the lack of organic soils and water in this area. Due to the complexity of vegetation indicators of wetland health differing for various wetland types, this preliminary analysis of vegetation communities cannot be used to summarize the loss or health of wetlands in the study area. However, this analysis can be used to indicate potential wetland types, areas that may be dryer, and help us prioritize areas for further survey. We hope to complete wetland classifications at a suite of sites in 2024, following the Wetlands of British Columbia Guidebook, to help provide more ecological context to the desktop and drone-based analysis. Once we have a better understanding of the existing wetland types and current stage of succession occurring on the western upland bench of the Columbia Valley, we can begin to interpret the loss of ecosystem services caused by successional transition as a result of drying and climate change.

Overall, 91 (42%) of the FWA wetland polygons and 126 (93%) of the FWA lake polygons were dominated by wetland vegetation (i.e., cattail, bulrush, sedge) or open water indicating an adequate water supply to maintain hydrophytic plant species that require water and will not survive prolonged soil desiccation (Figure 3). We can infer that these features remain wetted for most of the year.

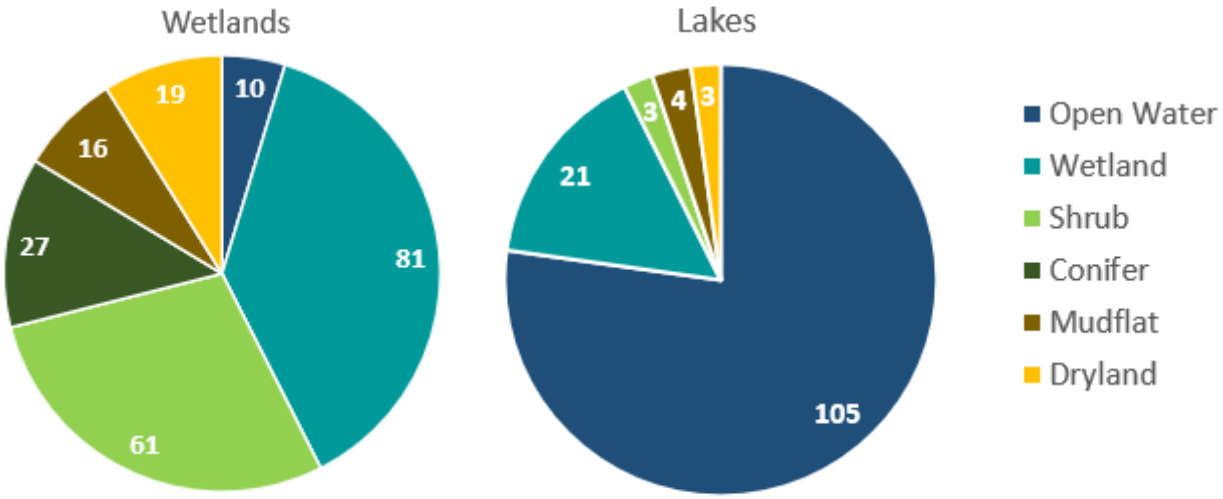


Figure 3. Dominant vegetation communities observed in 2023 drone imagery of BC Freshwater Atlas wetland and lake polygons.

Based on observations made during the field season it seems that areas of open water, including small areas that would typically be classified as a shallow water wetland, were mapped in FWA as lakes – we have not been able to confirm this theory in the literature. However, from this observation we suspect that the transition of 23% of the FWA lakes to non-open water dominated habitats (i.e., wetland, shrub, mudflat, and dryland) indicates a decrease of this habitat type on the landscape. All FWA lake polygons that are not dominated by open water (n = 31) are smaller than 1.5 ha, and total 10.34 ha (3.5% of total FWA Lake area) overall (Table 1).

Table 1. Dominant vegetation community classifications for the Freshwater Atlas Lake polygons separated by size class (0 - 3 ha, 3 - 10 ha, and 10 - 35 ha).

		Dominant Vegetation Community									
Size	**#**	**% Open Water**	**Area Open Water (ha)**	**% Wetland**	**Area Wetland (ha)**	**% Shrub**	**Area Shrub (ha)**	**% Mudflat**	**Area Mudflat (ha)**	**% Dryland**	**Area Dryland (ha)**
0 - 3 ha	**111**	72%	53.74	19%	6.39	3%	0.38	4%	2.81	3%	0.76
3 - 10 ha	**19**	100%	106.30	~	~	~	~	~	~	~	~
10 - 35 ha	**6**	100%	128.55	~	~	~	~	~	~	~	~

Similarly, we suspect that FWA wetland polygons now dominated by open water may reflect an increase of this habitat type since the FWA was created – these 10 polygons total 19.86 ha in size. Three of these occurrences are associated with current beaver activity (e.g., observed newly maintained dams), three had evidence of past beaver activity but presence was not confirmed (e.g., dam present in system), one had evidence of potential beaver activity but was not investigated in the field, and three

had no sign of beaver and increases in open water may be related to groundwater changes. These transitions represent natural dynamic fluctuations on the landscape and highlight the role of beaver in maintaining habitat and healthy aquatic systems.

As mentioned above, 91 (42%) of the FWA wetland polygons were dominated by open water or wetland vegetation; however, only half of this subset (n = 45) also have a secondary dominant community of open water or wetland vegetation (Figure 4). These features, hereafter termed "adequately wetted" will likely persist on the landscape the longest and are thus the least likely wetlands to be immediately lost due to natural drying cycles or climate change. The other half of the wetlands dominated by open water or wetland vegetation have subdominant communities of shrub, conifer, dryland, or mudflat - these communities may indicate drying and transition of marshes into other dryer wetland types (hereafter termed "mostly wet but drying").

Unexpectedly, features dominated by shrub (n = 4) and dryland (n = 1) did have subdominant communities of open water - features dominated by conifer and mudflat did not (Figure 4). In this case, three of the four features dominated by shrub appear to have beaver activity while the dryland occurrence was due to the connected lake polygon expanding slightly higher up an exposed shoreline. Wetland (n = 6) and conifer (n = 4) dominant vegetation communities were the only types to have features without a subdominant community, though these were rarely observed (Figure 4).

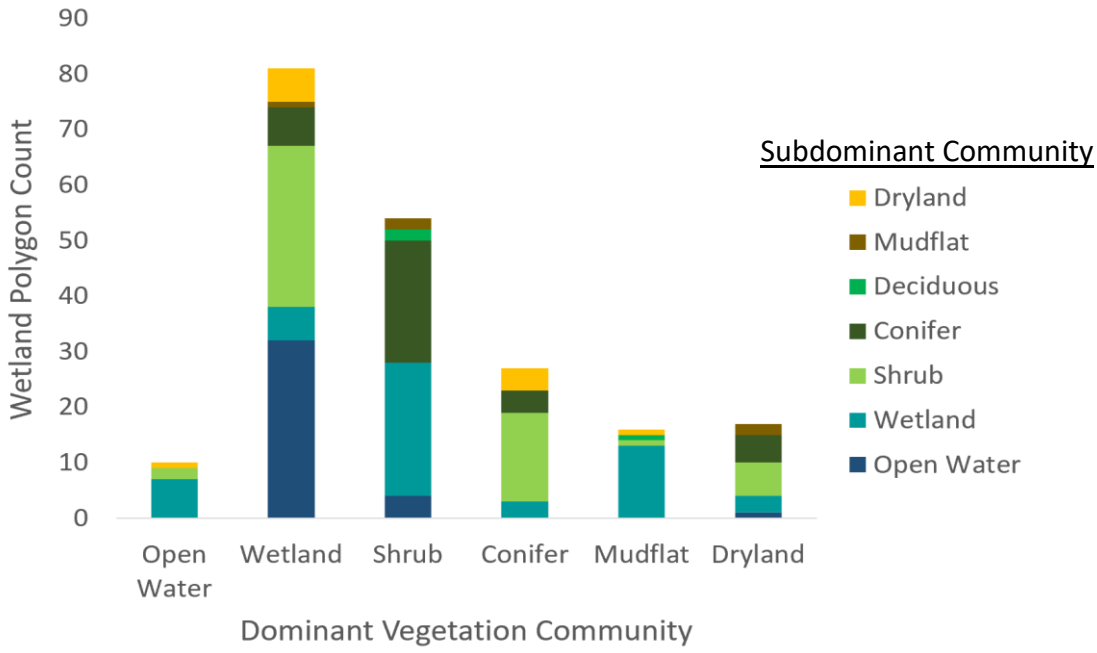


Figure 4. The dominant (categorized on the X axis) and subdominant vegetation communities (coloured stacked bars) observed in assessed FWA wetland polygons (n = 214) on the western upland bench of the Columbia Valley.

To simplify the data and to broadly assess wetland trends on the upland bench, we summarized wetland status into four categories:

- **Adequately wet** - Dominant: Open Water/Wetland Vegetation, Subdominant: Open Water/Wetland Vegetation

- **Mostly wet, but drying** - Dominant: Open Water/Wetland Vegetation Dominant, Subdominant: Shrub, Conifer, Mudflat, Dryland
- **Drying with wetted areas** - Dominant: Shrub, Conifer, Mudflat, Dryland and Open Water/Wetland Vegetation present
- **No signs of water -** Dominant: Shrub, Conifer, Mudflat, Dryland and Open Water/Wetland Vegetation Absent

This analysis shows that 21% (n = 45) of the assessed wetlands on the western upland bench are receiving adequate water supply to maintain open water and wetland vegetation and are currently the least vulnerable to loss due to climate change (Figure 5). Over 79% of wetlands (n= 169) showed some evidence of drying or are dry. For example, 24% (n = 51) of the assessed polygons did not have any detectable signs of water and are either dryer wetland types with overstory (e.g., bogs - although unlikely since organic soils are required for bogs) or are now dry features on the landscape and no longer contributing to the ecosystem services of wetlands. Lastly, 55% of the assessed wetlands are at intermediary stages of succession (21% mostly wet but drying, 34% drying with wetted areas) and are a mix of dryer vegetation types but still maintain evidence of some water supply and aquatic vegetation/habitats. These wetlands are likely most at risk of experiencing visible/detectable impacts due to climate change as water supply may already be limited and becoming scarcer. In 2024, field visits and conducting wetland classifications will be useful to document the current state of these intermediary wetlands, understand their health, and ensure we can detect changes and loss of ecosystem services in the future.

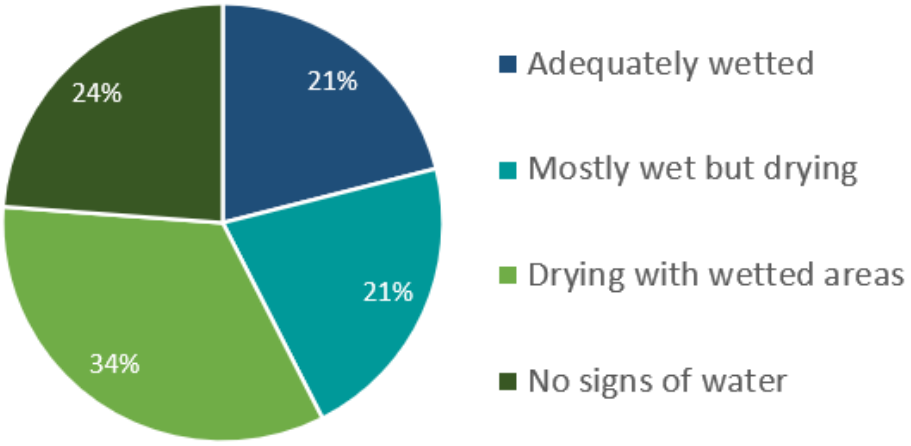


Figure 5. Preliminary assessment of water supply to wetlands (n= 214) based on vegetative community observed in 2023 drone imagery. 79% of wetlands (n= 169) showed evidence of lack of water. Wetland status is classified as: adequately wetted - open water/wetland vegetation dominant and subdominant, mostly wet but drying - open water/wetland vegetation dominant but hydrophobic vegetation (shrub, conifer, deciduous, mudflat, or dryland) subdominant, drying with wetted areas - hydrophobic vegetation dominant but open water or wetland vegetation present, and no signs of water - no open water or wetland vegetation observed in the polygon.

Section 1.2: Comparison of benchland wetlands by region

We divided our study area into six regions based on the settlements in the Columbia Valley – Canal Flats to Fairmont, Fairmont to Invermere, Invermere to Radium, Radium to Edgewater, Edgewater to Brisco, and Brisco to Spillimacheen.

The southernmost region (between Canal Flats and Fairmont) exhibited the most drying and had no 'adequately wet' or 'mostly wet but drying' wetlands present (Table 2). However, of the wetlands dominated by hydrophobic communities (e.g., shrub, conifer, mudflat, dryland), there was open water or wetland vegetation present in 50% (n=8) of the wetlands assessed in this region (category: drying with wetted areas). The Sun Creek Wetland Restoration, led by the Nature Trust of British Columbia, is one example of a 'drying with wetted areas' wetland within this region (Figure 6).

Figure 6. Sun Creek Restoration project located at 50.184874 N, 115.885420 W on the west side of Columbia Lake between Canal Flats and Fairmont. Drone image taken on September 15, 2023.

The highest percentage of adequately wetted features on the western upland bench were observed between Fairmont and Invermere, but this is likely an artifact of the small sample size within this region and the presence of beaver ponds adjacent to Westside Road (38%, n = 3). The small sample size between Fairmont and Invermere is due to access and a higher proportion of private land compared to the other areas assessed. The section of upland bench between Invemere and west of Radium was fairly evenly distributed among the wetland status categories (Table 2). The regions from Radium to Spillimacheen (i.e., Radium to Edgewater, Edgewater to Brisco, Brisco to Spillimacheen) were all mostly comprised of 'drying with wetted area' features - this aligns with the overall trend as this category of wetland status was the most common (Figure 5).

Table 2. Regional estimate of wetland status based on vegetation communities observed in 2023 drone imagery. Adequately wet wetlands have open water/wetland vegetation dominant and subdominant, Mostly wet but drying means open water/wetland vegetation dominant but hydrophobic vegetation (shrub, conifer, deciduous, mudflat, or dryland) subdominant, Drying with wetted areas means hydrophobic vegetation dominant but open water or wetland vegetation present, and No signs of water means no open water or wetland vegetation observed in the polygon.

	N	Adequately Wet	Mostly wet but drying	Drying with wetted areas	No signs of water
Canal Flats to Fairmont	16	~	~	50% (8)	50% (8)
Fairmont to Invermere	8	38% (3)	25% (2)	25% (2)	13% (1)
Invermere to Radium	15	20% (3)	27% (4)	20% (3)	33% (5)
Radium to Edgewater	32	22% (7)	19% (6)	34% (11)	25% (8)
Edgewater to Brisco	56	21% (12)	30% (17)	30% (17)	18% (10)
Brisco to Spillimacheen	86	23% (20)	19% (16)	36% (31)	22% (19)

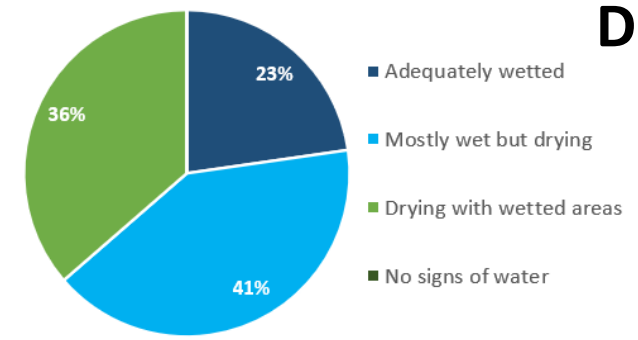
Section 1.3: Geomorphic Characterization of Wetlands and Lakes

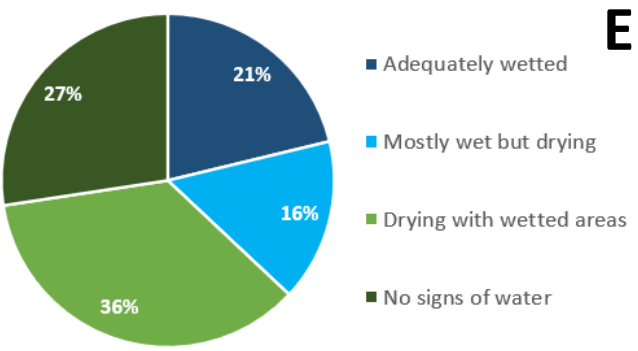
During field assessments, we identified three main categories of wetlands present on the upland bench – wetlands on lake edges, wetlands in stream channels, and isolated pocket wetlands which presumably obtain their water from precipitation and/or ground water (Figure 7A-C). We classified the FWA wetland polygons with vegetation community information (n = 214) into these categories to reflect the three main apparent sources of water. Wetlands that are on edges of lakes greater than 3 ha were classified as 'lake edge wetlands', those with a continuing FWA Route (route is the FWA term for stream) running through them were classified as stream channel wetlands, and those that did not possess a FWA Route or possessed a route contained within the wetland boundary were classified as isolated wetlands.

The most common type of wetland within our study area were those in stream channels (68%; n = 146). We hypothesize that wetlands with smaller drainage basins or are positioned closer to the headwaters of a small stream are likely exhibiting more signs of drying. In an effort to distinguish whether this might be true, we compared wetlands positioned either at the very beginning of a FWA route (n = 23) to those that occur downstream of the FWA route origin (n = 123). Stream channel wetlands at the beginning of a FWA route exhibited a lower percentage of adequately wet polygons (13%; n = 3), open water/wetland vegetation as their dominant and subdominant communities, than wetlands that occurred later in the stream network (n = 28; 23%). In contrast, there was a higher proportion of wetlands with no signs of water (open water or wetland vegetation absent) observed in wetlands located along a stream (n = 35; 28%) than those at the beginning of one (22%; n = 5). Due to the conflicting trends, we hope to quantify drainage basin and stream order to clarify the relationship between water input and vegetation community composition in 2024. This analysis does not incorporate the presence of groundwater sources, which may have significant influence on FWA route source wetlands and the associated streams. All further discussion in this report, and data displayed in Figure 7E, does not distinguish between stream-channel wetlands at the start or along a stream.

The other wetland types, isolated (n = 46; 21%) and lake edge (n = 22, 10%) were significantly less common than stream-channel wetlands in our study area. Wetlands along large lake edges seem to be the most stable as they all had open water or wetland vegetation present. Unexpectedly, isolated wetlands exhibited a fairly equal proportion of adequately wetted wetlands (20%, n = 9) compared to the other wetland types (lake edge = 23%, stream channel (combined) = 21%) – Figure 7D,E, and F. While isolated and stream-channel water sources have fairly similar proportions of wetlands in transition states (i.e., mostly wet but drying, drying with wetted areas), it appears that stream-channel wetlands may be experiencing more drying as the proportion of 'drying with wetted areas' state is more common.

Overall, the trends in vegetation community indicate that wetlands relying on water from streams are receiving the least amount of water supply to maintain hydrophytic vegetation. While we were conducting our field assessments, we noticed an astonishing number of old degraded beaver dams (visible as dirt mounds) on the landscape. The decomposition of a large number of beaver dams, which likely created many of these stream channel wetlands, may be the reason for the observed successional changes observed in this wetland type. In addition, the loss of water and increase in ephemerality of streams is already being observed and predicted to increase with climate change – another factor increasing the vulnerability of these wetlands (S. Bayley, pers. comm).





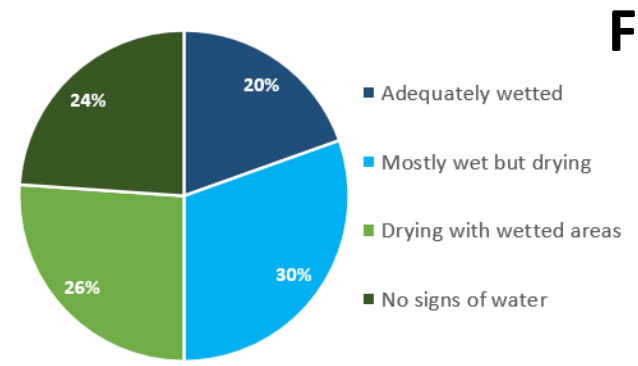


Figure 7. Examples of the three main wetland categories observed on the western upland bench of the Columbia Valley – wetlands on lake edges (A), wetlands in stream channels (B), and isolated pocket wetlands (C). The proportion of wetlands in each status category, derived from vegetation community classifications, is also displayed for the three water source types (D, E, and F). Wetland status was defined as: Adequately wet wetlands have open water/wetland vegetation dominant and subdominant, Mostly wet but drying means open water/wetland vegetation dominant but hydrophobic vegetation (shrub, conifer, deciduous, mudflat, or dryland) subdominant, Drying with wetted areas means hydrophobic vegetation dominant but open water or wetland vegetation present, and No signs of water means no open water or wetland vegetation observed in the polygon.

