Columbia River Project Water Use Plan

Arrow Lakes Reservoir Operations Management Plan

CLBWORKS-30B Wildlife Enhancement Program – Wetland Enhancement Program

Implementation Year 1

Reference: CLBWORKS-30B

CLBWORKS-30B Burton Flats Fish Stranding Assessment – Risk Analysis and Summary Report

Study Period: January 2018 to October 2018

Nupqu Development Corporation

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December 2018

CLBWORKS-30B Burton Flats Fish Stranding Assessment - Risk Analysis and Summary Report

Prepared for:

BC Hydro
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Project No. 989445-01

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December 5, 2018
Project No. 989445-01

BC Hydro
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Burnaby, BC V3N 4X8

Attention: **Trish Joyce – Natural Resource Specialist, Environment**

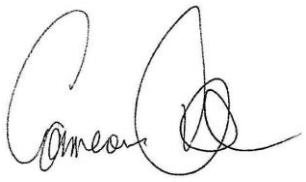
Dear Trish,

Re: **CLBWORKS-30B Burton Flats Fish Stranding Assessment – Risk Analysis and Summary Report, Arrow Lakes Reservoir Wildlife Management Plan, Wildlife Enhancement Program**

Nupqu Development Corporation and Hemmera Envirochem Inc. are pleased to provide you with an electronic copy of our technical report summarizing desktop and field-based analyses for the Burton Flats Fish Stranding Assessment (assessment) related to the BC Hydro CLBWORKS-30B Wildlife Enhancement Program – Wetland Enhancement Program (Project).

We appreciate the opportunity to work with you on this Project, and we trust that this report meets your requirements for this stage of the assessment. Please note that while the information and results provided in the enclosed report result from a desktop review and two seasons of field reconnaissance, the report could continue to be further supplemented if the Project's preferred design changes or if additional sampling/field verification related to fish habitat use and/or potential is warranted. Please feel free to contact the undersigned by phone or email regarding any questions or further information that you may require.

Report prepared by:
Hemmera Envirochem Inc.



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EXECUTIVE SUMMARY

As part of the BC Hydro Lower Arrow Lakes Reservoir Wildlife Enhancement Program (CLBWORKS-30B), the Wildlife Enhancement Project at Burton Flats, B.C. (the Project) is intended to create, protect, or enhance habitat for the primary benefit of migratory and nesting birds, pond-breeding amphibians, and bats. The Project is designed, with a phased approach beginning in summer 2019, to increase diversity and complexity of habitat using naturalized elements and bio-technical approaches for creation of wetland and deep-water pond features in the drawdown zone of the Lower Arrow Lakes Reservoir (LALR). The Project location occurs immediately downslope from the confluence of Burton and Caribou creeks.

The Project's design focuses on using excavation to create wetlands, with access to shallow groundwater levels, and use of excavated material to create adjacent habitat mounds and terrestrial habitat. The resulting wetlands will become inundated during seasonal reservoir filling events (inundation period); however, they are also intended to remain 'in the wet' as reservoir levels recede during the reservoir drawdown period, thereby providing wildlife habitat year-round. As the Project's features are located in the drawdown zone of the LALR and, therefore, subject to fluctuating water levels, the potential risk of stranding fish in the wetlands was identified as a potential consequence requiring further assessment.

The Burton Flats Fish Stranding Assessment (assessment) was commissioned by BC Hydro to investigate the potential risk of fish stranding. This assessment comprised a desktop review and analysis of existing fish species information, historical habitat, and reservoir-level data in the context of the conceptual Project design. A resulting preliminary understanding of fish stranding potential, focussed specifically on select target species (Bull Trout, Kokanee, and Mountain Whitefish), was then supplemented with data collected during field sampling conducted during the drawdown and inundation periods in spring and summer 2018.

A risk-rating tool was developed to support the assessment's translation of desktop and field-based data into categorized risk potentials for the target species. The risk-rating tool considered multiple influences from both abiotic and biotic perspectives: Project Design and Associated Reservoir Levels; Fish Presence and Significance; and Habitat Suitability.

Although a Low stranding risk was predicted for most of the Project's design features, the assessment identified a Moderate risk for fish stranding, for each of the target species, associated with the Project's deep waterfowl pond feature. This feature is characterized as having the greatest wetted area and water depth, as compared to the other features, and is located at the lowest elevation, which results in a comparatively greater percentage of time inundated.