Section 2: Identification of Restoration Sites

Our project is focusing on the use of Beaver Dam Analogues (BDAs) to restore existing wetlands by containing more snow melt, stream flow, and groundwater than is currently being held on the landscape. BDAs are a low-tech process-based method that mimic natural beaver dams - both in appearance and ecosystem benefit (Pollock *et al.,* 2018). These structures are built out of mostly natural materials (e.g., wooden posts, branches, and mud) and reinforced with minimal man-made materials (e.g., burlap sacks) to ensure a simplistic, cost-effective restoration design that provides great benefit to the system (Pollock *et al.,* 2018). The benefits of these structures include raising the riparian water table, improving floodplain connectivity, creating small open water ponds to help slow water in the stream, moderate stream temperatures, replenish shallow groundwater stores, and nourish streams with sediment (Pollock *et al.,* 2018; Munir and Westbrook, 2020).

While in the field conducting assessments of the overall status of wetlands on the western upland bench of the Columbia Valley, we also identified wetlands with the potential to be successfully restored through BDAs. The most important factor in identifying wetlands suitable for this type of restoration is the presence of an outflow in which we can build a BDA for water to pool behind it. Due to this constraint, all of our potential restoration sites are located in stream channels. We observed that many wetlands along stream channels on the upland bench had dirt mounds (often covered with trees) near their outflow which we suspect is an indication of historic beaver dams that are now decomposed. In these cases, the stream has eroded a small gap (often 1 – 3 m) through the historic beaver dam which no longer allows water to pool behind the dam, subsequently causing the loss of a wetland.

While BDAs have been a popular method in the United States for stream and wetland restoration, the method is newer to British Columbia and is thus subject to regulation constraints. We have strategically chosen sites that will be low-risk due to their remote location, small construction footprint, and theme of small repairs to existing, but degraded, natural beaver dams. There is an increasing interest in low-tech process-based restorations among multiple conservation groups in BC and we are working together to address regulatory concerns around project implementation.

Of the 371 FWA wetland and lake polygons assessed this year, we identified 22 potential restoration sites. In 2023, we focused our efforts on collecting baseline data for permit applications and effectiveness monitoring at ten sites; however, during preliminary assessments one site (North Leadqueen) was found unsuitable for our restoration priorities. All information we collected at this site has been forwarded to the BC Wildlife Federation, one of our project partners, to see if it meets their restoration requirements. The remaining nine prioritized restoration sites total 39.8 hectares of mapped FWA wetland or lake polygons; once restorations are complete, we estimate to flood a total of 13 hectares and store 54,415 m^3 of water (Equation 1). Our proposal and contribution agreement require a minimum of 5 hectares of benchland wetlands to be restored (**Objective 2.6**). We submitted two Section 11 Change Approval permit applications in January 2024 for the restoration activities planned at S-Land (Reference Number: 491817) and Beaver Channels (Reference Number: 464746) but are still awaiting review and feedback. Restoration of these two areas will total 13.7 ha of mapped FWA polygon area, 6.3 ha of flooded area, and store 27,030 m3 of water on the landscape which will exceed our obligations for the CBT's EEP grant requirement. These calculations only include surface storage behind the dam, but the riparian groundwater storage downstream of the dam can be 60-80 times more

than the surface water storage (Westbrook *et al.,* 2006). We have no estimate of riparian storage at this time.

$$Estimated\ volume\ stored = \frac{Flooded\ Area\ (m2) * Water\ Level\ Increase\ (m)}{2}$$

Equation 1. Formula used to calculate the estimated volume of water stored in our restoration sites.

The measurements we collected at potential restoration sites in 2023 include stream flow and water quality, remnant beaver dam profile and gap needing repair, estimated flood area, bathymetry, vegetation community mapping, vegetation plots, and orthomosaic drone imagery - these metrics address Objective 2.1 (***Monitor hydrologic***, SAR species ***and ecological parameters in a suite of potential wetlands pre and post restoration activities. Generate effectiveness benchmarks***). In 2023, stream flow was measured using a Flowmeter; however, this device is typically better suited for larger streams. In 2024, we hope to return to site and take more appropriate stream flow measurements using the salt-dilution method which would provide a more accurate metric for our stream type. Water quality measurements were taken with a calibrated YSI probe. A rotary laser level was used to measure the beaver dam and gap profile, estimated flood area, and bathymetry transects. Vegetation community mapping was achieved with a combination of on-the-ground site notes and drone orthoimagery. We recorded species and percent cover observed within 1 m x 1 m vegetation plots and will return to these same locations in future years to monitor species composition shifts as a result of our restoration efforts.

Not all measurements were completed at all sites, but progress has been summarized in Table 3. Additional effectiveness monitoring will continue in 2024 and may potentially include these measurements at additional sites or groundwater, fish, and other wildlife surveys at the prioritized sites. This current list of restoration sites differs from the project video created in 2023 due to the addition of two sites that were still in discussion when the video was created.

Table 3. Measurement progress for permit requirements and effectiveness monitoring at the nine restoration sites prioritized in 2023. Green shading indicates complete, yellow shading indicates partially complete, and white shading indicates incomplete.

Site	Area (ha)	Flow and Water Quality	Gap	Flood Area	Bathymetry	Veg Communities	Veg Plots	Drone Imagery
S-Land	1.17							
Beaver Channels	12.49							
Northbound	2.88							
Upper Double Dam	10.19							
Lower Double Dam	0.70							
Limbo	1.03							
Coltsfoot	1.91							
Sam's Folly Outflow	5.70							
Rand Creek Wetland	3.72							
North Leadqueen	~	~	~	~	~	~	~	~

Section 2.1: S-Land (Freshwater Atlas WATERBODY_ID: 705006345 and 705007160)

The S-Land restoration site is along the outflow of Upper and Lower Halgrave Lakes (a designated recreation site) and is located entirely on provincial crown land (Figure 8). We propose repairing two beaver dams within the perimeter of this wetland to restore 3,797 m^3 of open water, spread over 12,793 m^2. A permit application for a Section 11 Change Approval was submitted to the BC Government on January 3, 2024 (Reference Number: 491817) and we are still awaiting review and feedback.

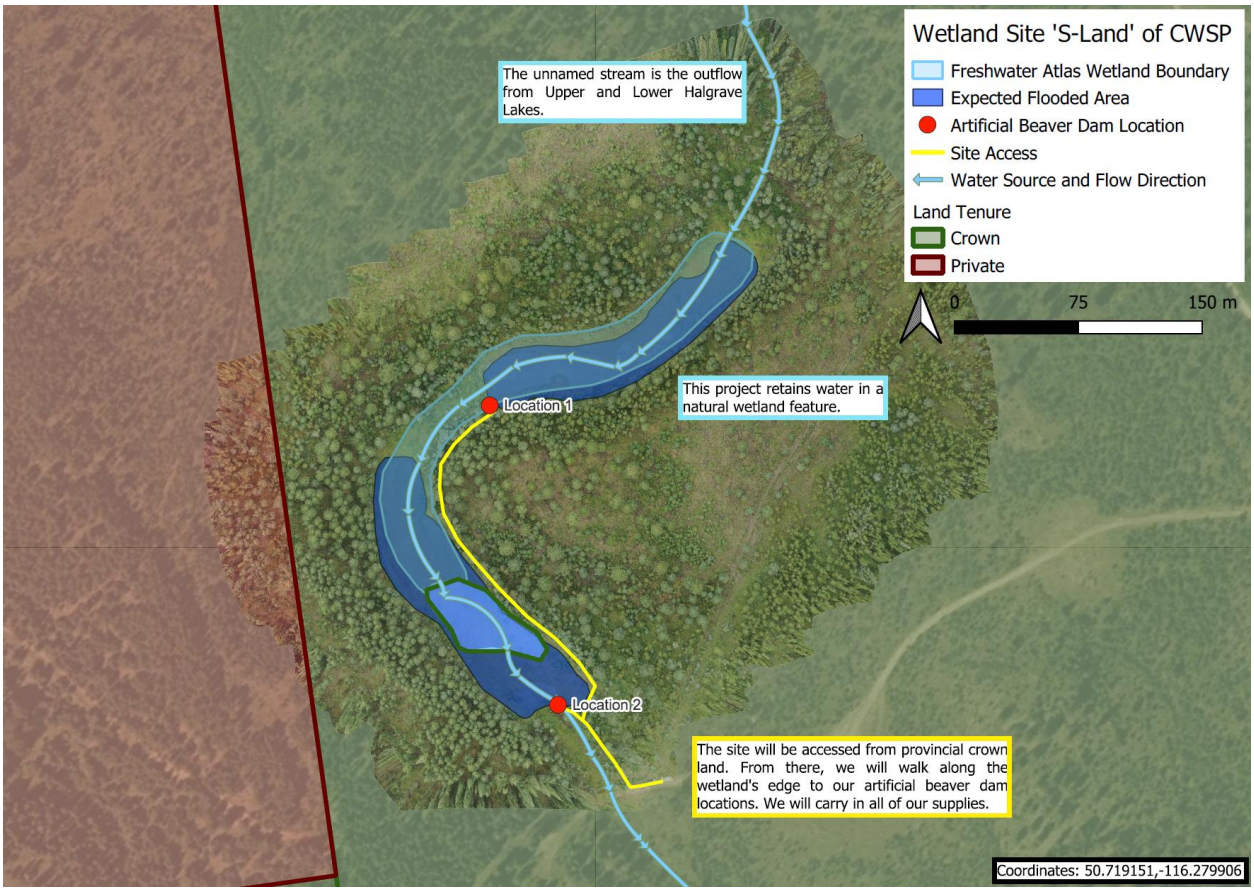


Figure 8. Site restoration plan for S-Land.

Section 2.1.1: Water Characteristics

The outflow of Halgrave Lakes flows through this restoration site (unnamed stream - FWA ROUTE ID 497318). This S4 classified stream averages 0.4 m in width (measurements taken above and below the FWA mapped wetland) and had an average flow rate of 0.028 m^3/s on August 9, 2023. We collected water quality data at this site on August 25, 2023 (1 location) and September 20, 2023 (2 locations), and values are presented in Table 4.

Table 4. Water quality data collected at restoration site S-Land during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
25-Aug-23	~	12.3	674.5	70.5	7.51	459.2	347.9	8.36	0.68
20-Sep-23	BD1 Pool	10	670.5	90.2	10.19	448	319	8.7	0.27
20-Sep-23	BD2 Pool	8.2	670.7	93.2	11.14	458.7	310.9	8.46	0.24

Section 2.1.2: Beaver Dam Profile and Repairs

Based on the profile of Beaver Dam 1 at S-Land, there is a 3.5 meter gap between 31.5 m (0.26 m above water) and 35 m (0.275 m above water) from the left bank that needs to be constructed (Figure 9). However, there are additional low spots along the length of the dam that would require some extra material in order to raise the water level in the wetland by 0.26 m. The total distance of the dam that would need additional material is 18.5 m, which includes regions 9 – 26.5 m and 29.5 – 30.5 m from the left bank. If we did not add additional material, the lowest elevation is at 16.5 m from the left bank and would only allow us to increase the water level by 0.109 m.

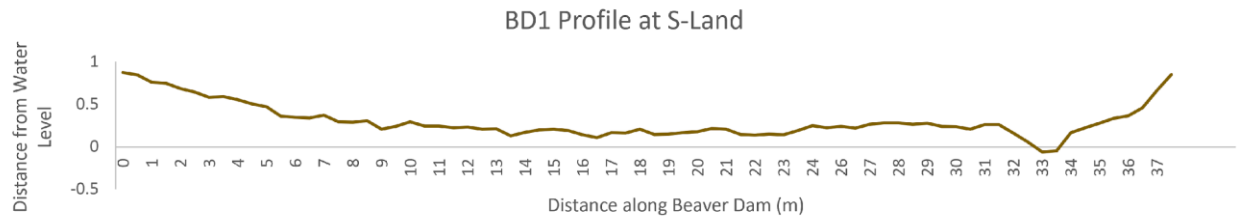


Figure 9. The upstream beaver dam (BD1) profile at S-Land restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

The downstream beaver dam, Beaver Dam 2, at S-Land has a 2.5 m gap between 18.5 m (0.37 m above water) and 21 m (0.49 m above water) from the left bank that requires a BDA repair (Figure 10). If we only did this small repair, we could raise the water level in the wetland by 0.415 m. However, if we increased the height of this main repair and added additional material, about 30 cm in height, to the left and right of this main BDA (7 - 18.5 m and 21 - 27 m) we could raise the water level in the wetland by 0.85 m.

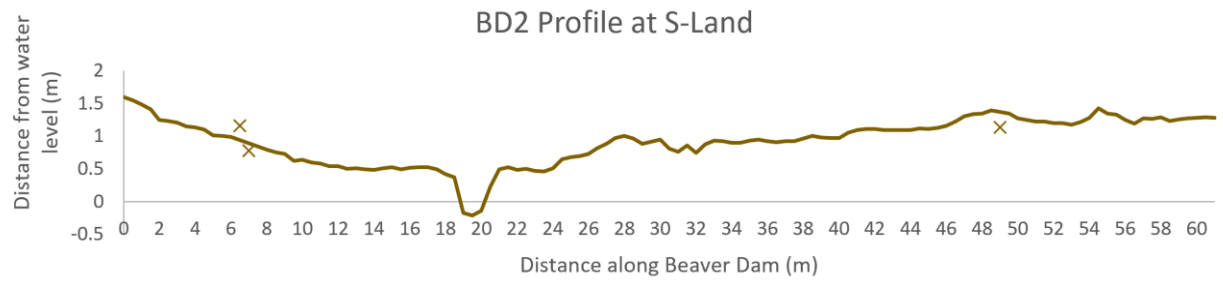


Figure 10. The downstream beaver dam (BD2) profile at S-Land restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.1.3: Ecological Values

The wetland is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and American Badger (jeffersonii subspecies) and is surrounded by ungulate winter range for Mule deer *(Odocoileus hemionus),* White-tailed deer (*O. virginianus)*, Elk *(Cervus elaphus),* Bighorn Sheep (*Ovis canadensis)*, and Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Grizzly Bear, Elk, and American Badger (Figure 11). Other wildlife observations at this site include a Northern saw-whet owl upstream of Beaver Dam 1 on September 20, 2023.

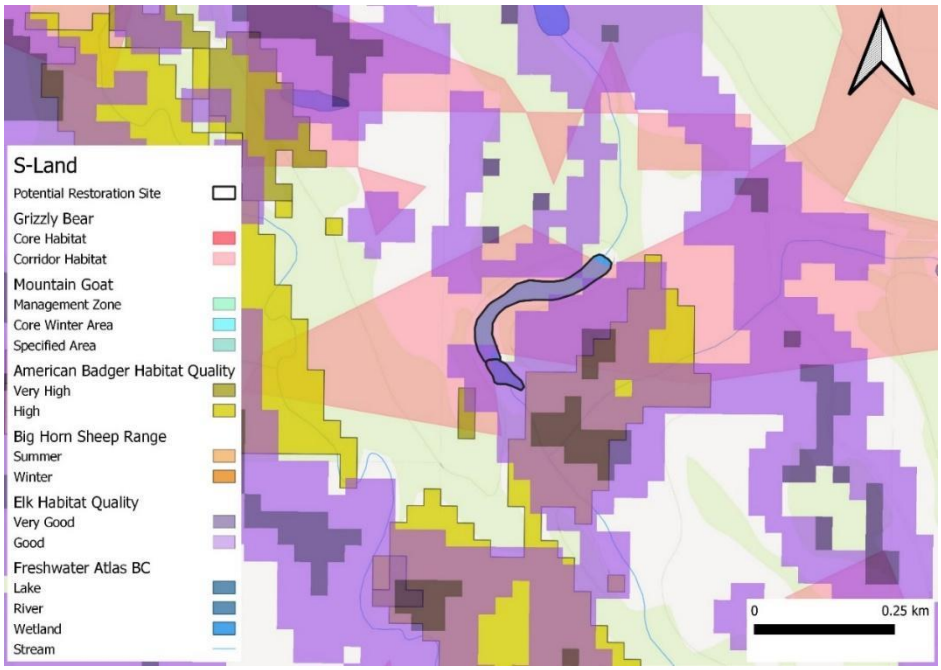


Figure 11. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the S-Land restoration site.

Darcie Quamme of Integrated Ecological Resources (IER) attended site with us on August 9, 2023 and collected four samples to be submitted for eDNA Metabarcoding Analysis at the University of Guelph - we are currently awaiting the results. This sample was collected to preliminarily address Objective 2.4 (***Use eDNA metabarcoding*** and eDNA qPCR technology ***to assist in monitoring effectiveness based on benchmarks****).*

Section 2.1.4: Vegetation

While mapping the vegetation communities at S-Land, we noticed that the FWA Wetland and Lake polygons (black line in Figure 12) encompass a slightly smaller area than the wetland basin observed on the landscape (coloured polygons in Figure 12) – due to this, area calculations of vegetation communities will not equal the area of FWA polygon. There is currently 0.27 ha of open water habitat and 0.03 ha of stream channel at S-Land. We expect to add depth to the existing open water and expand the flooded area to 1.3 ha. We observed cattail, sedge, grass, forbs, willow, and birch vegetation communities within the wetland basin – the dominant vegetation type was sedge which covers 0.7 ha of the wetland. The presence of willow (0.1 ha) and birch (0.04 ha) within the basin indicates slight drying of the wetland – these communities are observed at the back of the two remnant beaver pools. Dryer

upland forb species, totaling 0.4 ha of cover, were observed along wetland edges where the basin transitions into conifer overstory (Figure 12).

Figure 12. Pre-restoration vegetation communities at S-Land mapped during the summer of 2023.

There were 29 plant species identified in the 10 quadrat vegetation plots established in this wetland in September 2023. These species include *Betula sp., Calamagrostis canadensis, Carex aquatilis, C. flava, Carex sp., C. utriculata, Chara sp., Cirsium arvense, Cornus canadensis, Elymus glaucus, Fontinalis antipyretica, Hippurus vulgaris,* Lichen sp., *Mentha arvensis,* Moss sp., *Myriophyllum sp., Nymphaea tetragona, Picea engelmanni, Poaceae sp., Potamogeton natans, Potentilla diversifolia, Rosa sp., Salix sp., Solidago lepida, Typha latifolia, Typha sp., Utricularia macrorhiza,* and *Viola canadensis,* and an unidentified seedling.

Section 2.2: Beaver Channels (Freshwater Atlas WATERBODY_ID: 705005755, 705006605, and 705005932)

The Beaver Channels restoration site is along an unnamed creek and is located entirely on provincial crown land (Figure 13). We propose repairing two beaver dams within the perimeter of this wetland to restore 23,233 m^3 of open water, spread over 50,517 m^2. A permit application for a Section 11 Change Approval was submitted to the BC Government on January 4, 2024 (Reference Number: 464746) and we are still awaiting review and feedback.

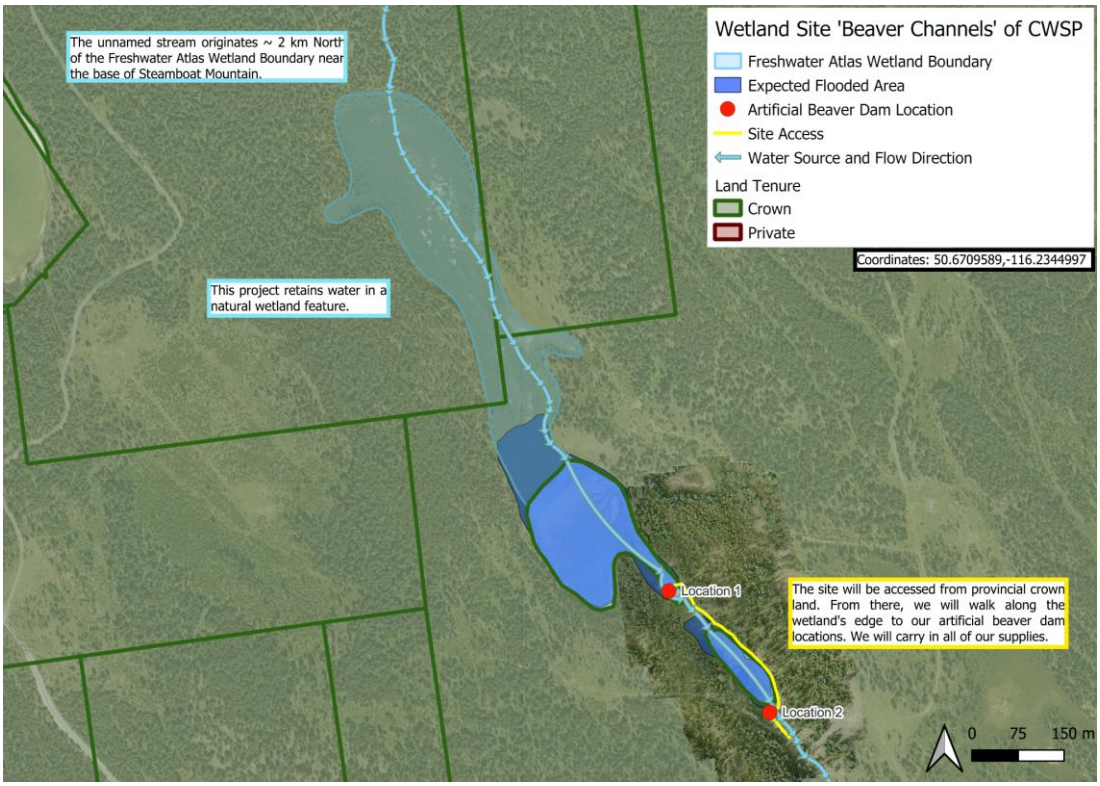


Figure 13. Site restoration plan for Beaver Channels.

Section 2.2.1: Water Characteristics

An unnamed stream (FWA ROUTE ID 594791) originates at the base of Steamboat Mountain, ~ 2 km North of the site, then flows south through this restoration site. During a site visit on June 7th 2023, water was observed flowing out of the most southerly FWA polygon - stream width was approximately 20 cm wide and 5 cm deep. However, on all other site visits (July 24th, August 9th, August 30th, and September 22nd) there was no water observed flowing in the mapped stream, meaning this S6 classified stream is ephemeral. We collected water quality data at this site on August 30, 2023 - the values are presented in Table 5.

Table 5. Water quality data collected at restoration site Beaver Channels during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
30-Aug-23	~	15.5	670.7	75.3	7.5	865	706	9.33	0.68

Section 2.2.2: Beaver Dam Profile and Restoration

Based on the profile of Beaver Dam 1 at Beaver Channels, there is a 6.5 meter gap between 15.5 m (1.12 m above water) and 22 m (0.97 m above water) from the left bank that needs to be constructed (Figure 14). However, there are additional low spots along the length of the dam that would require some extra material in order to raise the water level in the wetland by 1 m. The total distance of the dam that would need additional material is 9.5 m, which extends from 22 m to 31.5 m from the left bank. If we did not add additional material, the lowest elevation is at 29.5 m from the left bank and would only allow us to increase the water level behind the dam by 0.74 m.

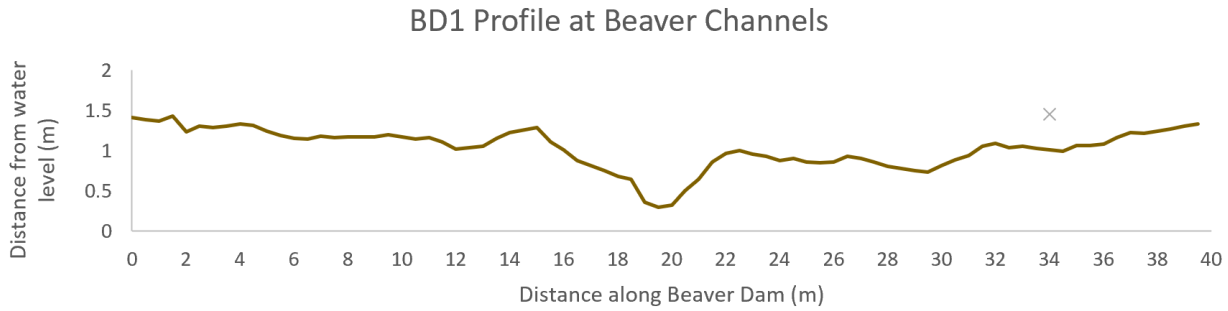


Figure 14. The upstream beaver dam (BD1) profile at Beaver Channels restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Based on the profile of Beaver Dam 2 at Beaver Channels, there is a 5 meter gap between 10.5 m (0.37 m above water) and 15.5 m (0.42 m above water) from the left bank that needs to be constructed (Figure 15). However, there are additional low spots along the length of the dam that would require some extra material in order to raise the water level in the wetland by 0.46 m. The total distance of the dam that would need additional material is 6 m, which occurs in two different sections - 2 m to 4.5 m, 5.5 m to 9 m from the left bank. If we did not add additional material, the lowest elevation is at 3 m from the left bank and would only allow us to increase the water level behind the dam by 0.31 m.

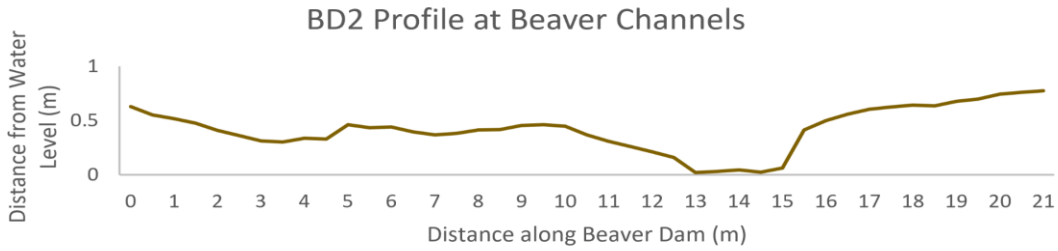


Figure 15. The downstream beaver dam (BD2) profile at Beaver Channels restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.2.3: Ecological Values

The wetland is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and American Badger (jeffersonii subspecies) and is surrounded by ungulate winter range for Mule deer *(Odocoileus hemionus),* White-tailed deer (*O. virginianus)*, Elk *(Cervus elaphus),* Bighorn Sheep (*Ovis canadensis)*, and Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Grizzly Bear, Elk, and American Badger (Figure 16). On the initial site visit on June 7, 2023, a Columbia Spotted Frog was observed in the outflow of the southernmost polygon.

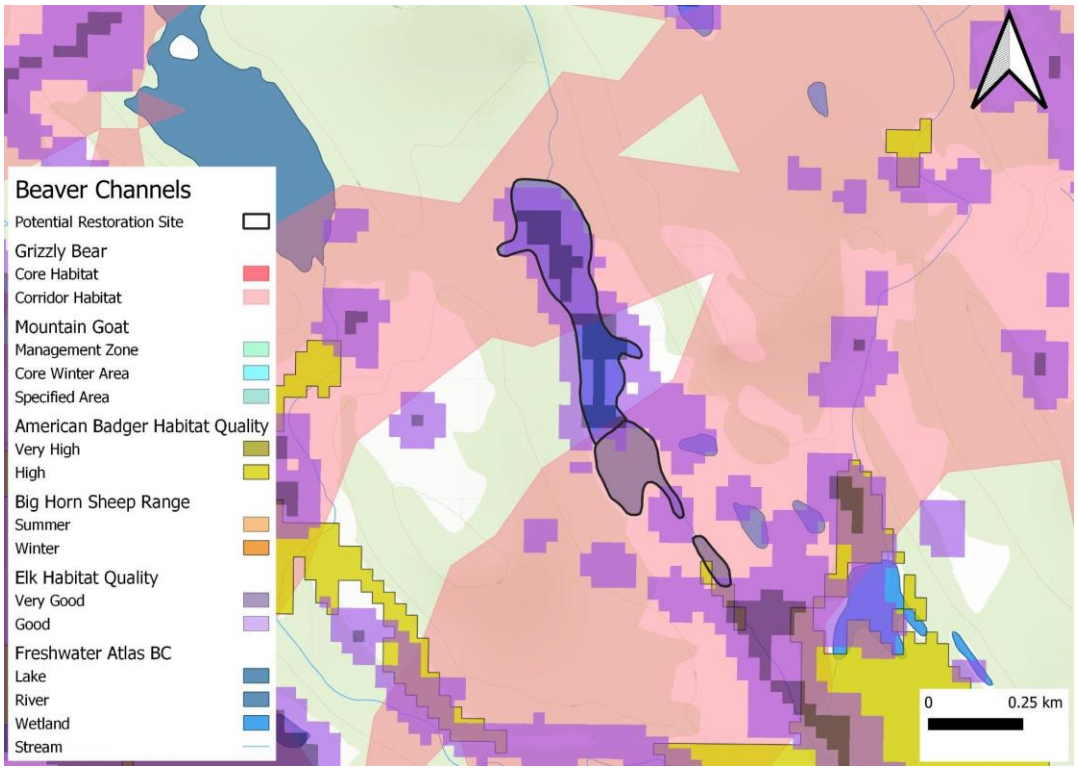


Figure 16. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Beaver Channels restoration site.

Section 2.2.4: Vegetation

Vegetation communities were mapped during a site visit on August 30, 2023 (Figure 17). We were unable to collect drone imagery for this entire restoration site to create a stitched orthomosaic, so the vegetation community mapping is approximated from Google Satellite imagery and field notes. We will return to this site in 2024 to collect drone imagery and subsequently remap the vegetation communities to increase the accuracy. There are small discrepancies between the FWA boundaries and our vegetation community mapping, which means the area calculations of vegetation communities will not equal the area of the FWA polygon.

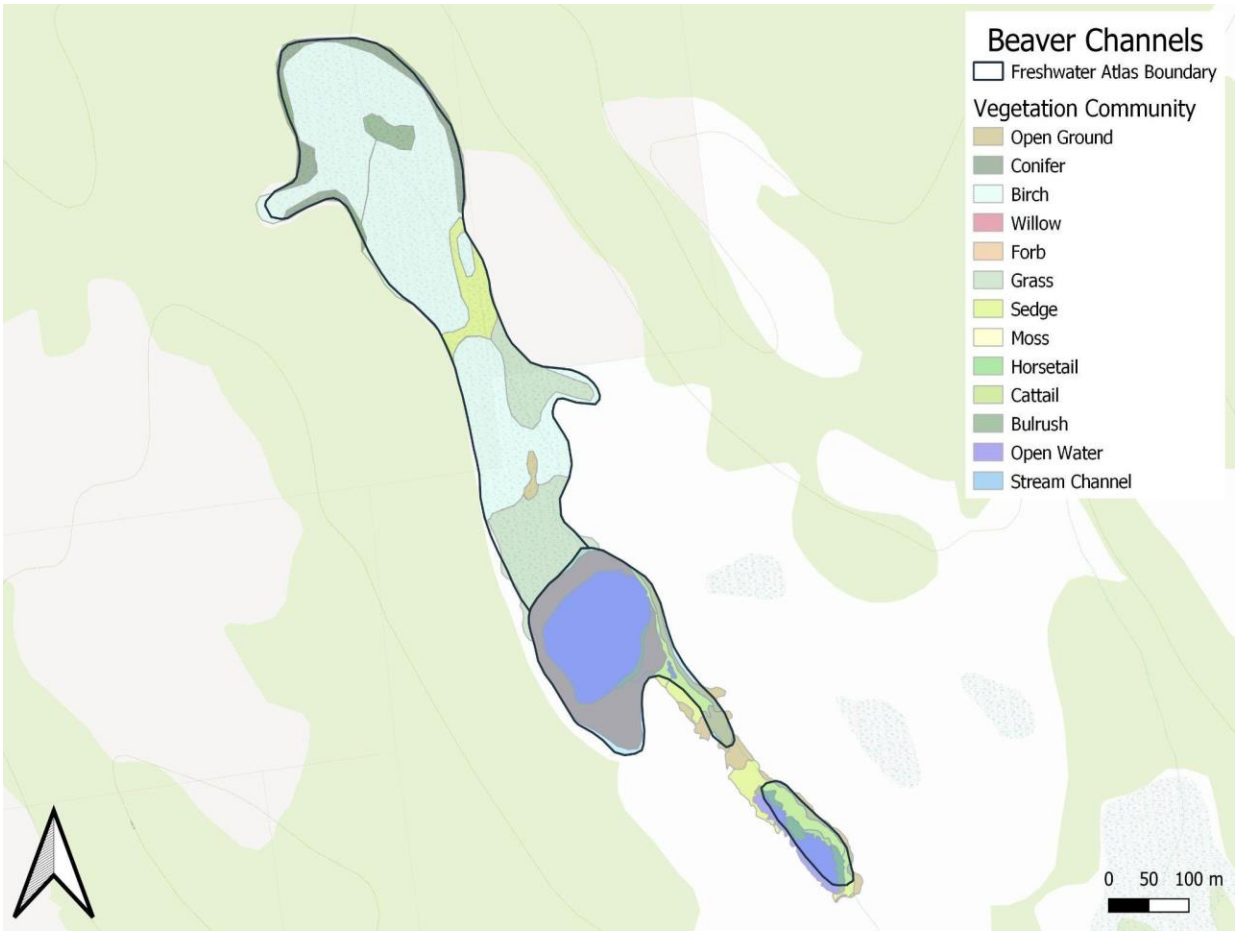


Figure 17. Pre-restoration vegetation communities at Beaver Channels mapped during the summer of 2023.

There is currently 1.76 ha of open water habitat at Beaver Channels. We expect to add depth to the existing open water and expand the flooded area to 5.1 ha. We observed bulrush, cattail, sedge, grass, willow, birch, and conifer vegetation communities within the wetland basin. The dominant vegetation type was birch (6.2 ha), which is largely due to the uppermost polygon which did not contain any signs of water. The lower two FWA polygons are mapped as lakes, which as mentioned earlier in Overview analysis of wetlands along the western side of Columbia Valley is suspected to have been mapped over areas of open water. These polygons are no longer entirely composed of open water

which indicates a loss of this habitat type within these wetlands which will be restored once our BDAs are constructed.

There were 15 plant species identified in the 10 quadrat vegetation plots established in this wetland in September 2023. These species include Betula sp., Carex aquatilis, C. utriculata, Chara sp., Hippurus vulgaris, Juncus mertensianus, Mentha arvensis, Myriophyllum sp. Poaceae sp., Potentilla sp., Schenoplectus tabermontani, Stuckenia pectinata, Typha sp., Viola canadensis, and an unidentified seedling.

Section 2.3: Northbound (Freshwater Atlas WATERBODY_ID: 705005960)

The Northbound restoration site is at the confluence of two unnamed creeks (no flow observed in northern creek) and is located entirely on provincial crown land (Figure 18). We propose repairing two beaver dams within the perimeter of this wetland to restore 6673 $m^3$of open water, spread over 13776 m^2. The culvert that is located at the nearest road crossing of the south stream is no longer functioning properly and would benefit from replacement. A permit application has been prepared but won't be submitted until we receive feedback from the province on other submitted applications.

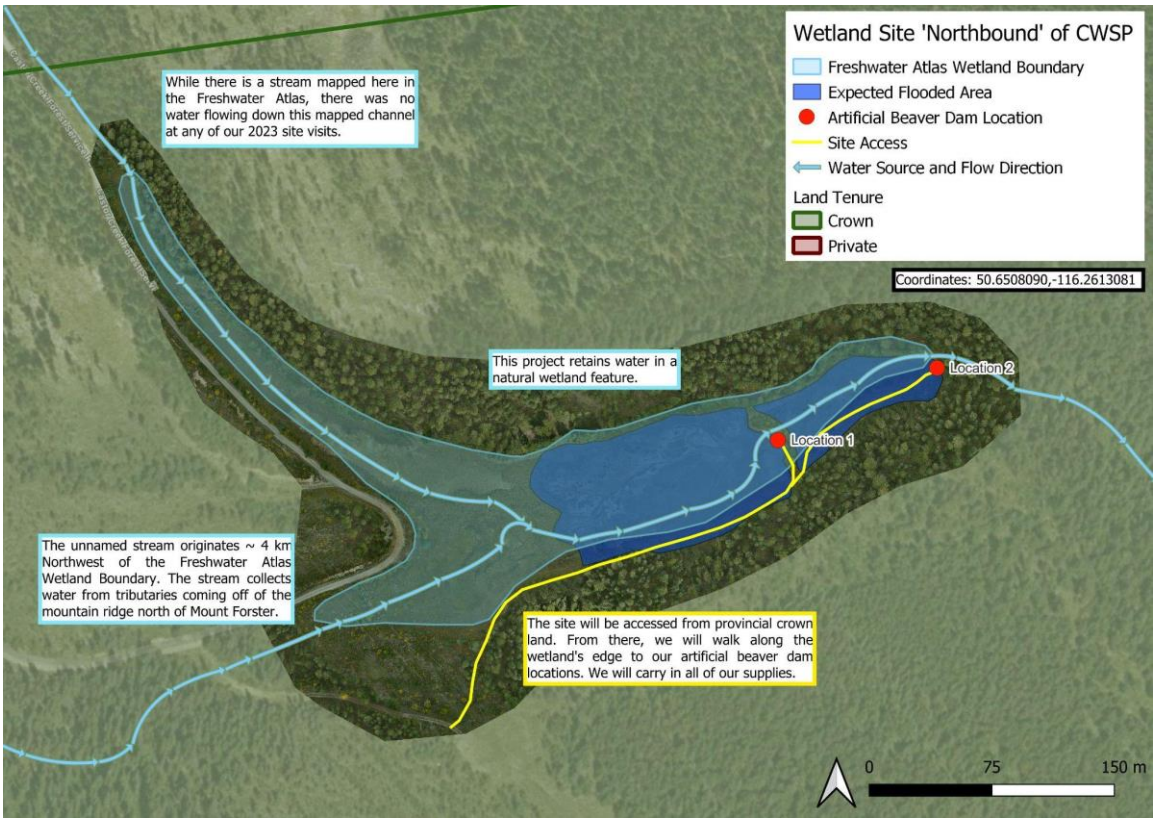


Figure 18. Site restoration plan for Northbound.

Section 2.3.1: Water Characteristics

Although there are two unnamed streams that meet in the boundary of this wetland, the northern tributary (FWA ROUTE ID 542844) did not have flow on any site visits. Where stream flow was measured, the southern stream (FWA ROUTE ID 598162) was 0.66 m wide and had a flow rate of 0.006 m^3/s on August 28, 2023. We collected water quality at two locations at this site on September 19, 2023 - the values are presented in Table 6.

Table 6. Water quality data collected at restoration site Beaver Channels during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
19-Sep-23	BD1 Pool	9.4	667	97.6	11.25	509	354.2	8.77	0.3
19-Sep-23	Creek	7.6	666.8	89.9	10.75	504	335.9	8.92	0.12

Section 2.3.2: Beaver Dam Profile and Restoration

The main repair will be focused in a 1.5 m section, at 36 m (0.40 m above water) to 37.5 m (0.39 above water) from the left bank, where the existing degraded beaver dam is undercut and the stream flows through (Figure 19). We will have to excavate this section of dam, likely with 1 - 2 m extra on each side to ensure structural stability, and then build the main BDA (3.5 m to 5.5 m repair) here. In order to increase the water level by 0. 94 m additional material would need to be added to 8.5 m of the dam (from 32.5 m to 40.5 m and from 47 to 47.5 m from left bank). If we did not add additional material to these low spots, we would only be able to raise the water in the wetland by 0.39 m.

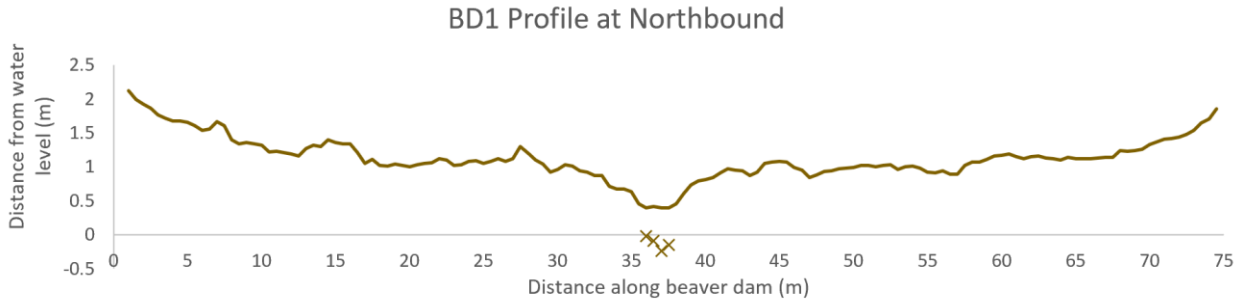


Figure 19. The upstream beaver dam (BD1) profile at Northbound restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

The second beaver dam in the perimeter of this wetland has a 3 m main gap between 22 m (1.15 m above water) and 25 m (1.05 m above water) - Figure 20. However, there is an additional low spot between 9 m and 13 m from left bank that would require material to raise the water in the wetland by 1.05 m. If we did not add this extra material, the lowest dam height is at 10.5 m and would only allow us to raise the water level by 0.72 m.