Several recommendations and potential mitigation strategies to reduce the potential for fish stranding are proposed as part of the assessment.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
assessment	Burton Flats Fish Stranding Assessment
ASL	above sea level
CGU	channel geomorphic units
CLBWORKS-30B	Lower Arrow Lakes Reservoir Wildlife Enhancement Program
CPUE	catch-per-unit effort
CRA	commercial, recreational, or Aboriginal fisheries
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
Hemmera	Hemmera Envirochem Inc.
KWL	Kerr Wood Leidal
LALR	Lower Arrow Lakes Reservoir
Nupqu	Nupqu Development Corporation
Project	Wildlife Enhancement Project at Burton Flats
QEP	Qualified Environmental Professional
SARA	*Species at Risk Act*
Tool	fish stranding risk rating tool

SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
>	greater than
<	less than
%	percent
°C	degrees Celsius
ft.	foot
ha	hectare
Hz	hertz
km	kilometre
mg/L	milligrams per litre
km	kilometre
m	metre
ms	millisecond
mm	millimetre
m^2	square metre
m^3	cubic metre
m/s	metres per second
m^3/s	cubic metre per second

1.0 PROJECT OVERVIEW

1.1 Introduction

As part of the BC Hydro Lower Arrow Lakes Reservoir Wildlife Enhancement Program (CLBWORKS-30B), the Wildlife Enhancement Project at Burton Flats, B.C. (Project) is intended to create, protect, or enhance habitat for the primary benefit of migratory and nesting birds, pond-breeding amphibians, and bats. The Project's original Feasibility Design Final Report (KWL 2017) included two design options that proposed to increase diversity and complexity of habitat using naturalized elements and bio-technical approaches, specifically through the creation of wetlands within the drawdown zone of the Lower Arrow Lakes Reservoir (LALR). Subsequent to the drafting of the Feasibility Design Report (KWL 2017), it has been determined that the Project's Option 1 (KWL 2017) is the preferred design option (preferred design) and its concept will be carried forward through the Project's remaining review and regulatory engagement stages (Joyce pers. comm. 2018). In July 2018, Kerr Wood Leidal (KWL) prepared detailed design drawings and updated feasibility drawings for features of the preferred design (KWL 2018). Within this Project design update, it was also proposed that the Project's preferred design would be constructed in a phased approach, with complete or interim construction of some Project features occurring during Phase 1. Phase 2 is proposed to be implemented following a Phase 1 evaluation period, after the successes or potential remedial needs of Phase 1 have been identified. Phase 2 is proposed to include the expansion of select Project features originally constructed during Phase 1 and complete construction of the Project's remaining features.

Given that surface flow is limited (in volume and spatial distribution) within the proposed Project area (KWL 2017), the Project's design focuses on using excavation to create wetlands with access to shallow groundwater levels. The resulting wetlands and other terrestrial features will become inundated during seasonal reservoir filling events (inundation period); however, they are also intended to remain 'in the wet' as reservoir levels recede during the LALR drawdown period, thereby providing wildlife habitat year-round. As the Project's features are located in the drawdown zone of the LALR, and therefore subject to fluctuating water levels as dictated by reservoir levels, the potential risk of stranding fish in the wetlands was identified as a potential consequence requiring further assessment.

Nupqu Development Corporation (Nupqu), in partnership with Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc., has been retained by BC Hydro to inform the Project about the potential likelihood of fish stranding in the Project area as a result of the preferred design option, through its full potential scope at the completion of Phase 2 (KWL 2018). At the direction of BC Hydro, the Burton Flats Fish Stranding Assessment (assessment) initially comprised a desktop review and analysis of existing fish species information, historical habitat, and reservoir-level data in the context of the conceptual Project design (KWL 2017). The initial desktop analysis resulted in a preliminary understanding of fish-stranding potential (Hemmera and Nupqu 2018). However, to further enhance the understanding and validate presumptions made during the desktop analysis, BC Hydro subsequently commissioned field sampling during two seasons in the immediate Project area. These field sampling events occurred in spring and summer 2018 and were strategically timed with reference to LALR water levels. Analysis of the results of the desktop study and data collected in the field were then collectively assessed with context to the detailed drawing designs for features included in Phase 1 and updated feasibility drawings for components of Phase 2 (KWL 2018). For convenience of the reader, this summary report represents collective analyses incorporating the assessment's desktop and field-based components.