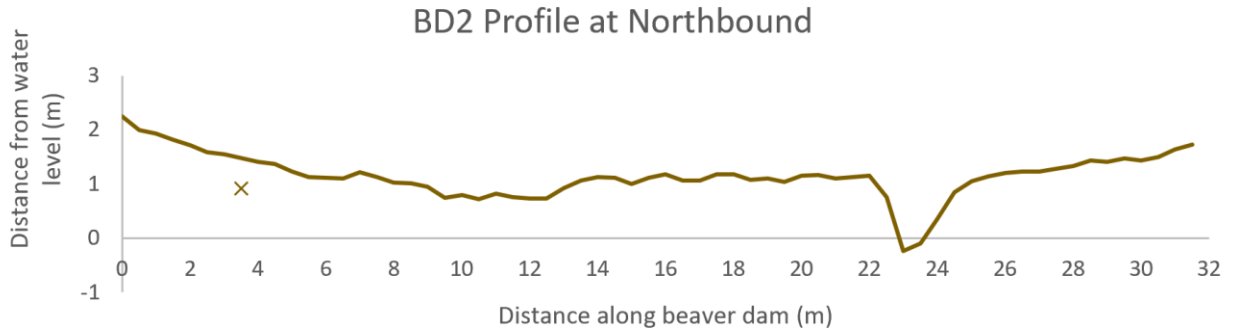


Figure 20. The downstream beaver dam (BD2) profile at Northbound restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.3.3: Ecological Values

The wetland is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and is surrounded by ungulate winter range fo**r** Mule deer *(Odocoileus hemionus),* White-tailed deer (*O. virginianus)*, Elk *(Cervus elaphus),* Bighorn Sheep (*Ovis canadensis)*, and Moose (*Alces alces).* The wetland and surrounding area provides important habitat for Kootenay Conservation Program's identified wildlife species – specifically Grizzly Bear and Elk (Figure 21). Other wildlife observed in the wetland include a Wilson's Snipe within the wetland boundary and a Northern Goshawk (potentially an adult and a juvenile calling) on the southwest hill above the wetland - both occurrences were observed on August 15, 2023. We will return to site in 2024 to determine whether the adjacent upland habitat is a potential breeding site for Northern Goshawk.

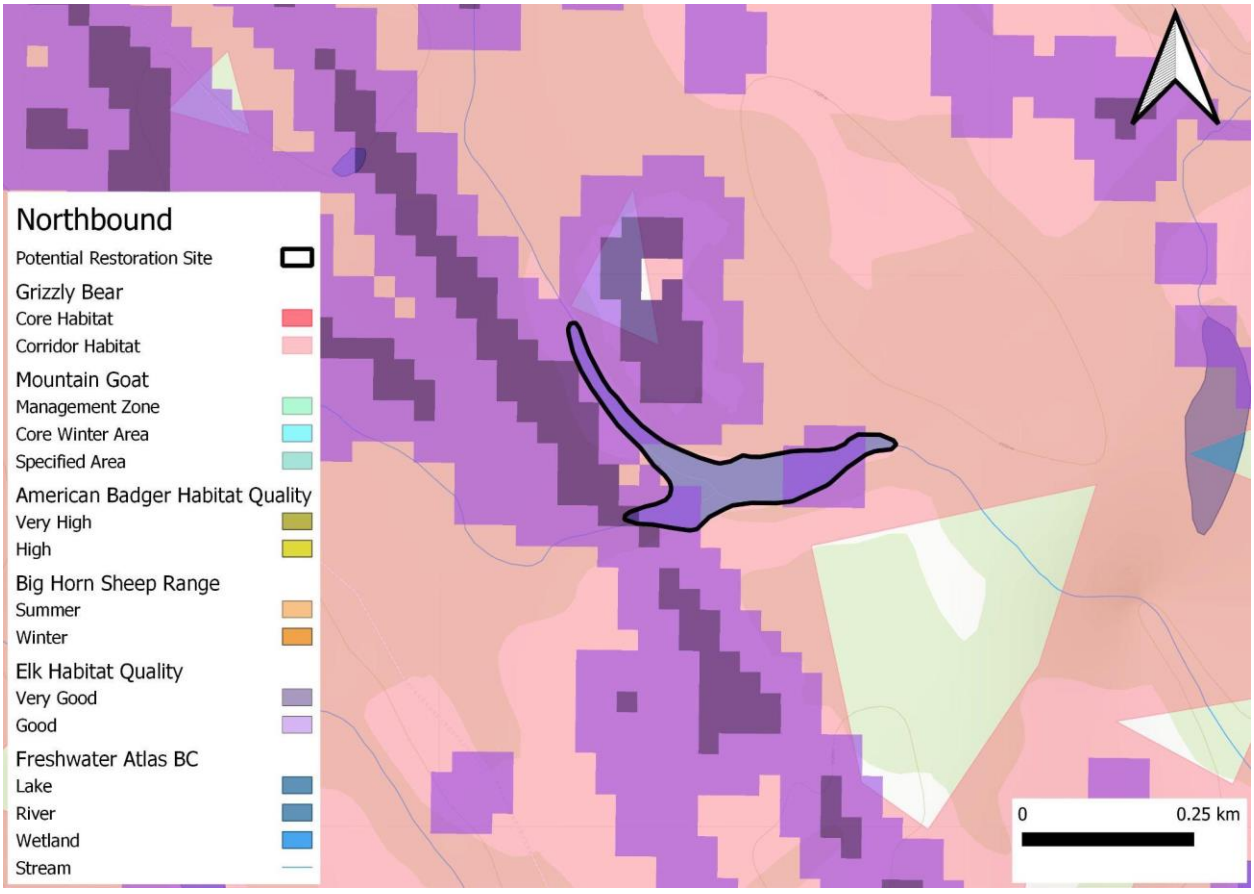


Figure 21. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Northbound restoration site.

Section 2.3.4: Vegetation

Vegetation communities were mapped during a site visit on September 18, 2023 (Figure 22). There are small discrepancies between the FWA boundaries and our vegetation community mapping, which means the area calculations of vegetation communities will not equal the area of the FWA polygon.

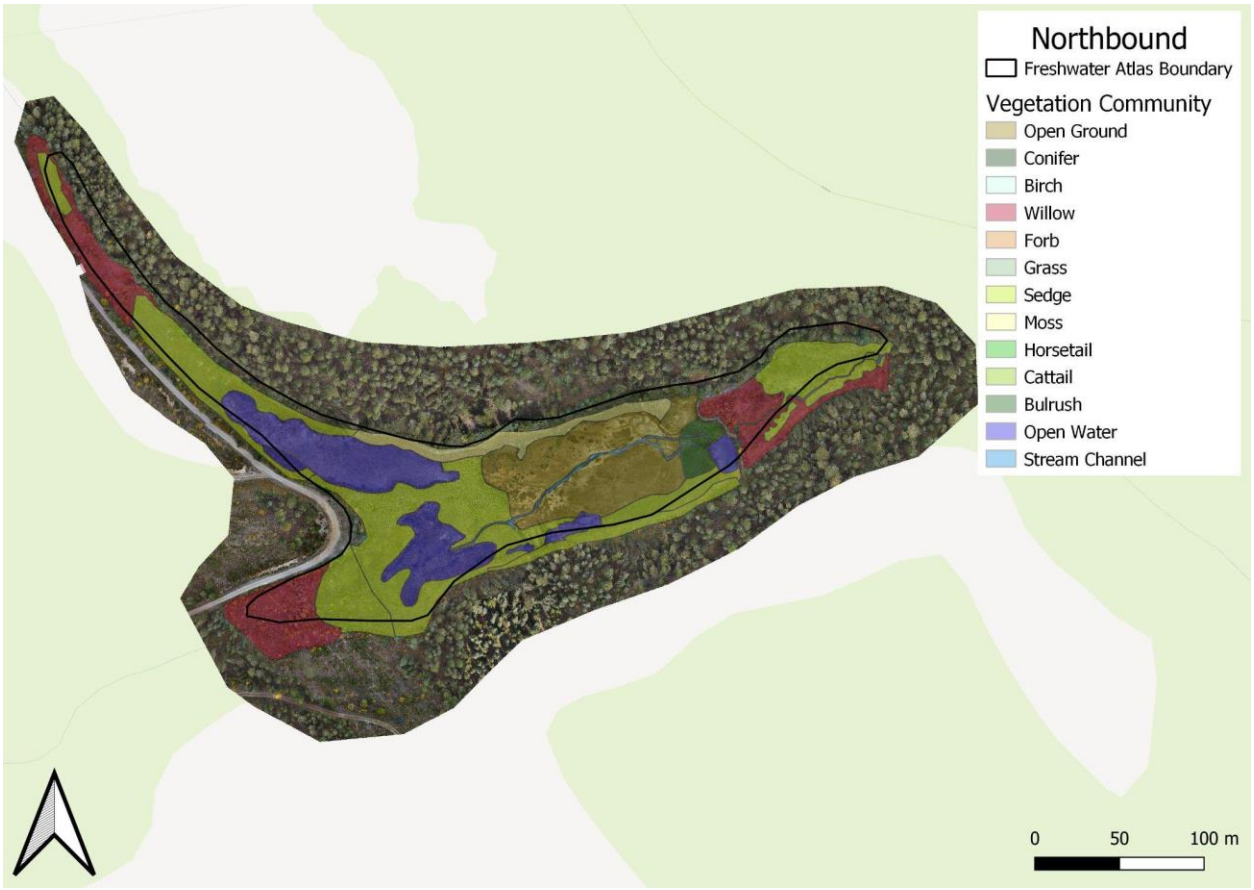


Figure 22. Pre-restoration vegetation communities at Northbound mapped during the summer of 2023.

There is currently 0.56 ha of open water habitat at Northbound, all of which is located behind Beaver Dam 1. We expect to add depth to the existing open water and expand the flooded area to 1.38 ha. We observed bulrush, cattail, sedge, moss, and willow vegetation communities within the wetland basin. Overall, the dominant vegetation type was sedge (1.27 ha), which was followed by willow (0.58 ha) and open ground (0.4 ha). We expect to see the most dramatic vegetation changes behind Beaver Dam 2 as this dam is no longer holding any open water on the landscape.

There were 21 plant species identified in the 8 quadrat vegetation plots established in this wetland in August 2023. These species include *Arctostaphylos ura-ursi*, *Carex aquatilis, C. aurea, C. utriculata, Chara sp., Eleocharis palustris, Fontinalis antipyretica, Hippuris vulgaris, Juncus mertensianus,* a species of Liverwort, *Mentha arvensis, Picea engelmanni, Pyrola chlorantha, Salix sp., Schenoplectus tabermontani, Sphagnum sp., Stuckenia pectinata, Typha latifolia, Utricularia macrorhiza, Viola canadensis,* and an unidentified seedling.

Section 2.4: Upper and Lower Double Dam (Freshwater Atlas WATERBODY_ID: 705000207, 705005982, 705005990, 705006635, 705006513)

The Double Dam restoration area is composed of two restoration sites, termed Upper Double Dam and Lower Double Dam. Due to close proximity, these sites have been mapped and described together in this section of the report; however, since the associated site FWA wetland polygons are not connected these are counted as two restoration sites. The Upper Double Dam restoration site is composed of 4 FWA polygons (WATERBODY_ID: 705000207, 705005982, 705005990, 705006635), and the Lower Double Dam restoration site is FWA WATERBODY_ID 705006513. There is a confluence of two unnamed creeks (FWA ROUTE_ID: 568348, 587312) within Upper Double Dam, which then flow out as one creek through the Lower Double Dam site. Both of these sites are located entirely on provincial crown land (Figure 23). We propose repairing one beaver dam at each site to restore a total of 5760 $m^3$of open water, spread over 16,655 m^2 within this creek drainage.

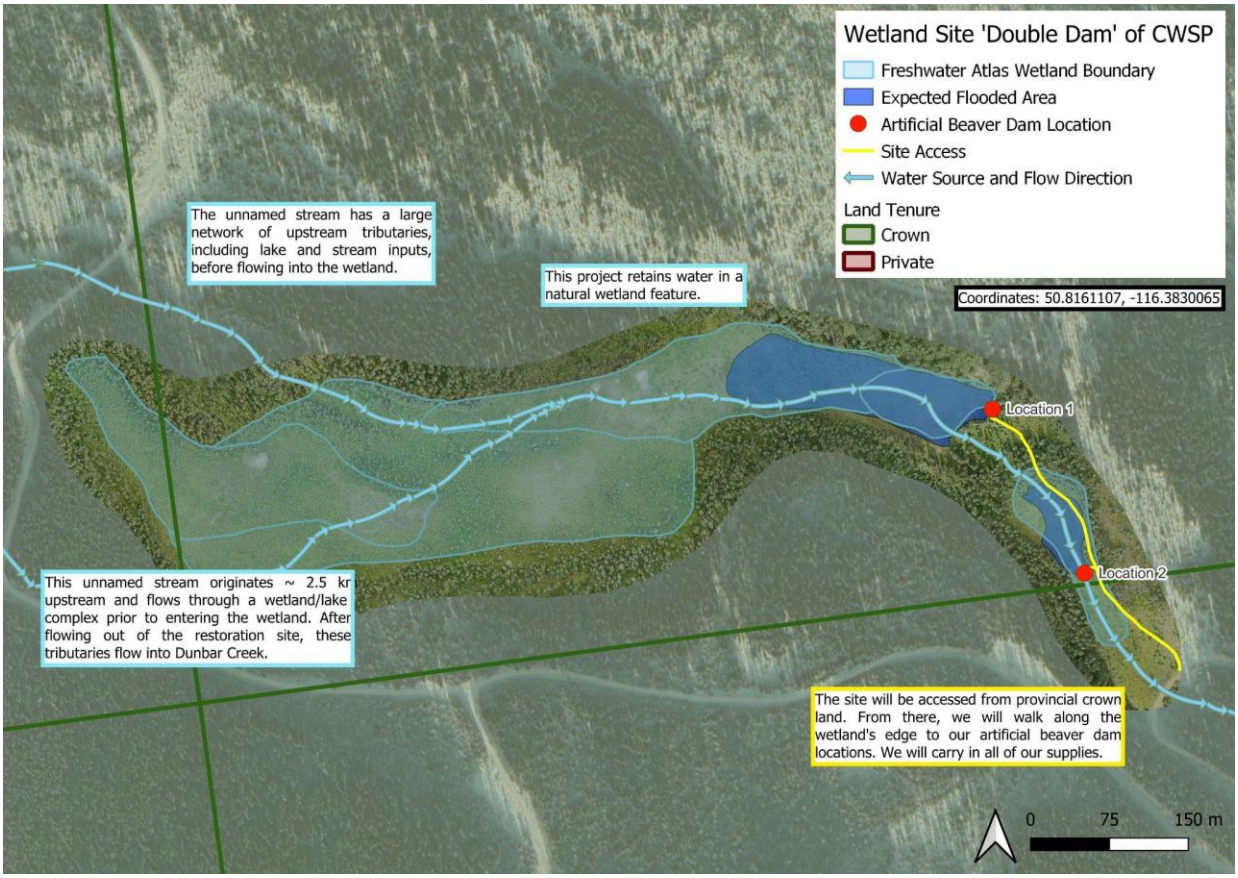


Figure 23. Site restoration plan for Upper and Lower Double Dam.

Section 2.4.1: Water Characteristics

Stream flow was measured at two locations, just downstream of the remnant beaver dams we propose repairing on August 28, 2023. The stream averaged 0.39 m wide and had a stream flow of 0.0002 m3/s. We collected water quality at four locations within this system - at the inflow, outflow, and pools behind associated beaver dams on September 20, 2023 (Table 7).

Table 7. Water quality data collected at restoration sites Upper and Lower Double Dam during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
20-Sep-23	Inflow	7	669.4	85.8	10.42	598	391.8	8.67	3,92
20-Sep-23	Upper DD	7.6	670	64.3	7.6	654	435	8.32	0.14
20-Sep-23	Lower DD	7.1	670.2	86.1	10.4	606	399.4	8.53	0.42
20-Sep-23	Outflow	8	670	79.3	9.37	612	412	8.33	0.26

Section 2.4.2: Beaver Dam Profile and Restoration

There are multiple repairs needed to restore the degraded beaver dam at Upper Double Dam (Figure 24). The largest gaps that require repairs are from 30 m to 40.5 m, 47.5 m to 50 m, 60 m to 67.5 m, and 76 m to 78 m. These repairs vary in height from 0.5 m to 0.9 m and are large enough that they should receive post, wicker weave, and burlap sack constructions. The steam channel is currently flowing through the dam between 34.5 m to 36 m and at 65 m from the left bank. There are other areas of the dam that would need additional material added in order to raise the water level by 0.69 m. These sections include 28 m to 29.5 m, 41 m to 47 m, 79 m to 83.5 m, and 90 m to 93.5 m from the left bank. In addition, there are a few sections (at 46.5 m, 51 m, 76.5 m, and 89.5 m from left bank) that are undercut or are compromised by large conifer roots that will need extra material to ensure structural stability of the dam. Therefore, this dam would require 22.5 m of large, 15.5 m of small, and four areas of internal repairs. If the smaller repairs weren't made, the water level would only be increased by 0.43 m.

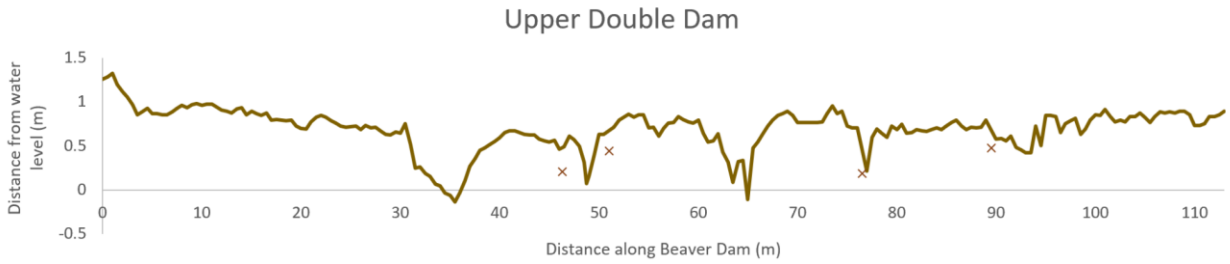


Figure 24. The beaver dam profile at Upper Double Dam restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

The beaver dam in Lower Double Dam only requires a few small repairs, totaling 4 m in BDA construction and approximately 5 m of additional fill (Figure 25). There are two 1 m gaps from 16 m to 17 m and from 20.5 m to 21.5 m, and a 2 m gap from 22.5 to 24.5 which will require beaver dam analogue constructions. The additional low spots along the dam that will require extra fill material occur at 12.5 m, from 14 m to 16 m, 21.5 m to 22.5 m, 24.5 m to 25 m, and at 26m and 27 m from the left bank. Once all of the repairs are complete, we will be able to raise the water level in the wetland by 0.7 m.

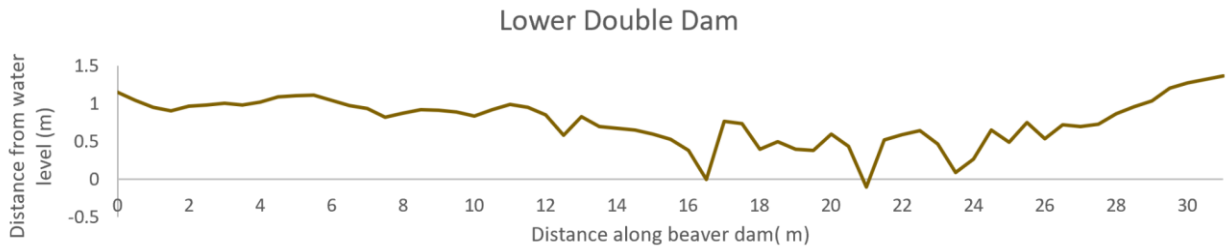


Figure 25. The beaver dam profile at Lower Double Dam restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.4.3: Ecological Values

This restoration complex (Upper and Lower Double Dam) is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and American Badger. It is also surrounded by ungulate winter range for Mule deer *(Odocoileus hemionus)*, Elk *(Cervus elaphus),* Bighorn Sheep (*Ovis canadensis)*, and Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Elk and American Badger (Figure 26).