Nupqu and Hemmera understand the objectives of the assessment are as follows:

- Determine the fish species that enter or have a reasonable expectation to enter in the Project area during inundation.
- Evaluate the potential level of stranding risk for select fish species (target species) in the Project area during drawdown.

1.2 Study Area

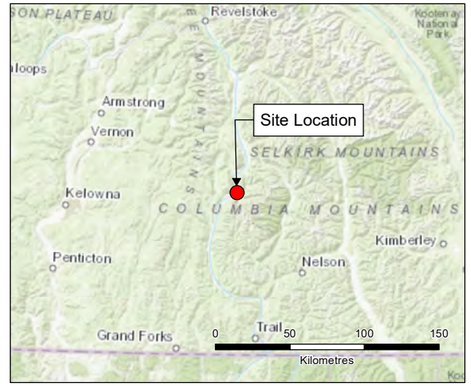
The Arrow Lakes Reservoir (inclusive of the LALR) extends approximately 230 kilometres (km) between Revelstoke and Castlegar, B.C., and is the result of the impoundment of the Columbia River. The reservoir was created by the construction of the Hugh Keenleyside Dam, near Castlegar, in the late 1960s and was designed to provide hydroelectric storage and flood control throughout the Columbia River Basin, including the LALR.

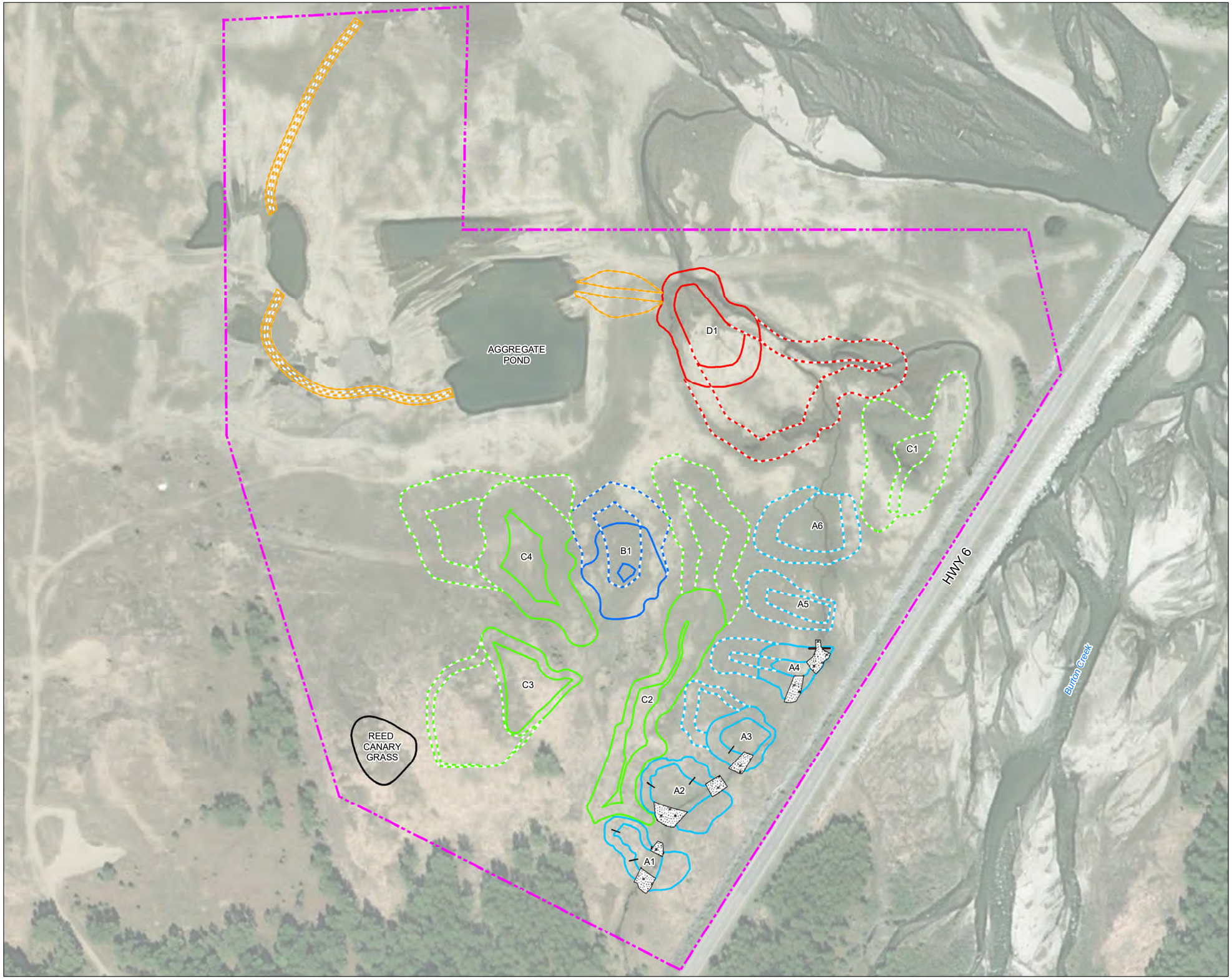
Burton Flats is located south of the settlement of Burton, B.C., in the West Kootenay and northwest of Highway 6 at the confluences of Burton and Caribou creeks (**Figure 1**). The Project's potential footprint is seasonally flooded, as it is entirely encompassed within the drawdown zone of the LALR. Burton Flats is located downstream of a locally known feature named the Narrows, consisting of a narrowing section of Arrow Lakes Reservoir that separates the upper and lower reaches of the reservoir.

Historical daily mean, maximum, and minimum water levels of the LALR at Fauquier (08NE102), as recorded from 1969 to 2015 (BC Hydro 2018), are provided in **Figure 2**. The Fauquier water level station is located approximately 20 km downstream of Burton Flats. Based on an analysis of data collected at this station, water levels in LALR typically begin to rise in mid-April and reach a maximum height in mid-July. While year-to-year variation in reservoir levels is dependent on snow pack, melt timing, and rainfall, the normal maximum reservoir level is 440.13 metres (m) above sea level (ASL). Following peak levels in the summer period, water levels typically recede during the fall and winter months, with minimum water levels varying from year to year. To ensure Kokanee Salmon (*Oncorhynchus nerka*) and Bull Trout (*Salvelinus confluentus*) have access to spawning habitats, BC Hydro adopted a soft constraint target to maintain reservoir levels above 434 m from late August to early November (BC Hydro 2007).

Burton Flats Wildlife Enhancement
Burton Flats, British Columbia

Burton Flats Wildlife Enhancement Project Area





Legend

Phase I
- Deep Waterfowl Pond
- Habitat and Planting Mounds
- Primary Shallow Wetland
- Reed Canary Grass Trial Area
- Secondary Wetlands

Phase II
- Connection to Existing Ponds and Reservoir
- Deep Waterfowl Pond
- Habitat and Planting Mounds
- Primary Shallow Wetland
- Reed Canary Grass Trial Area
- Secondary Wetlands
- Approximate Site Boundary
- Log Outlet Sill Structure
- Potential Cobble at Inlet & Outlet

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Nupqu Development Corporation

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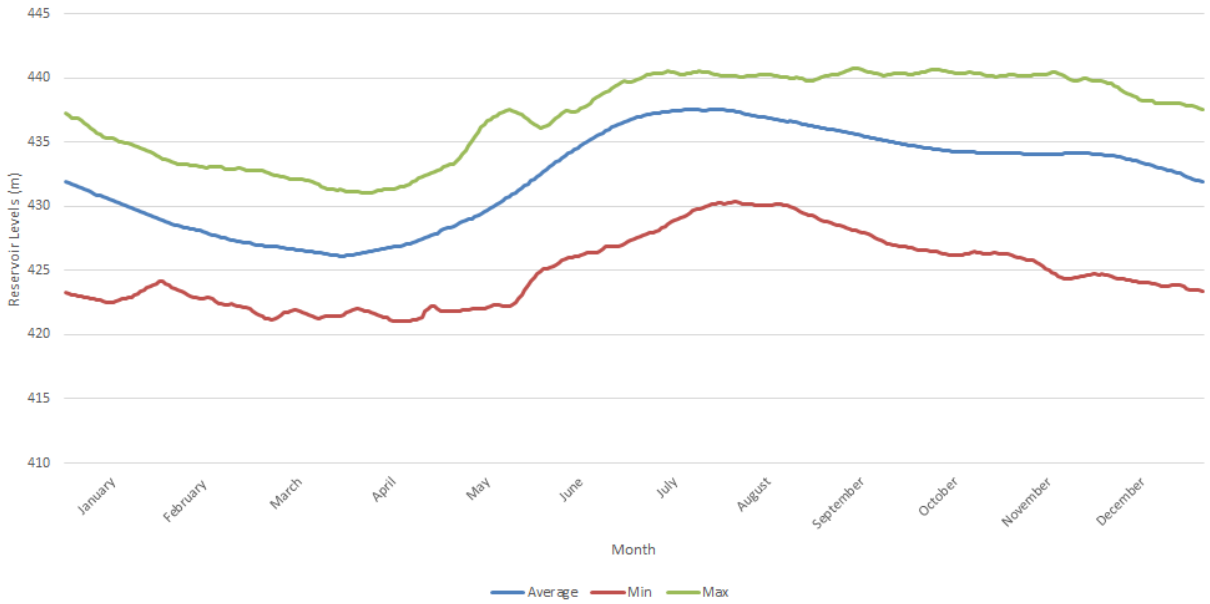