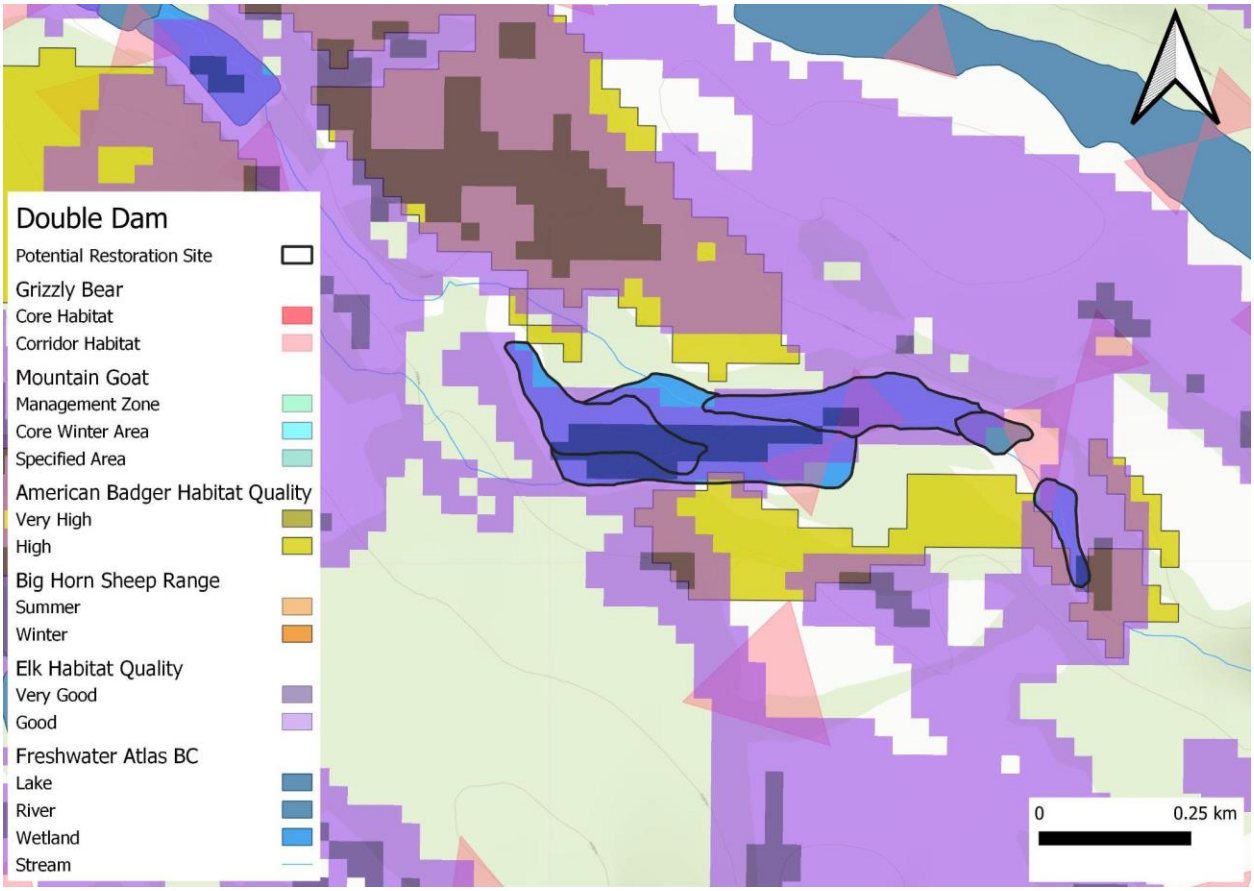


Figure 26. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Double Dam restoration complex.

Section 2.4.4: Vegetation

Vegetation communities were mapped during site visits on August 14 and August 29, 2023 (Figure 27). There are small discrepancies between the FWA boundaries and our vegetation community mapping, which means the area calculations of vegetation communities will not equal the area of the FWA polygon.

Figure 27. Pre-restoration vegetation communities at Upper and Lower Double Dam mapped during the summer of 2023.

There is currently 0.1 ha of open water in the Upper Double Dam restoration site. Our beaver dam construction will add depth to this existing area and expand the flooded area and increase this area to 1.38 ha. The mapped area that we expect to flood looks very similar to open water visible behind this beaver dam in provincial air photos from 1980 - 1989. Historic air photos also show another open water pond further upstream within this restoration site; however, that lost pond is not addressed in our restoration plans. The most common vegetation community found at Upper Double Dam was birch (7.6 ha) as a majority of this wetland is dry and grown in with shrubs. The other most common vegetation types were sedge (2.0 ha) and willow (1.1 ha). Bulrush, cattail, horsetail, forb, and conifer vegetation communities were also found within the wetland basin.

There were 21 plant species identified in the five quadrat vegetation plots established in Upper Double Dam in September 2023. These species include *Agastache urticifolia, Betula sp., Carex aquatilis, C. flava, C. utriculata, Carex sp., Chara sp., Equisetum hyemale., Juncus arcticus, J. mertensianus,* Liverwort sp.,

Lycopus uniflorus, Mentha arvensis, Picea engelmanni, Potentilla diversifolia, Salix sp., Schenoplectus tabermontani, Typha sp,., Utricularia intermedia, Viola canadensis, and an unidentified seedling.

The dominant vegetation community found in Lower Double Dam was conifer trees (0.33 ha); however, this is likely due to the FWA polygon including a large amount of upland forest within the boundary. When comparing the 2023 drone orthoimagery to provincial air photos from 1980, the band of conifers separating the Upper and Lower Double Dam sites looks to be of similar size. The second dominant vegetation type was sedge (0.26 ha) - cattail, horsetail, grass and willow vegetation communities were also at this site. There is currently no open water within this wetland boundary, but provincial air photos do show open water in this wetland up to 1989 (the next photo is taken in 1999 and open water is not visible).

There were 15 plant species identified in the 4 quadrat vegetation plots established in Lower Double Dam in September 2023. These species include *Carex aquatilis, C. utriculata, Equisetum sp, Fontinalis antipyretica, Fragaria verginiana, Lonicera sp., Lycopus uniflorus, Mentha arvensis, Picea engelmanni, Pinus sp., Poaceae sp., Potentilla diversifolia, Salix sp, Typha sp., Viola canadensis,* and an unidentified seedling.

Section 2.5: Limbo (Freshwater Atlas WATERBODY_ID: 705006322)

The Limbo restoration site is along an unnamed stream (FWA ROUTE ID: 548673) and is located entirely on provincial crown land (Figure 28). We propose repairing one beaver dam within the perimeter; however, we are still deciding whether to proceed with a BDA construction or with a larger mechanical restoration method. With a low-tech construction we could realistically restore 1716 m^3 of open water spread over 5720 m^2. However, if we completed a restoration with mechanical equipment, we could repair a larger, and higher, section of dam that could restore 6,693 m^3 of open water spread over 9232 m^2 - this would allow us to store approximately 4 times the amount of water. In addition, equipment access to this site would not have any impact on the wetland as it is immediately adjacent to a road for access, can be approached from the downstream side of the beaver dam, and equipment would only need to walk ~ 50 m through upland habitat to reach the site.

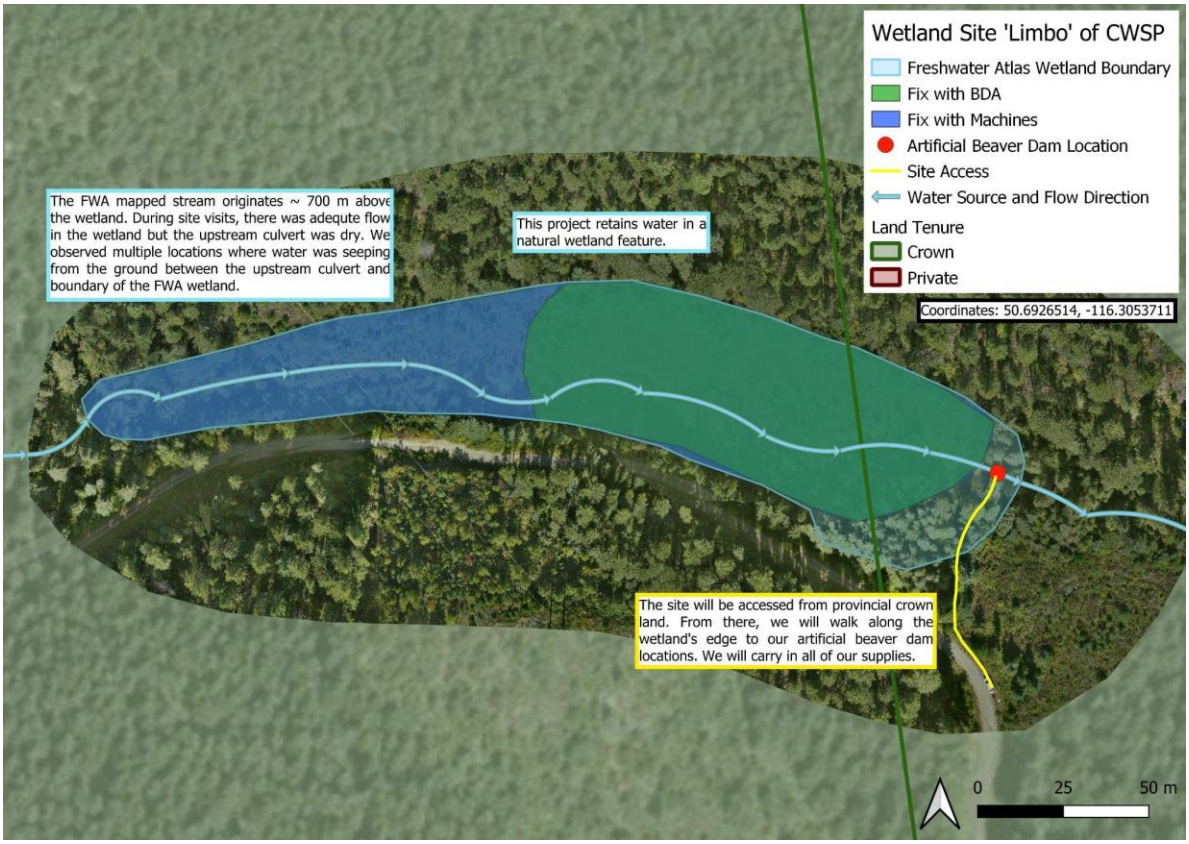


Figure 28. Site restoration plan for Limbo.

Section 2.5.1: Water Characteristics

The unnamed stream (FWA ROUTE ID: 548673) that flows through the wetland originates approximately 700 m above the wetland. However, during site visits we observed adequate flow in the wetland but no flow at the upstream culvert. While walking along the stream route, we found multiple locations where water was flowing up from underground. Stream flow was measured within the wetland boundary where water flows through the degraded beaver dam on August 28, 2023. The stream was 1.54 m wide and had a stream flow of 0.05 m^3/s. We collected water quality at two locations within this system on two different days - values are presented in Table 8.

Table 8. Water quality data collected at restoration site Limbo during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
19-Sep-23	Pond	6.3	665.6	90.1	11.12	385	247.4	8.53	0.0
21-Sep-23	~	6.4	671.6	87	10.71	385.6	248.4	8.42	-0.13

Section 2.5.2: Beaver Dam Profile and Restoration

The remnant beaver dam present at the Limbo restoration site offers a unique opportunity where mechanical construction could greatly improve the amount of open water stored on the landscape. If we were to only use BDA construction methods, we could realistically repair a 2.5 m gap from 39 m to 41.5 m from the left bank (Figure 29). This repair would also require some additional material from 35.5 m to 39 m and 41.5 m to 43 m. This construction would allow us to raise the water level by 0.6 m. Using mechanical equipment to repair a larger gap from 33 m to 50 m from the left bank and add additional material at low sections between 19 m and 33 m, we could raise the water level by 1.45 m (Figure 29).

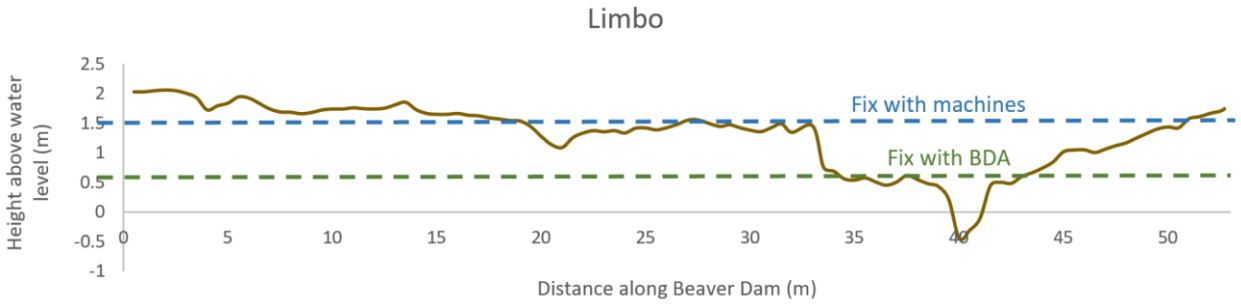


Figure 29. The beaver dam profile at Limbo restoration site. The height and area that would require fixing is illustrated for both BDA construction (green) and construction with machinery (blue) by the area between the line and profile of the beaver dam. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.5.3: Ecological Values

This restoration site is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and is surrounded by ungulate winter range for Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Elk (Figure 30).

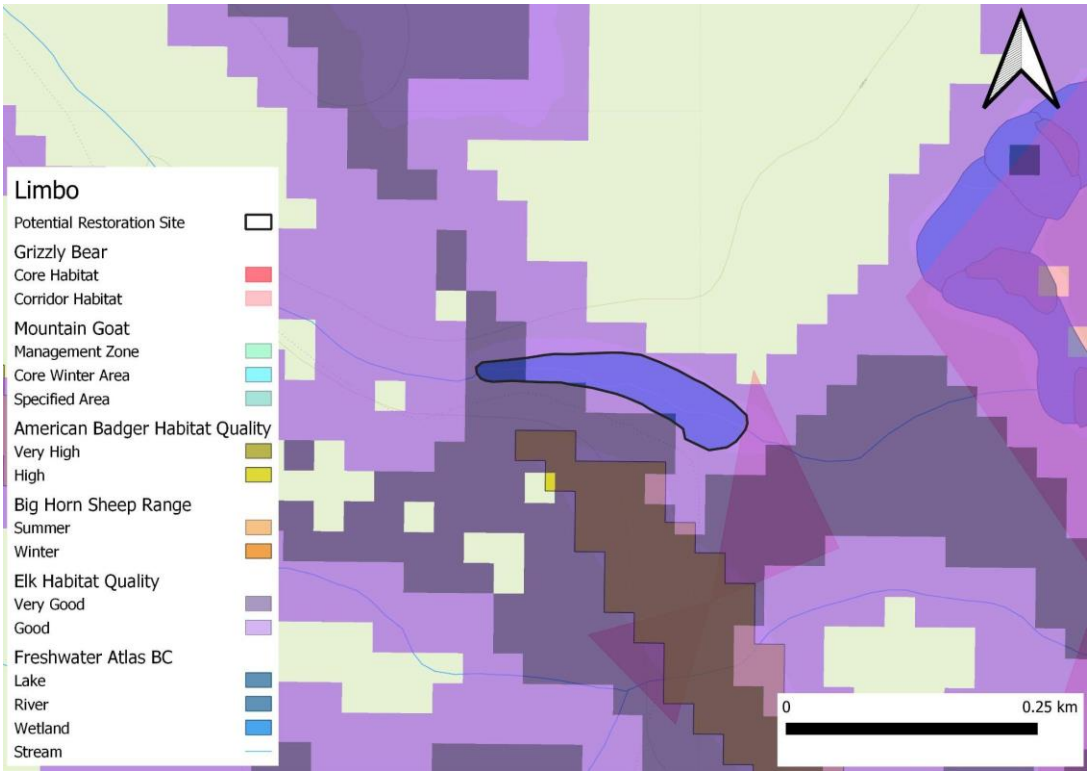


Figure 30. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Limbo restoration site.

Section 2.5.4: Vegetation

Vegetation communities were mapped during site visits on September 21, 2023 (Figure 31). There are small discrepancies between the FWA boundaries and our vegetation community mapping, which means the area calculations of vegetation communities will not equal the area of the FWA polygon.

Figure 31. Pre-restoration vegetation communities Limbo mapped during the summer of 2023.

There is currently 0.01 ha of open water in the Limbo restoration site. Our beaver dam construction will add depth to this existing area and expand the flooded area to 0.5 or 0.9 ha (pending restoration method decision). The dominant vegetation community found at Limbo was conifer (0.54 ha), followed by sedge (0.18 ha) and birch (0.11 ha). Moss, grass, and small rush vegetation communities were also observed in the wetland basin.

There were 18 plant species identified in the six quadrat vegetation plots established in Limbo in September 2023. These species include *Anaphalis margaritacea, Carex aquatilis, C. flava, C. utriculata, Eleocharis palustris, Elymus glaucus, Eucephalus engelmannii, Fragaria virginiana,* Liverwort sp., Moss sp., *Picea engelmanni, Pinus sp., Populus tremuloides, Rosa sp., Salix sp., Sphagnum sp., Viola canadensis* and an unidentified seedling.

Section 2.6: Coltsfoot (Freshwater Atlas WATERBODY_ID: 705006076)

The Coltsfoot restoration site is located downstream of our Northbound restoration site and is accessed from a branch road off of the Dogleg Forest Service Road. The restoration site is located entirely on provincial crown land (Figure 32). Initially, we had planned to repair two beaver dams within the perimeter of this FWA mapped wetland; however, the downstream restoration did not provide a large enough flooded area to warrant the work. The upper beaver dam repair would raise the water level would flood 3301 m^2 and store 1370 m^3 of water. There is another FWA wetland polygon ~ 200 m upstream of Coltsfoot that has also been identified as a potential restoration site; however, we did not focus on collecting any measurements here in 2023. We did not complete all of our pre-restoration effectiveness monitoring measurements at this site and will return to site in 2024 to finish mapping vegetation communities and collect data on other metrics that may be required.

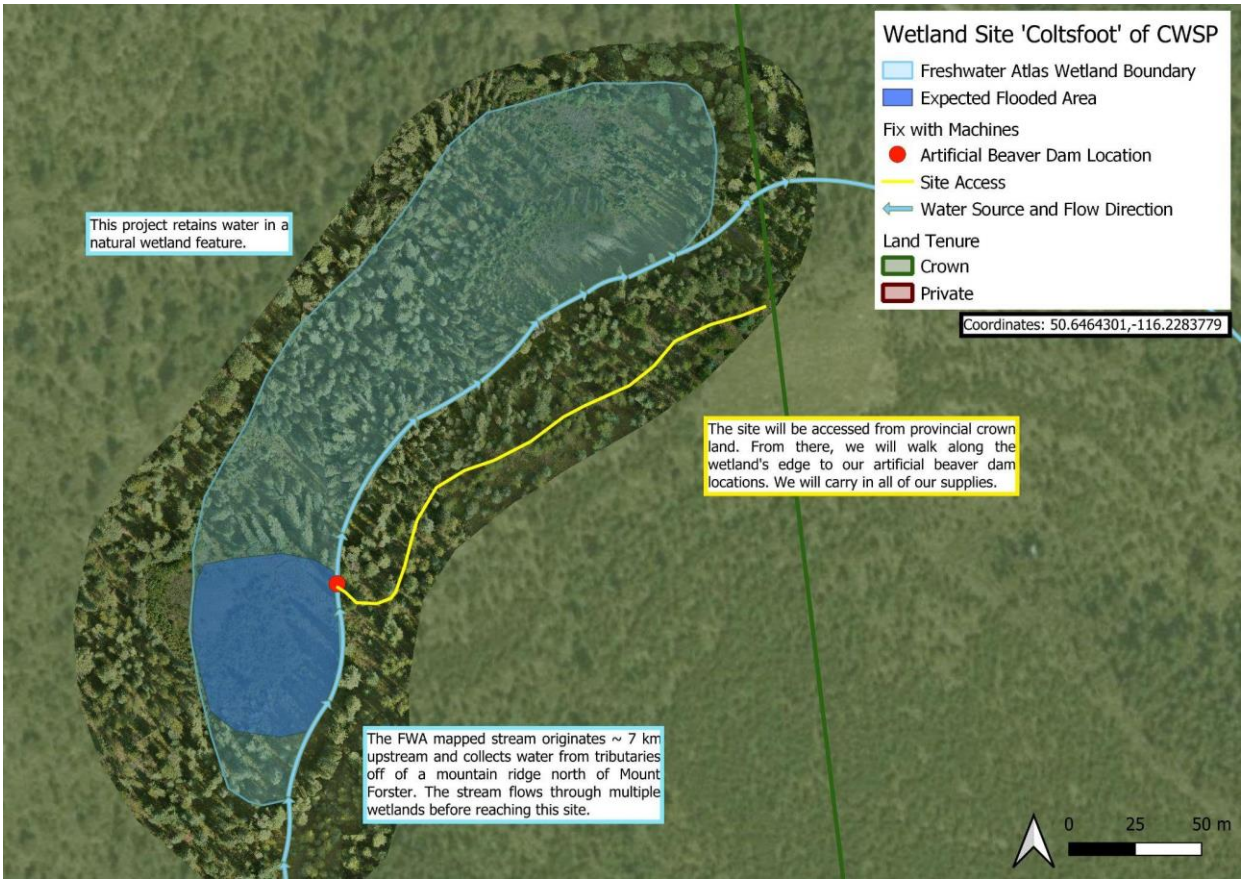


Figure 32. Site restoration plan for Coltsfoot.

Section 2.6.1: Water Characteristics

There are multiple upstream wetlands that this stream (FWA ROUTE ID: 598162) flows through before reaching our restoration site, including our other restoration site 'Northbound'. Where the stream was measured at this restoration site it was 1.45 m wide and had a flow rate of 0.008 m^3/s, indicating that the stream got wider and had more flow compared to our measurement location near Northbound. We collected water quality at a few different locations on two different dates in 2023 – the values are presented in Table 9.

Table 9. Water quality data collected at restoration site Coltsfoot during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
22-Aug-23	~	13.9	674	65.6	6.73	710	555	8.13	2.38
21-Sep-23	BD1 Pool	4.6	677.2	59.3	7.57	759	463.4	8.2	0.81
22-Sep-23	BD2 Pool	7.3	676.8	87.4	10.53	534	353	8.8	0.37

Section 2.6.2: Beaver Dam Profile and Restoration

The main gap in the beaver dam where the stream is flowing through is 1.5 m wide and occurs from 5.5 m to 7 m from the left bank (Figure 33). There is another shallower 1 m gap from 58 to 59 m from the left bank that is slightly undercut and would require intensive repair. In order to raise the water level in the wetland by 0.83 m, additional material would also need to be added to approximately 3.5 m of the dam – spanning sections 17.5 m – 18.5 m, 29 – 29.5 m, 58 – 59 m, and small areas at 25.5 and 34.5 m from left bank. If we did not fill in these sections, we would only be able to raise the water level in the wetland by 0.6 m.

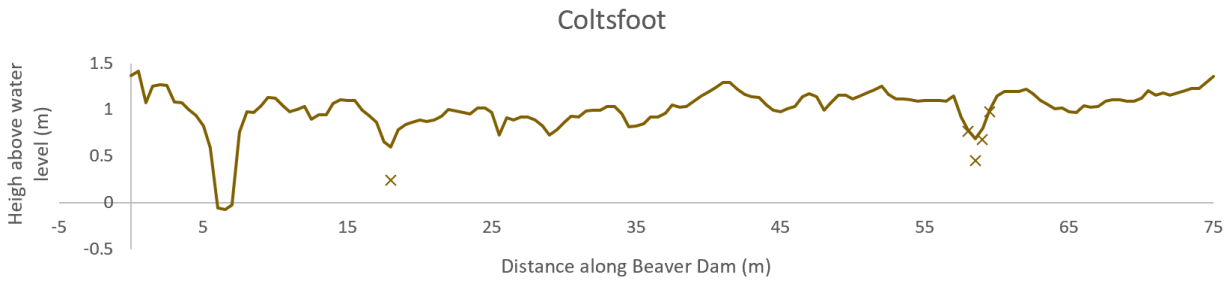


Figure 33. The beaver dam profile at Coltsfoot restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.6.3: Ecological Values

The wetland is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and American Badger. The wetland is surrounded by ungulate winter range for Mule deer *(Odocoileus hemionus),* White-tailed deer (*O. virginianus)*, Elk *(Cervus elaphus),* Bighorn Sheep (*Ovis canadensis)*, and Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Grizzly Bear, Elk, and American Badger (Figure 34). Other wildlife observations include a Western Toad spotted on the upland bank of the wetland.

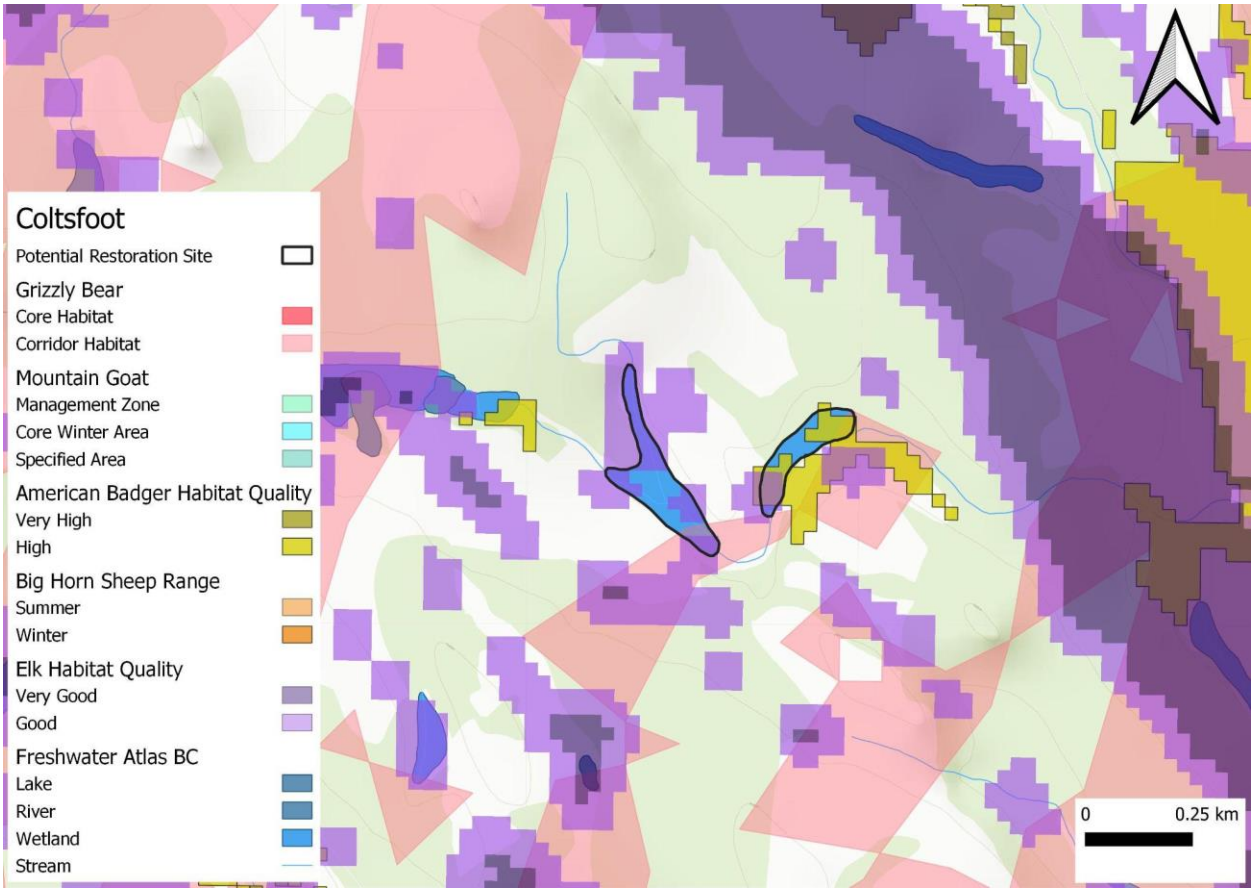


Figure 34. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Coltsfoot restoration site.

Section 2.6.4: Vegetation

Vegetation community mapping was partly completed during 2023 but will be finished and reported on in 2024. There were 28 plant species identified in the eight quadrat vegetation plots established in Coltsfoot in August/September 2023. These species include *Arctostaphylus ura-ursi, Betula sp., Calamagrostis canadensis, Carex aquatilis, C. flava, C. utriculata, Cirsium arvense, Dasiphora fruticosa, Eleocharis palustris, Elumus glaucus, Equisetum arvense, Eucephalus engelmannii, Fragaria virginiana, Lactuca serriola,* Liverwort sp., *Lobelia kalmii, Mentha arvensis,* Moss sp., *Petasites frigidus, Picea engelmanni, Poaceae sp., Potentilla diversifolia, Salix sp, Schenoplectus tabermontani, Solidago lepida, Symphyotrichum laeve, Viola canadensis,* and an unidentified seedling.

Section 2.7: Sam's Folly Outflow (Freshwater Atlas WATERBODY_ID: 705005813)

The Sam's Folly Outflow restoration site is located just north of Sam's Folly, a large lake and recreation site, and is accessed from the Dogleg Forest Service Road. The mapped outflow from Sam's Folly flows through the restoration wetland (Figure 35). The restoration site is located entirely on provincial crown land. We propose repairing one beaver dam within the perimeter of this wetland to restore 2,626 m^3 of open water, spread over 5836 m^2. Due to the larger length of a BDA structure at this site (and the potential increased risk because of this), we plan on strategically saving this restoration site until 2025 or 2026 so that we can display other examples of successful restorations with this method to the permitting office. As such, we did not complete all of our pre-restoration effectiveness monitoring measurements at this site and will return in 2024 to map vegetation communities, establish quadrat vegetation plots, collect drone orthoimagery, and data on other metrics that may be required.

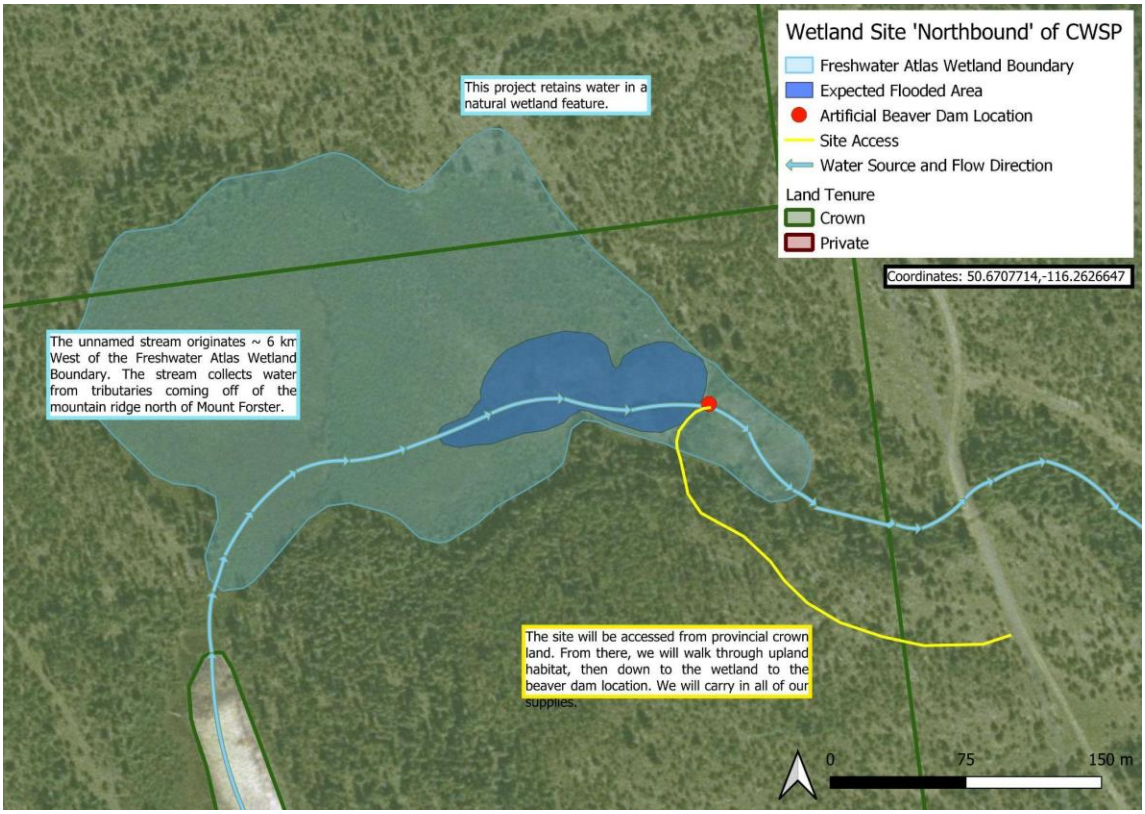


Figure 35. Site restoration plan for Sam's Folly Outflow.

Section 2.7.1: Water Characteristics

The mapped and unnamed stream (FWA ROUTE ID: 597403) that flows through the wetland originates approximately 6 km upstream on a mountain ridge west of the restoration site, and flows through a small lake and Sam's Folly before entering the wetland basin. However, during site visits, we identified a spring within the mapped wetland basin that water was originating at and supplying flow to the stream leaving the wetland. Stream flow was measured downstream of the wetland boundary where the channel became confined (0.7 m wide) on August 28, 2023. The steam had a flow rate of 0.002 m^3/s. We collected water quality at two locations within this system on two different days - values are presented in Table 10.

Table 10. Water quality data collected at restoration site Sam's Folly Outflow during the 2023 field season. Measurements were collected with a calibrated YSI Probe.

Date	Location	Temp (°C)	Pressure	DO %	DO (mg/l)	SPC	Conductivity	pH	Turbidity
26-Sep-23	Origin	6.9	670.4	47.8	5.36	540	345.4	8.17	0.34

Section 2.7.2: Beaver Dam Profile and Restoration

There are multiple remnant and degraded beaver dams present at the Sam's Folly Outflow restoration site. In 2023, we focused our efforts on one beaver dam that we suspect has the greatest potential for restoration benefits. This beaver dam is 65 m long and both sides of the gap slowly slope down which allows lots of flexibility to decide how high to build our BDA structure (Figure 36). The lowest spot not included within the gap is at 12 m from the left bank and is 0.9 m above the current water level. If we build a BDA structure to this elevation, the main construction would be 12 m long and extend from 30 m to 42 m from the left bank and would require additional material on either side - the total fixed area would be from 26 m to 44.5 m from the left bank (18.5 m).

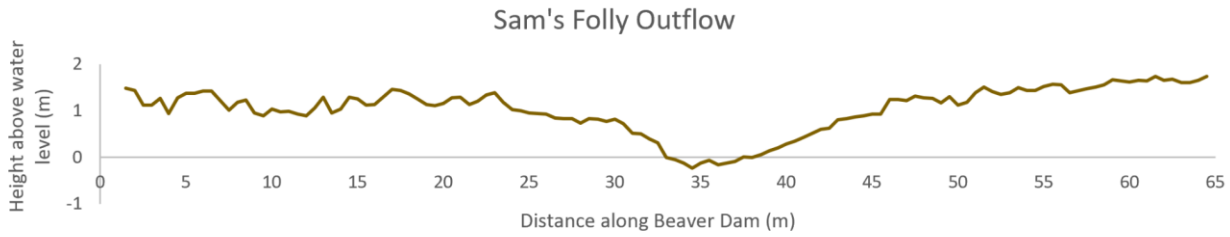


Figure 36. The beaver dam profile at Sam's Folly Outflow restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.7.3: Ecological Values

The wetland is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and is immediately adjacent to critical habitat mapped for American Badger. The wetland is surrounded by ungulate winter range for Mule deer *(Odocoileus hemionus),* White-tailed deer (*O. virginianus)*, Elk *(Cervus elaphus),* Bighorn Sheep (*Ovis canadensis)*, and Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Grizzly Bear, Elk, and American Badger (Figure 37). Other wildlife observed in the wetland include a Columbia Spotted Frog in the outflow downstream of the proposed dam repair.

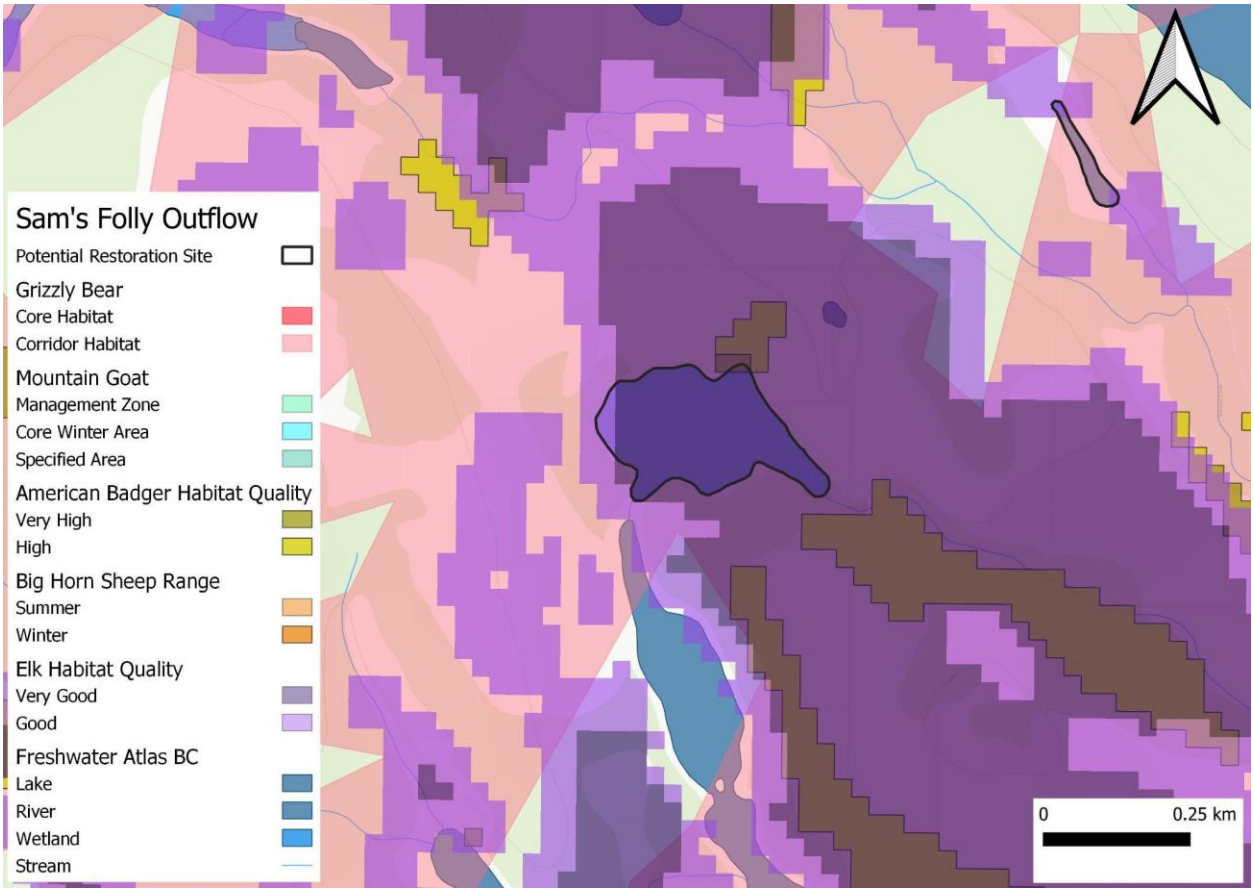


Figure 37. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Sam's Folly Outflow restoration site.

Section 2.8: Rand Creek Wetland (Freshwater Atlas WATERBODY_ID: 705005933, 705006570)

The Rand Creek Wetland restoration site is accessed off of the Leadqueen - Frances Forest service Road, north of Cartwright Lake Recreation Site. The restoration site is located entirely on provincial crown land (Figure 38). We propose repairing one beaver dam within the perimeter of this wetland to restore 4,262 m^3 of open water, spread over 18136 m^2. This restoration site requires a more complex repair where the stream has undercut and is currently flowing through the dam. This section of dam would need to be removed in order to repair it which may potentially drain an area of open water (which would be replaced by our structure) which increases the risk associated with the construction. We plan on strategically saving this restoration site until 2025 or 2026 so that we can display other examples of successful restorations with this method to the permitting office. As such, we did not complete all of our pre-restoration effectiveness monitoring measurements at this site and will return to site in 2024 to map vegetation communities, establish quadrat vegetation plots, and collect data on other metrics that may be required.