Source: Data provided by BC Hydro 2018

Figure 2 Average daily water level at Lower Arrow Lakes Reservoir at Fauquier. Average, maximum, and minimum levels correspond to 34 years of data recorded, 1984–2018.

1.3 Project Description

The Project is intended to create a mixture of shallow and deep wetland habitats, primarily through excavation of the features and connection to shallow groundwater sources. Two variations of the Project's design concept were initially considered (KWL 2017), each with unique scopes of potential enhancement and Project footprints. Conceptual Project footprints for these two designs ranged between 5.7 hectares (ha) to 6.1 ha, potentially creating 1.4 ha to 1.7 ha of wetland area and wetted surface, with water retentions of 10,000 cubic metres (m^3) to 12,000 m^3 (KWL 2017).

Following internal evaluations of the conceptual design options (KWL 2017), it was determined that the preferred design option would potentially create greater wildlife habitat area. As a result, the preferred design option was selected for design advancement (KWL 2018) and for analysis of the potential risk of fish stranding.

Main Project design features for the preferred design option (KWL 2018) include:

- Multiple primary, shallow-tiered wetlands paralleling an existing drainage – identified as features A1 through A6 (KWL 2018)
- A secondary, shallow, disconnected wetland – identified as feature B1 (KWL 2018)
- Habitat and planting mounds constructed to full-pool elevation – identified as C1 through C4 (KWL 2018)
- A deep waterfowl pond at the lower end of the tiered wetlands – identified as D1 (KWL 2018)
- A reed canary grass trial removal area to test suppression techniques (KWL 2018)
- Drainage channels and/or grading to connect primary shallow wetlands and the deep waterfowl pond to the existing gravel pond and LALR (KWL 2018).

Phase 1 of the Project will include the construction of wetlands A1 and A2 and construction of interim extents of wetlands A3, A4, and B1 and habitat and planting mound C2. Habitat and planting mounds C3 and C4 and the deep waterfowl pond (D1) will also be constructed to interim extents in Phase 1. Pending regulatory approval, Phase 1 is expected be implemented in fall 2019. Completion of Phase 1 will also be dependent on reservoir levels (i.e., construction of the deep waterfowl pond (D1) may extend to spring 2020).

The Project's Phase 2, which remains at the feasibility analysis stage, is expected to commence following an evaluation of the successes or potential remedial needs of components constructed during Phase 1 (KWL 2018). However, it is currently expected that Phase 2 will include the expansion of wetlands A3 and A4 and complete construction of wetlands A5 and A6. The secondary disconnected wetland B1 will also be expanded, and construction of habitat and planting mound C1 will occur, as will the expansion of habitat and planting mound C2. Expansion of the deep waterfowl pond (D1) is also proposed during Phase 2. In addition, the construction of connecting drainage channels between deep waterfowl pond D1 and existing aggregate ponds and between the aggregate ponds and the LALR are identified as Phase 2 activities. The reed canary grass trial area will be constructed independently of Phase 1 and Phase 2 of the Project (KWL 2018).

The estimated surface area and average water depth for each proposed wetland feature and deep waterfowl pond associated with the Project design are provided in **Table 1**. The average inundation window and percentage of time each feature will be inundated between April 1 and October 31 are also provided in **Table 1**. The reed canary grass trial area, drainage channels, and wildlife habitat and planting mounds are not expected to result in stranding risks for fish, so are excluded from further discussion in this report.