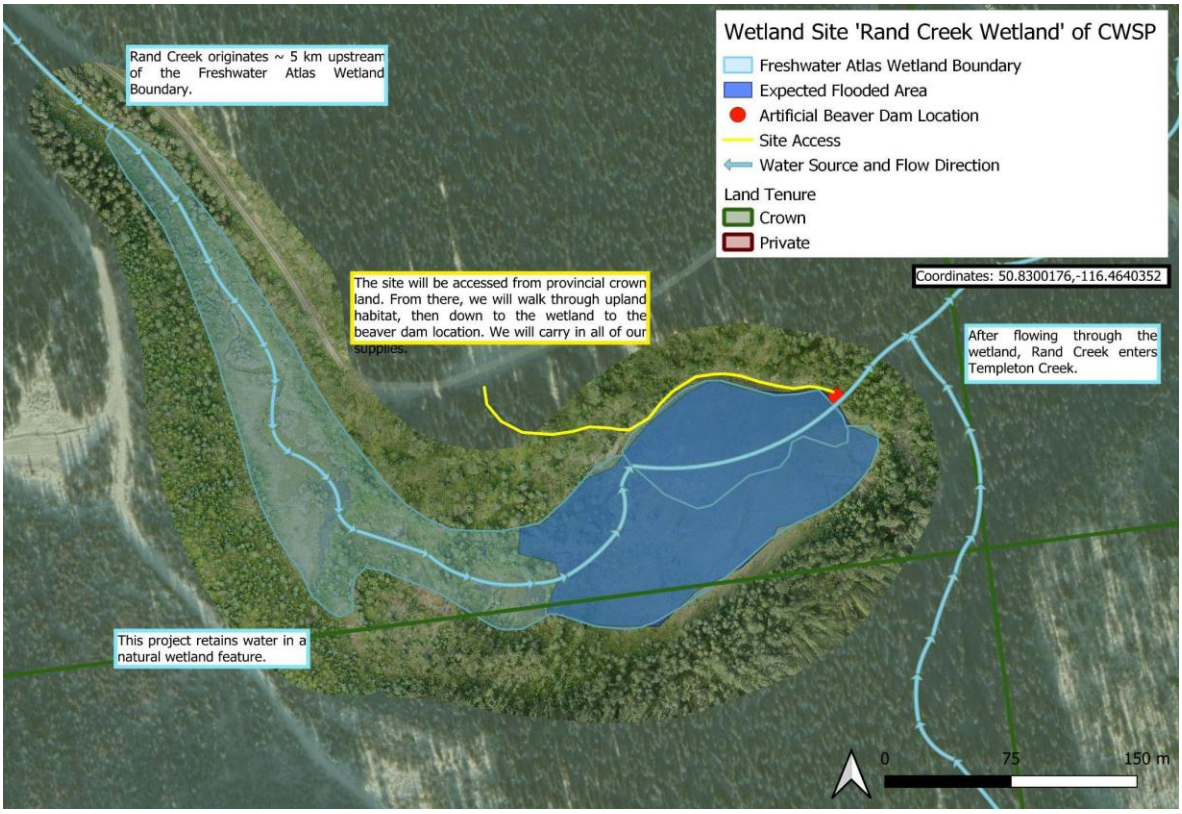


Figure 38. Site restoration plan for Rand Creek Wetland.

Section 2.8.1: Water Characteristics

Rand Creek (FWA ROUTE ID: 589940) originates approximately 5 km upstream on a mountain ridge - the creek flows through a few wetlands before reaching the restoration site. After leaving the wetland, Rand Creek immediately flows into Templeton Creek. Stream flow was measured upstream of the wetland boundary where the steam was 1.1 m wide and had a discharge of 0.002 m^3/s. We have not yet collected water quality measurements at this site.

Sectio 2.8.2: Beaver Dam Profile and Restoration

This dam would require the addition of two BDA structures - there is a smaller section from 30.5 to 33.5 m that would require repair, and a larger section between 49.5 m and 57 m from the left bank (Figure 39). However, in order to conduct the larger repair, we would need to dig out the existing section of dam and replace it as the stream has undercut and is currently flowing underneath the dam. We could also add additional material to some lower sections of the dam (at 12.5 m, from 37.5 m to 41.5m, and from 44 m to 46 m) which would raise the water level in the wetland by 0.47 m. This construction would require a total of 10.5 m of BDA construction and 6.5 m of additional fill in locations across the top of the dam.

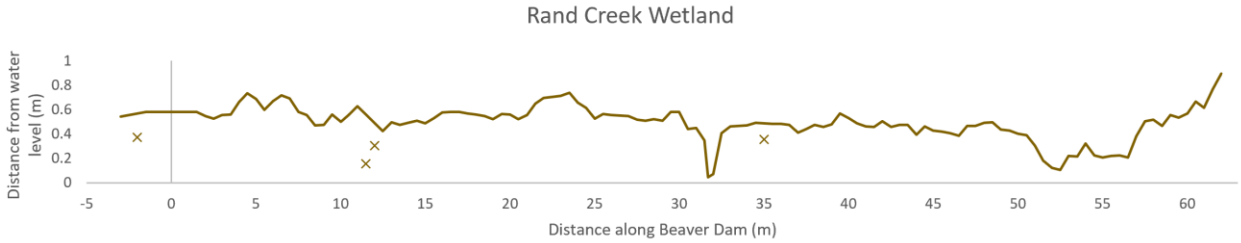


Figure 39. The beaver dam profile at Rand Creek Wetland restoration site. Measurements of the beaver dam were taken every 0.5 m using a laser level. Measurements were then normalized to the water depth in the wetland observed on the day of survey.

Section 2.8.3: Ecological Values

The wetland is within federally mapped critical habitat for Woodland Caribou (Southern Mountain Population) and American Badger and is surrounded by ungulate winter range for Moose (*Alces alces).* The wetland and surrounding area also provide important habitat for Kootenay Conservation Program's identified wildlife species – specifically Grizzly Bear, Elk, and American Badger (Figure 40).

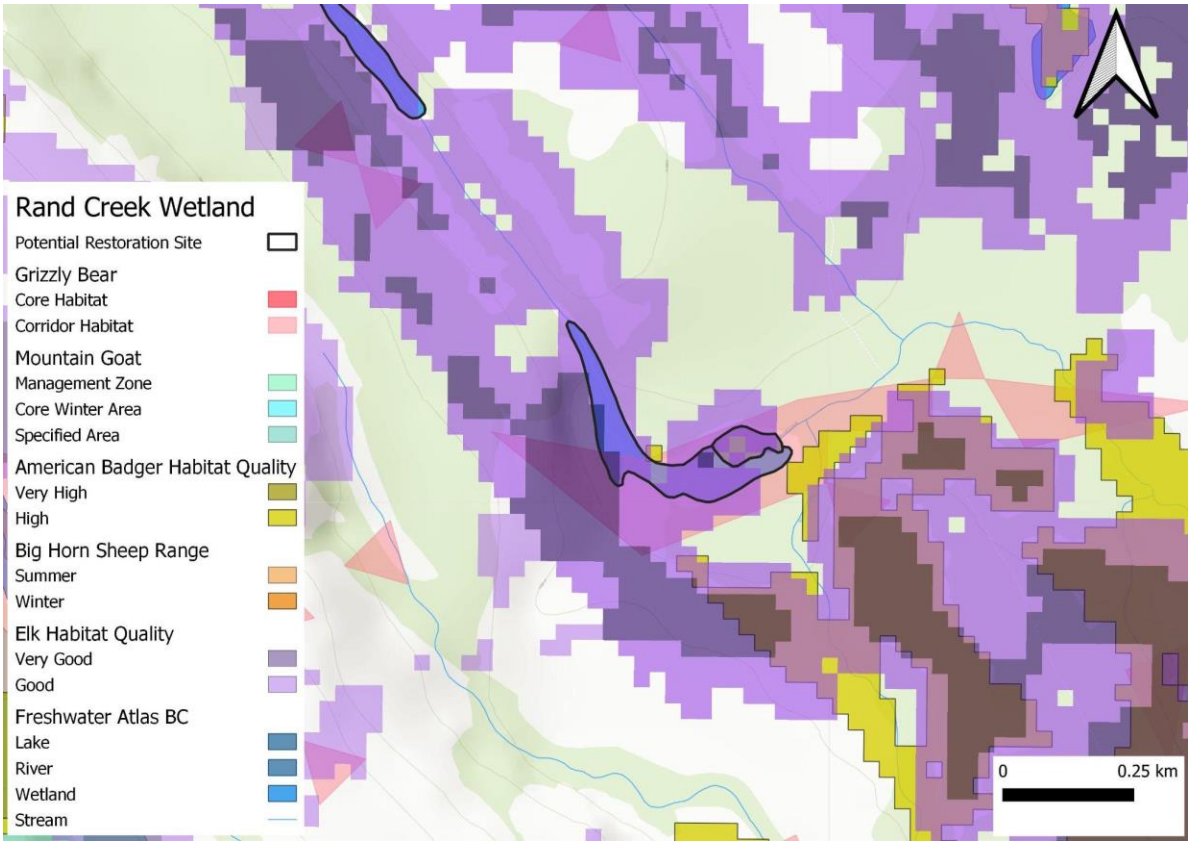


Figure 40. Wildlife habitat values for Kootenay Conservation Program's identified focal species (Grizzly Bear, Mountain Goat, American Badger, Big Horn Sheep, and Elk) around the Rand Creek Wetland restoration site.

Section 3: Species at Risk on the Western Upland Bench of the Columbia Valley

The British Columbia Conservation Data Centre (BC CDC) was used to identify species with the potential to occur within our study area. The query tool is not perfect, and does sometimes include species that do not occur within the uploaded area of interest - for example, the search query identified White Sturgeon as a potential species due to its presence in the upper Columbia River but habitat needs are not met, and thus the species does not occur, on the western upland bench of the Columbia Valley (Fisheries and Oceans Canada, 2023). In addition to this concern, species and subspecies are both counted within the summarized data as their own entries (e.g., BC CDC reports two potential turtles to occur but this refers to the parent species, Painted Turtle, and the subpopulation, Painted Turtle - Intermountain - Rocky Mountain Population)). However, to ensure repeatability of the species summary, no species were removed from the CDC export.

The CDC export identified 134 species (including invertebrates, fish, amphibians, reptiles, birds, and mammals) with the potential to occur within our area of interest. Of these species, 31 of them are provincially red listed species (extirpated, endangered, or threatened in British Columbia) and 82 are provincially blue listed (of special concern in British Columbia) - summaries by clade are presented in Figure 41.

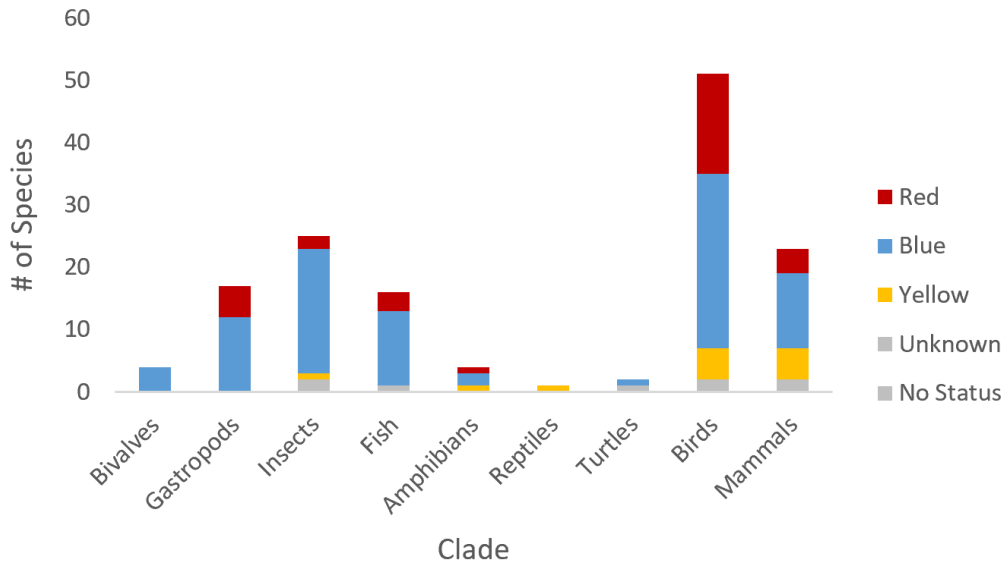


Figure 41. British Columbia provincial status ranking for invertebrate and vertebrate animals, identified by the Conservation Data Centre, with the potential to occur within our study area.

Forty-five of the 134 identified species are currently listed on the *Species at RIsk Act*. Eight of these species are threatened, 10 are endangered, and 27 are of special concern - summaries by clade are presented in Figure 42.

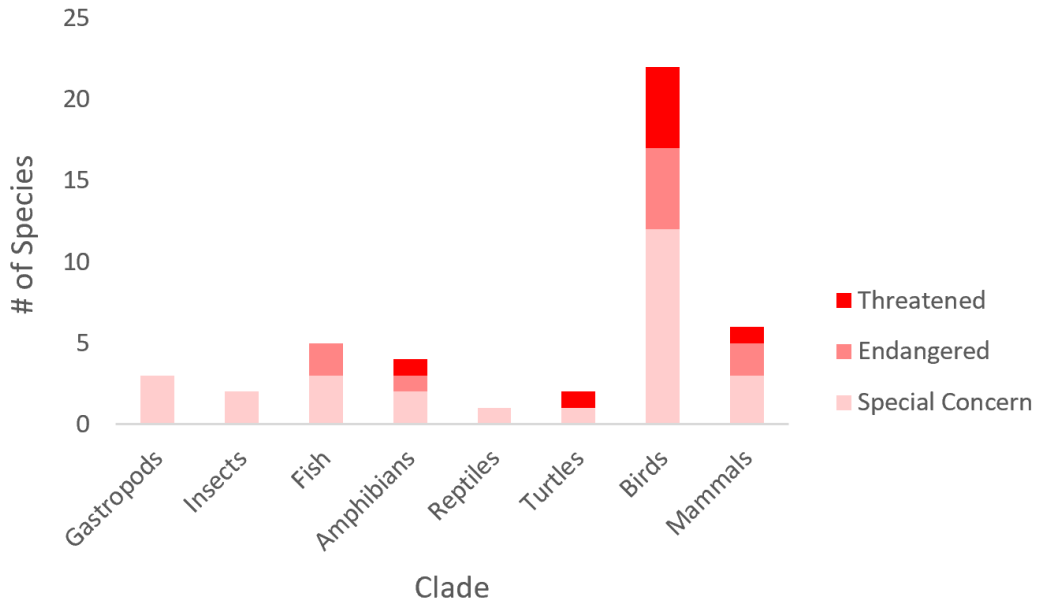


Figure 42. Federal *Species at Risk Act* listings for invertebrate and vertebrate animals, identified by the Conservation Data Centre, with the potential to occur within our study area.

The BC provincial rankings and federal listings on the *Species at Risk Act* often differ for a species; thus, both ranking systems were considered in this analysis. For example, nineteen of the red listed species in BC are not listed on the *Species at Risk Act* (e.g., peregrine falcon (*anatum* subspecies)). In addition, 11 species that are listed on the *Species at Risk Act* are provincially yellow listed (considered secure). The two combined ranking systems identify 64 species that are threatened, endangered, or of special concern (45 listed on SARA, 31 red listed in BC and 12 duplicates removed).

We conducted literature reviews for each of these species to identify whether their distribution overlaps with our study area and if there are potential surveys that could be conducted to address Objective 2.3 (Monitor hydrologic, ***SAR species*** and ecological parameters in a suite of potential wetlands pre and post restoration activities. Generate effectiveness benchmarks). We identified 21 species that we could conduct surveys (e.g., visual, wildlife cameras, acoustic) for at our identified upland restoration sites (Table 11). Our team will continue to discuss, internally and with subject matter experts, these identified species and consider how to implement SAR monitoring in the next four years of our project.

Table 11. Reduced list (from the original BC CDC export) of provincially red-listed and SARA listed species that occur within our study area and could be monitored for in or around or restoration sites on the west upland bench of the Columbia Valley.

Scientific Name	English Name	BC List	SARA Status	Potential to Survey
Gastropods (n = 5)				
Valvata humeralis	Glossy valvata	Red	~	Yes, visual surveys within restoration sites
Gastrocopta holzingeri	Lambda Snaggletooth	Red	~	Maybe - field crews will be made aware of species identification in case of incidental

				observation.
Magnipelta mycophaga	Magnum Mantleslug	Blue	Special Concern	Yes - visual surveys within restoration sites
Vertigo ventricosa	Tapered Vertigo	Red	~	Maybe - visual surveys within restoration sites.
Valvata tricarinata	Threeridge Valvata	Red	~	Maybe - visual surveys within restoration sites.
Insects (n = 1)				
Danaus plexippus	Monarch	Red	Endangered	Maybe - field crew will be look for incidental observations of monarch butterflies and Showy Milkweed.
Fish (n = 1)				
Oncorhyncus clarkii lewisi	Cutthroat Trout, *lewisi* subspecies	Blue	Special Concern	Yes - potential partnership with CHARS project. Could do eDNA surveys of creeks at restoration sites.
Amphibians (n = 1)				
Anaxyrus boreas	Western Toad	Yellow	Special Concern	Yes - could do visual or eDNA survey within restoration sites and broader locations on the upland bench to identify breeding areas.
Reptiles (n = 1)				
Charina bottae	Northern Rubber Boa	Yellow	Special Concern	Maybe - during work in the uplands we can flag rock outcrops or talus slopes that could be potential habitat features.
Birds (n = 8)				
Hirundo rustica	Barn swallow	Yellow	Special Concern	Yes - songbird surveys at restoration wetlands.
Chordeiles minor	Common Nighthawk	Blue	Special Concern	Yes - Could collaborate with Birds Canada on their Canadian NightJar Survey, or do our own acoustic surveys
Coccothrausstes vespertinus	Evening Grosbeak	Yellow	Special Concern	Yes - Songbird surveys in coniferous upland edges around restoration sites.
Psiloscops flammeolus	Flammulated Owl	Blue	Special Concern	Yes - Night acoustic surveys.

Melanerpes lewis	Lewis's Woodpecker	Blue	Threatened	Yes - Conduct nesting surveys at potential restoration sites where suitable habitat occurs.
Contopus cooperi	Olive-sided Flycatcher	Yellow	Special Concern	Yes - Song bird surveys at restoration sites.
Bartramia longicauda	Upland Sandpiper	Red	~	Maybe - field crews will be made aware of species identification in case of incidental observation.
Coturnicops noveboracensis	Yellow Rail	Red	Special Concern	Maybe - Potentially calling surveys at night. The species typically inhabitants large wetlands, but have been found in 0.5 - 4 ha wetlands.
Mammals (n = 4)				
Taxidea taxus	American Badger	Red	Endangered	Yes - Partner with Goldeneye Ecological to conduct badger burrow surveys where suitable habitat occurs near restoration sites.Possibly monitor restoration sites with wildlife cameras.
Rangifer tarandus pop. 1	Caribou (Southern Mountain Population)	Red	Endangered	Yes - Possibly monitor restoration sites with wildlife cameras.
Ursus arctos	Grizzly Bear	Blue	Special Concern	Yes - Possibly monitor restoration sites with wildlife cameras.
Myotis lucifugus	Little Brown Myotis	Blue	Endangered	Yes - Could deploy acoustic monitoring devices, potentially partner with Cori Lausen at WCS.

We also conducted a preliminary desktop assessment of wildlife habitat values on the western upland bench of the Columbia Valley to address Objective 2.1 (Map water bodies on west benches, determine potential sources of water, and ***summarize GIS and SAR information on wetlands***). Our study area includes critical habitat for species at risk including whitebark pine, American Badger - *jeffersonii* subspecies, Northern Leopard Frog - Rocky Mountain population, Lewis's Woodpecker, Woodland Caribou (Southern Mountain population), and Bank Swallow (Figure 43). In addition, there are four approved Wildlife Habitat Areas, governed under the *Forest and Range Practices Act*, at the south end of our study area by Canal Flats (Figure 43). Three of these WHAs (4-002, 4-134, and 4-135) are designated for Lewis' Woodpecker, and one (4-102) is designated for American Badger. There are also BC CDC occurrences mapped for American Badger, Long-billed Curlew, Flammulated Owl, Limber Pine, White-throated Swift, and Lewis's Woodpecker throughout the study area. Ungulate winter range is mapped over a majority of the study area and encompasses management for moose, elk, black-tailed deer, white-tailed deer, and bighorn sheep (Figure 43).

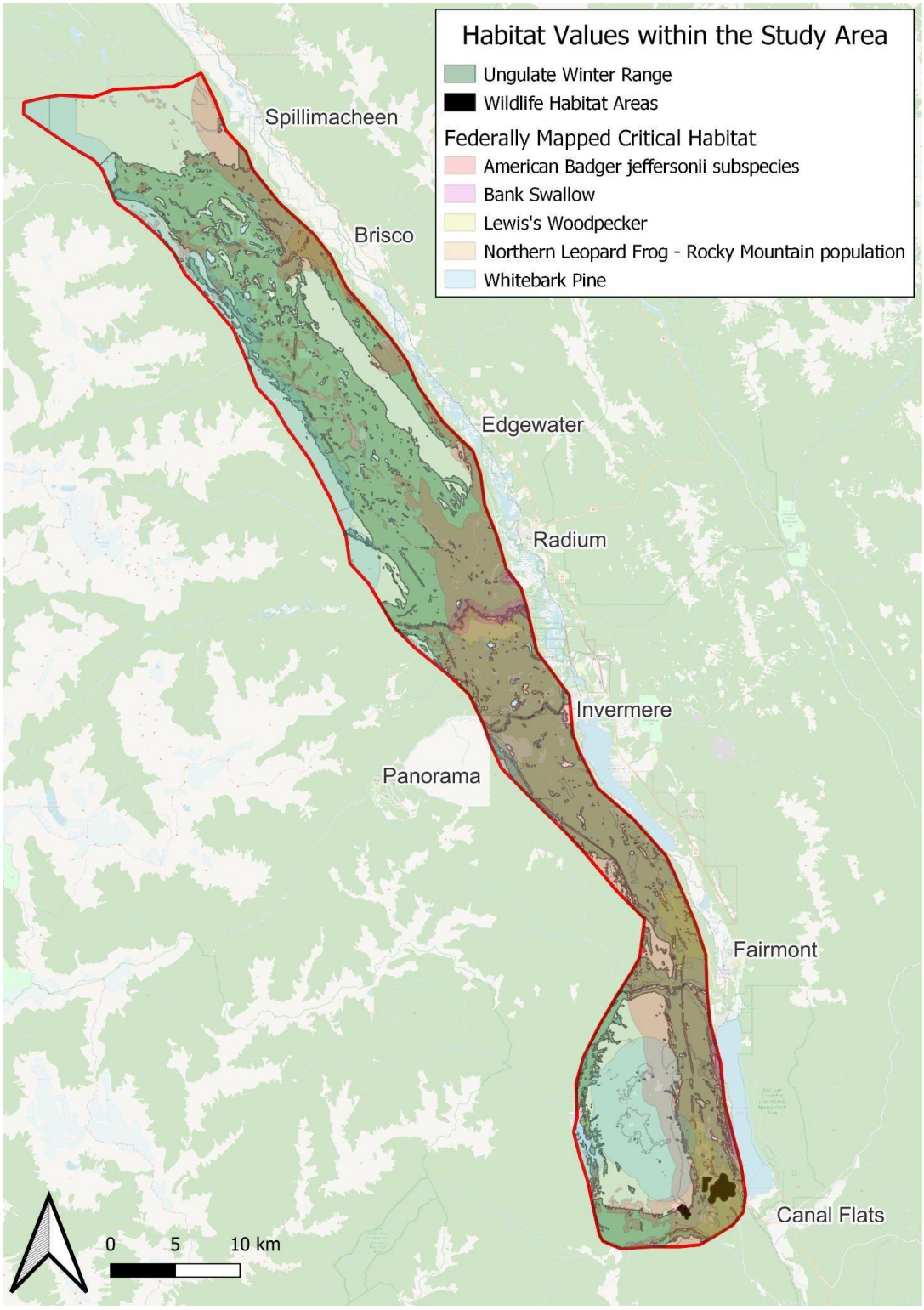


Figure 43. Habitat values (i.e., critical habitat, ungulate winter range, and wildlife habitat areas) mapped in open-source provincial databases within our study area on the west upland bench of the Columbia Valley. Critical habitat for Woodland Caribou (Southern Mountain Population) was omitted from the map as it is mapped for the entire study area.

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Appendix A: Red listed and *SARA* Species Analysis

Scientific Name	English Name	BC List	SARA Status	Within Species Range?	Identified Management Goals	Potential to Survey
Gastropods (n = 8)						
Valvata humeralis	Glossy valvata	Red	~	Yes - Collected from Columbia Lake in 1883 (BC CDC Conservation Status Report)	Inventory to help refine rank (BC CDC Conservation Status Report)	Yes, visual surveys within restoration sites
Gastrocopta holzingeri	Lambda Snaggletooth	Red	~	Maybe - One provincial occurrence located in Canal Flats (BC CDC Conservation Status Report)	Inventory needed	Maybe - field crews will be made aware of species identification in case of incidental observation.
Magnipelta mycophaga	Magnum Mantleslug	Blue	Special Concern	Yes - Range occurs in the Northern Columbia Basin (COSEWIC, 2012)	Maintain all subpopulations, protect or restore habitat for extant or additional subpopulations (BC Ministry of Environment and Climate Change Strategy, 2018).	Yes - visual surveys within restoration sites
Kootenaia burkei	Pygmy Slug	Blue	Special Concern	No - Selkirk and Purcell sub-ranges within the Columbia Mountains (COSEWIC, 2016).	~	~
Physella columbiana	Rotund Physa	Red	~	No - Limited information, current range is unknown. Species of large rivers - will not be on upland bench (E-Fauna BC).	~	~
Zaceleus idahoensis	Sheathed Slug	Blue	Special Concern	No - Limited range in the very south of the province (COSEWIC, 2016).	~	~

Vertigo ventricosa	Tapered Vertigo	Red	~	Yes - limited information on the species, but BC CDC Species Summary lists it as occurring in SE BC.	Inventory needs to establish whether this species is extant in southeast BC.	Maybe - visual surveys within restoration sites.
Valvata tricarinata	Threeridge Valvata	Red	~	Maybe - limited observations but found in the Columbia River (near trail). Found in Wasa Lake (BC CDC Conservation Status Report).	Inventory required to confirm the continued existence of this species in British Columbia (Lee, 2000).	Maybe - visual surveys within restoration sites.
Insects (n = 3)						
Lycaena dione	Dinoe Copper	Red	~	No - Species occurs around Cranbrook (BC CDC Conservation Status)	~	~
Danaus plexippus	Monarch	Red	Endangered	Yes - Species observed in the Rocky Mountain Trench.	Ensure conservation of the Monarch butterfly migratory phenomenon.	Maybe - field crew will be look for incidental observations of monarch butterflies and Showy Milkweed.
Argia vivida	Vivid Dancer	Blue	Special Concern	No - Species require hot springs for microclimate. No mapped geothermal springs on western upland bench (Environment and Climate Change Canada, 2022).	~	~
Fish (n = 6)						
Oncorhyncus clarkii lewisi	Cutthroat Trout, *lewisi* subspecies	Blue	Special Concern	Yes - occurs within the Columbia River basin, active project being implemented by CHARS (COSEWIC, 2016).	Maintain the native distribution, maintain wild populations at healthy abundance levels, maintain or rehabilitate natural habitat, and	Yes - potential partnership with CHARS project. Could do eDNA surveys of creeks at restoration

					optimize sustainable recreational benefits (Fisheries and Oceans Canada, 2016).	sites.
Cottus sp.	Rocky Mountain Sculpin	Red	Special Concern	No - In BC, the species is only present in the Flathead River (COSEWIC, 2010).	~	~
Cottus confusus	Shorthead Sculpin	Blue	Special Concern	No - Within the Columbia River drainage, but valley bottom species. Not present on upland bench (COSEWIC, 2010).	~	~
Rhinichthys umatilla	Umatilla Dace	Red	Threatened	No - Species occurs within the Columbia River basin, but is restricted to the West Kootenays and Okanagan (COSEWIC, 2010).	~	~
Acipenser transmontanus	White Sturgeon	~	Endangered	No - Valley bottom species, not present on upland bench (Fisheries and Oceans Canada, 2023).	~	~
Acipenser transmontanus (pop. 2)	White Sturgeon (Upper Columbia River Population)	Red	Endangered	No - Valley bottom species, not present on upland bench (Fisheries and Oceans Canada, 2023).	~	~
Amphibians (n = 4)						
Plethodon idahoensis	Coeur d'Alene Salamander	Blue	Special Concern	No - Not found North of Kimberley in the East Kootenay Trench	~	~
Lithobates pipiens	Northern Leopard Frog	Red	Endangered	No - Recovery program releases individuals in valley bottom	~	~

				wetlands, not present on upland bench (Environment and Climate Change Canada, 2017).		
Ascaphus montanus	Rocky Mountain Tailed Frog	Blue	Threatened	No - Species occurs around Yahk drainages and in the Flathead (IWIMS, 2004).	~	~
Anaxyrus boreas	Western Toad	Yellow	Special Concern	Yes - Species occurs within most of BC, with the exception of the Northeast corner (Environment and Climate Change Canada, 2016).	Maintain stable or increasing populations distributed throughout the species' present range.	Yes - could do visual or eDNA survey within restoration sites and broader locations on the upland bench to identify breeding areas.
Reptiles (n = 1)						
Charina bottae	Northern Rubber Boa	Yellow	Special Concern	Yes - peripheral range and all observations from unidentified observers.	Protect suitable habitat, mitigate threats, address knowledge gaps in range distribution, assess population size, and address knowledge gaps in habitat requirements	Maybe - during work in the uplands we can flag rock outcrops or talus slopes that could be potential habitat features.
Turtles (n = 2)						
Chrysemys picta	Painted Turtle	~	Threatened/ Special Concern	No - habitat requirements met in valley bottom wetlands, not an upland species.	~	~
Chrysemys picta (pop. 2)	Painted Turtle - Intermountain - Rocky Mountain Population	Blue	Special Concern	No - Habitat requirements met in valley bottom wetlands, not an upland species.	~	~

Birds (n = 32)						
Pelecanus erythrorhynchos	American White Pelican	Red	~	No - Potential incidentals during migratory seasons within valley bottom, but unlikely to be in upland habitat (IWIMS, 2004).	~	~
Patogioenas fasciata	Band-tailed pigeon	Blue	Special Concern	Unknown - Scattered sightings across the southern interior of British Columbia, spotted in the Rocky Mountain (COSEWIC, 2008).	Maintain the Canadian population at its current size and distribution.	No - field crews will be made aware of species identification in case of incidental observation.
Hirundo rustica	Barn swallow	Yellow	Special Concern	Yes - Species occurs throughout all of BC (COSEWIC, 2021).	~	Yes - songbird surveys at restoration wetlands.
Setophaga castanea	Bay-breasted Warbler	Red	~	No - Species occurs in Northern BC (IWIMS, 2004).	~	~
Cypseloides niger	Black Swift	Blue	Endangered	Yes - Species occurs throughout the southern half of British Columbia. However, nesting habitat is specific to waterfalls, caves, canyons, and cliffs - these features do not occur adjacent to any of our restoration sites (COSEWIC, 2015).	~	No - Habitat requirements not met in restoration sites. Field crew will record any potential habitat features observed in the uplands.
Nycticorax nycticorax	Black-crowned Night-Heron	Red	~	No - Potential to occur within valley bottom habitat, but is unlikely. No previous observations in the area.	~	~
Dolichonyx oryzivorus	Bobolink	Red	Threatened	Maybe - One iNaturalist observation north of Golden, and one in Cranbrook (likely	Stabilize Canada-wide population, recover Bobolink to maintain species in all provinces	No - Unlikely to occur on West Upland Bench. Field crews will

				migratory individuals).. However, prairie species and likely not residing in habitat around restoration sites (Environment and Climate Change Canada, 2022).	in known range.	be observant for incidental observations.
Athene cunicularia	Burrowing Owl	Red	Endangered	No - restricted to the Okanagan (around Kamloops/Kelowna) in BC (Environment Canada, 2012).	~	~
Larus californicus	California Gull	Red	~	No - Within migratory range of species, but likely only valley bottom. No confirmed breeding in area.	~	~
Chordeiles minor	Common Nighthawk	Blue	Special Concern	Yes - Species occurs, and breeds, throughout all of BC (Environment Canada, 2016).	Halt the national population decline, ensure a 10-year population trend for the species (Environment Canada, 2016).	Yes - Could collaborate with Birds Canada on their Canadian NightJar Survey, or do our own acoustic surveys
Coccothrausstes vespertinus	Evening Grosbeak	Yellow	Special Concern	Yes - Species occurs, and breeds, throughout most of British Columbia (Environment and Climate Change Canada, 2022).	Achieve a stable (or increasing) 30- yr population trend, maintain a long-term stable population trend, maintain current extant of occurrence (Environment and Climate Change Canada, 2022).	Yes - Songbird surveys in coniferous upland edges around restoration sites.
Psiloscops flammeolus	Flammulated Owl	Blue	Special Concern	Yes - Potential habitat is identified within the Columbia Valley uplands for this species (Provincial Flammulated Owl Working Group, 2011).	Identify population, habitat and distribution targets to maintain viable populations. Initiate protection/management of breeding habitat. Investigate knowledge gaps, implement a	Yes - Night acoustic surveys.

					monitoring program.	
Limosa haemastica	Hudsonian Godwit	Red	Threatened	No - Species occurs in the far North of Canada (Mackenzie Delta), in Alaska, and in Hudson's Bay (COSEWIC, 2019).	~	~
Melanerpes lewis	Lewis's Woodpecker	Blue	Threatened	Yes - Potential habitat has been identified within the East Kootenay Trench for this species(Environment and Climate Change Canada, 2017).	Maintain or increase the regional populations and the distribution of Lewis's Woodpeckers within Canada.	Yes - Conduct nesting surveys at potential restoration sites where suitable habitat occurs.
Numenius americanus	Long-billed Curlew	Yellow	Special Concern	Maybe - Species occurs within the Columbia Valley but within grasslands/agricultural areas (Environment Canada, 2012).	Maintain or increase the recent breeding distribution (Environment Canada, 2012).	No - Individuals breed in grasslands which are not common around our restoration sites.
Contopus cooperi	Olive-sided Flycatcher	Yellow	Special Concern	Yes - Species occurs, and breeds, within all of British Columbia. Occurs in coniferous stands, often located near wetlands (COSEWIC, 2007).	Halt national decline by 2025, ensure a positive 10-year population trend, and maintain the current extent of occurrence (Environment Canada, 2016).	Yes - Song bird surveys at restoration sites.
Falco peregrinus	Peregrine Falcon	~	Special Concern	Maybe - Range is mapped north and south of study area. However, habitat requirements would not be met around any of our restoration sites (Environment Climate Change Canada, 2017).	~	~
Falco peregrinus anatum	Peregrine Falcon, *anatum* subspecies	Red	~	Maybe - Range is mapped north and south of study area. However, habitat requirements would not be met around any of	~	~

				our restoration sites (Environment Climate Change Canada, 2017).		
Falco mexicanus	Prairie Falcon	Red	~	Maybe - Small numbers may breed in the East KootenY Trench, however the potential habitat is only mapped in the south (IWIMS, 2004).	~	~
Phalaropus lobatus	Red-necked Phalarope	Blue	Special Concern	No - Species occurs in more northern parts of BC (Environment and Climate Change Canada, 2022).	~	~
Euphagus carolinus	Rusty Blackbird	Blue	Special Concern	No - Species occurs throughout most of BC, but range map excludes the Kootenay region (Environment Canada, 2015).	~	~
Oreoscoptes montanus	Sage Thrasher	Red	Endangered	No - in BC, species only present in South Okanagan-Similkameen(Environment Canada, 2014).	~	~
Limnodromus griseus	Short-billed Dowitcher	Red	~	No - in BC, species only present along the West Coast (BC CDC Conservation Status Report)	~	~
Asio flammeus	Short-eared Owl	Blue	Threatened	No - The species breeds in arctic areas, coastal marshes, and interior grasslands. Grassland habitat is not common around our upland restoration sites (COSEWIC, 2008).	~	~
Buteo swainsoni	Swainson's	Red	~	Maybe - One observation of	~	~

	Hawk			breeding in the north of the Columbia Valley, however most breeding occurs within the Thompson - Okanagan.Breeding occurs within lower elevation and grasslands and agricultural areas, thus unlikely to occur on the upland bench (BC CDC Conservation Status Report)		
Bartramia longicauda	Upland Sandpiper	Red	~	No - In BC, the species mainly occurs in the Northeast. There are a few observations in the East Kootenays (north of Cranbrook), but no recent records have surfaced (BC CDC Conservation Status Report)	~	Maybe - field crews will be made aware of species identification in case of incidental observation.
Aechmophorus occidentalis	Western Grebe	Red	Special Concern	No - Within range, but unlikely to occur on the upland bench (Environment and Climate Change Canada, 2021).	~	~
Megascops kennicottii	Western Screech-Owl	~	Threatened	No - The Northern range of Western Screech Owl in the East Kootenay Trench is around Cranbrook (COSEWIC, 2012)	~	~
Megascops kennicottii macfarlanei	Western Screech-Owl, *macfarlanei* subspecies	Blue	Threatened	No - The Northern range of Western Screech Owl in the East Kootenay Trench is around Cranbrook (COSEWIC, 2012)	~	~
Sphyrapicus thyroideus	Williamson's Sapsucker	Blue	Endangered	No - The Northern range of the species in the East Kootenay Trench is around Kimberley (Ministry of Environment,	~	~

				2012).		
Coturnicops noveboracensis	Yellow Rail	Red	Special Concern	Maybe - The management plan does not include the Columbia Valley within the species' known range, but the BC Bird Atlas has mapped possible breeding evidence in the valley (Environment Canada, 2013).	Stabilize the quantity, quality, and distribution of Yellow Rail breeding, moulting, and stopover habitat across Canada.	Maybe - Potentially calling surveys at night. The species typically inhabitants large wetlands, but have been found in 0.5 - 4 ha wetlands.
Icteria virens	Yellow-breasted Chat	Red	Endangered	No - The species only occurs in three small populations; Okanagan, Trail, and Creston (Environment and Climate Change Canada, 2016).	~	~
Mammals (n = 8)						
Taxidea taxus	American Badger	Red	Endangered	Yes - The Eastern population of the *jeffersonii* subspecies occurs within the study area (Environment and Climate Change Canada, 2021).	Maintain or increase the populations to levels sufficient to ensure persistence over time, and maintain distribution across the known range in BC (Environment and Climate Change Canada, 2021).	Yes - Partner with Goldeneye Ecological to conduct badger burrow surveys where suitable habitat occurs near restoration sites.Possibly monitor restoration sites with wildlife cameras.
Rangifer tarandus pop. 1	Caribou (Southern Mountain Population)	Red	Endangered	Yes - This population does occur and has critical habitat mapped within our study area (Environment Canada, 2014).	Stop the decline in size and distribution, maintain current distribution, increase the population to self-sustaining levels (Environment Canada, 2014).	Yes - Possibly monitor restoration sites with wildlife cameras.
Ursus arctos	Grizzly Bear	Blue	Special Concern	Yes - The management plan and habitat models identify habitat	Maintain grizzly bear populations (Ministry of	Yes - Possibly monitor restoration sites with

				for this species within our study area (Ministry of Environment, 1979).	Environment, 1979).	wildlife cameras.
Neotamias minimus selkirki	Least Chipmunk, *selkirk* subspecies	Red	~	No - Near species range, but the species is confined to alpine areas. Thus, unlikely to occur on the upland bench (Nagorsen, 2004).	~	~
Myotis lucifugus	Little Brown Myotis	Blue	Endangered	Yes - Species distribution generally includes all of BC below the Boreal Forest (Environment and Climate Change Canada, 2018).	Maintain the extent of occurrence observed before White Nose Syndrome (Environment and Climate Change Canada, 2018).	Yes - Could deploy acoustic monitoring devices, potentially partner with Cori Lausen at WCS.
Neotamias ruficaudus ruficaudus	Red-tailed Chipmunk, *ruficaudus* subspecies	Red	~	No - Within species range, but the species in confined to subalpine coniferous forests between 1785 m to 1950 m. All of our restoration sites are significantly below this elevation (Nagorsen, 2004).	~	~
Gulo gulo	Wolverine	~	Special Concern	No - Within species range, but wolverines are active at high elevations (Ministry of Environment, 1989).	~	~
Gulo gulo luscus	Wolverine, *luscus* subspecies	Blue	Special Concern	No - Within species range, but wolverines are active at high elevations (Ministry of Environment, 1989).	~	~