KWL (2017) identified the window of April 1 to October 31 as a habitat window of interest for the wildlife enhancement features. The assessment also referred to the April 1 to October 31 period due to its overlap with biologically significant timing for fish species selected as target species for analysis. The percent inundation (**Table 1**) was calculated by KWL 2017 using the "high water level year-round" operating regime, which is the most common operating regime in the LALR during the last 15 years (KWL 2017).

Limited (and in most cases nearly indiscernible) differences are evident in footprint extent between conceptual designs (KWL 2017) and detailed designs and updated feasibility designs (KWL 2018) for the preferred design; therefore, this report references either or both documents as warranted in the context of unchanged design features or the interpretation of the design drawings. The analysis of stranding risk is inclusive of all Project features, presuming that Phase 1 and Phase 2 will be constructed as currently designed by KWL (2018).

Table 1 Proposed wetland enhancement features and inundation timing.

Wetland/Pond Feature	Estimated Surface Area (Wetted) (m^2)1	Estimated Average Water Depth[2] (m)	Outlet Elevation (m CGVD28)	Average Inundation Window[3]	Average Percentage of Time Inundated between April 1 and October 31[4] (%)
A1	900	0.50	438.5	June 25–July 29	16
A2	1,480	0.50	437.8	June 21–Aug 9	23
A3	1,600	0.50	437.2	June 16–Aug 22	32
A4	970	0.50	435.5	June 6–Sept 19	50
A5	1,020	0.50	435.0	June 4–Sept 30	56
A6	1,320	0.43	434.2	May 30–Oct 31	72
B1 - disconnected	1,640	0.50	No outlet	June 11–Sept 5	41
D1	7,970	1.2	432.5	May 18–Oct 31	78

Source: KWL 2018

Notes: 1 Phase 1 and Phase 2 combined

2 Average water depths in wetlands A1 though A6 do not include an additional 0.2 m–0.4 m pool in each feature to account for variability in groundwater levels

3 Based upon Operating Regime 3 (High-water Level Year-round), the most common regime used in the Arrow Lakes Reservoir in the last 15 years (KWL 2017)

4 Calculated from estimated retained water volume and estimated water surface area provided by KWL 2017.

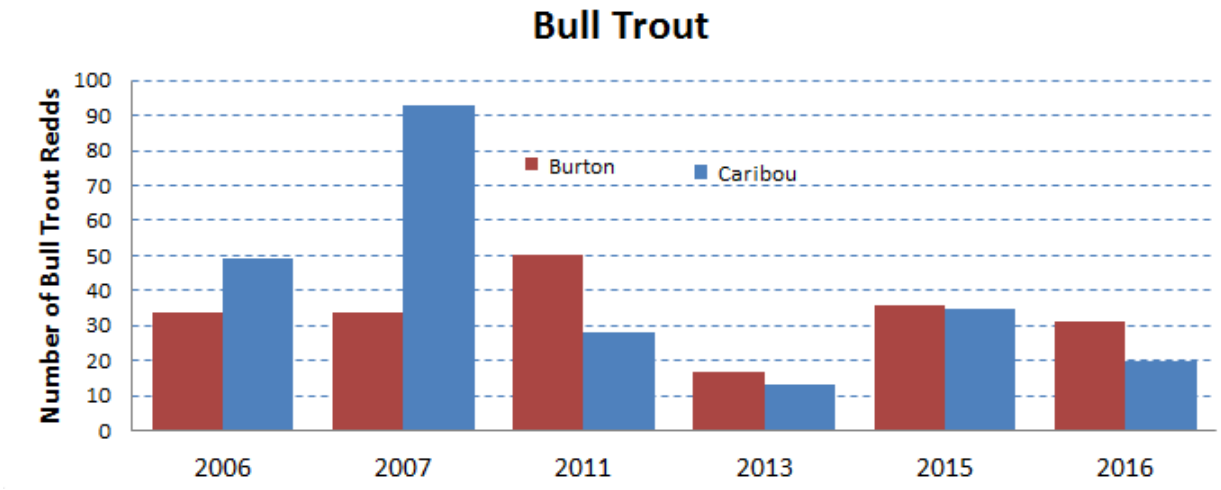
The Project is located southwest of the confluence of Burton and Caribou creeks and immediately upstream from Highway 6. The alluvial fan located downstream of Highway 6 is wide and heavily braided at low reservoir levels; however, during inundation, water levels within the reservoir extend upstream of the bridge. Spring flows maintain adequate channelization and depth for fish passage through the alluvial fan during spring conditions, when reservoir levels are low (Hawes and Drieschner 2013).

During summer and fall flow conditions, water depths near the Highway 6 bridge adjacent to the Project site (**Figure 1**) provide suitable cover for fishes preparing to migrate upstream to preferred spawning habitat in Burton or Caribou creeks. Spawning of both Bull Trout (**Figure 3**) and Kokanee Salmon (**Figure 4**) have been previously documented upstream, beyond the Highway 6 bridge. No passage concerns were noted for either Burton or Caribou creeks in the reservoir drawdown zone during studies from 2010 to 2012 (Hawes and Drieschner 2013), and aquatic habitat occurring in Burton and Caribou creeks has been determined to be of high value to multiple fish species (Hawes and Drieschner 2013).

Overland drainage, culvert crossings under Highway 6 to the east of the Project area, and groundwater intrusion (i.e., toe seepage) through Highway 6 along the Project's southeast extent all have the potential to influence the timing and volume of flow within the Project area (**Figure 1**), particularly during the drawdown period. However, the volume of these influences is considered negligible and was considered during the Project's detailed design stage (KWL 2018).

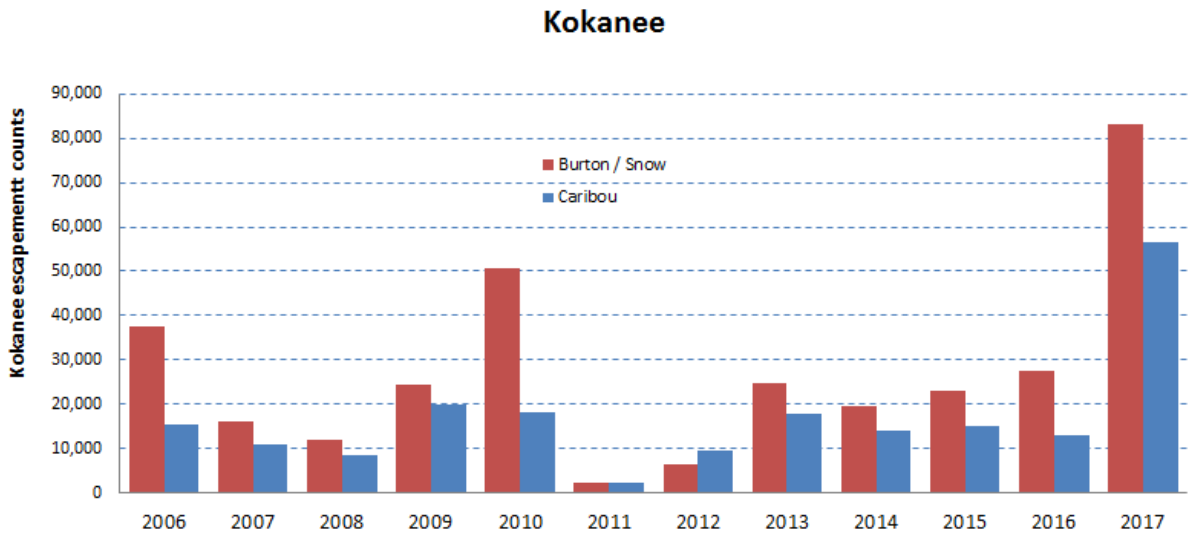
Burton Flats currently contains low-elevation, deep-water ponds (aggregate ponds), which are the result of previous aggregate mining operations in the area. Located within the northwest corner of the Project area (**Figure 1**), these ponds are seasonally inundated during the reservoir filling period and then isolated (although filled with water) during drawdown. These aggregate ponds will be connected to several of the Project design's features during drawdown periods via a drainage channel.

Substrate in the Project area largely consists of relatively coarse materials, which are moderately embedded (in areas other than the drainage and seepages) with fines. A diverse assemblage of annual and early seral plant species occur in the area (Hawkes and Tuttle. 2016) and is exposed during the drawdown period. During inundation, these species are submerged and additional emergent vegetation species are supported. While some of the Project's design features are located near the edge of the drawdown zone (e.g., D1, drainage channel), others are proposed for higher elevations near more upland areas (e.g., C3). These areas are anticipated to comprise a dry, grassy field during drawdown and would only be seasonally inundated.



Source: BC Hydro Environmental Field Services, B.C. 2018, pers. comm.

Figure 3 Bull Trout redd survey data from Burton Creek and Caribou Creek, 2006–2016.



Source: BC Hydro Environmental Field Services, B.C. 2018, pers. comm.

Figure 4 Kokanee Salmon escapement data from Burton Creek and Caribou Creek, 2006–2017.

1.4 Aquatic Habitat and Fish Community

Several different fish species are known to occur in the LALR, and/or Burton and Caribou creeks, including species of management and conservation concern, exotic species, and forage/coarse fish species. However, given the spatial extent of the LALR and in consideration for species-specific habitat preferences and historical documented presence in tributaries nearest the Project area (i.e., Burton and Caribou creeks), it is reasonable to anticipate that not all fish species in the LALR are likely to occur in the Project area. Species that are most reasonably expected to occur in the LALR and/or Burton and Caribou creeks are represented in **Table 2**. Species listed in **Table 2** are exclusive of exotic or introduced species (e.g., Brook Trout) and species historically documented but subsequently determined extirpated from the area (e.g., Columbia Sculpin (*Cottus hubbsi*) (COSEWIC 2010a), Umatilla Dace (*Rhinichthys umatilla*) (COSEWIC 2010b), and Shorthead Sculpin (Cottus confuses) (COSEWIC 2010c)).

With this understanding, the Project team established a select list of target species for consideration during this assessment to provide a detailed evaluation on species of management and/or conservation concern most likely to be influenced by the Project. Selection of the assessment's target species was strategic, to ensure inclusion of those fish species that are:

- Most reasonably anticipated to occur in the Project area (i.e., based on historically documented fish presence)
- Most representative of commercial, recreational, or Aboriginal (CRA) fisheries in the area
- Of greatest conservation concern (e.g., provincial or federal listing).

The list of target species was originally established during the desktop review based on area-specific historic sampling. The Project team reviewed and validated this list throughout the assessment, although it remained unchanged, based on the sampling results of the field-based component completed in spring and summer 2018.

Table 2 Fish species most reasonably expected to occur near the Project area.

Waterbody Documented[1]			Common Name	Scientific Name	Provincial Status[2]	COSEWIC Status[3]	SARA Status[3]
LALR	Caribou Creek	Burton Creek					
SPORTFISH							
X	X	X	Bull Trout	*Salvelinus confluentus*	Blue	special concern	-
X			Cutthroat Trout[4]	*Oncorhynchus clarkii*	Blue	-[4]	-[4]
X	X	X	Rainbow Trout	*Oncorhynchus mykiss*	Yellow	-	-
X			Burbot	*Lota lota*	Yellow	-	-
X	X		Mountain Whitefish	*Prosopium williamsoni*	Yellow	-	-
X			Lake Whitefish	*Coregonus clupeaformis*	Yellow	-	-
X	X	X	Kokanee Salmon	*Oncorhynchus nerka*	Yellow	-	-
X			White Sturgeon[5]	*Acipenser transmontanus*	Red	endangered	endangered

Waterbody Documented[1]			Common Name	Scientific Name	Provincial Status[2]	COSEWIC Status[3]	SARA Status[3]
LALR	Caribou Creek	Burton Creek					
NON-SPORTFISH							
X			Bridgelip Sucker	*Catostomus columbianus*	Yellow	-	-
X			Largescale Sucker	*Catostomus macrocheilus*	Yellow	-	-
X			Longnose Sucker	*Catostomus catostomus*	Yellow	-	-
X	X		Lake Chub	*Couesius plumbeus*	Yellow	-	-
X			Peamouth Chub	*Mylocheilus caurinus*	Yellow	-	-
X			Leopard Dace	*Rhinichthys falcatus*	Yellow	not at risk	-
X	X		Longnose Dace	*Rhinichthys cataractae*	Yellow	-	-
X			Slimy Sculpin	*Cottus cognatus*	Yellow	-	-
X			Torrent Sculpin	*Cottus rhotheus*	Yellow	-	-
X			Prickly Sculpin	*Cottus asper*	Yellow	-	-
X			Northern Pikeminnow	*Ptychocheilus oregonensis*	Yellow	-	-
X			Pygmy Whitefish	*Prosopium coulterii*	Yellow	not at risk	-
X			Redside Shiner	*Richardsonius balteatus*	Yellow	-	-

Notes/Sources: COSEWIC – Committee on the Status of Endangered Wildlife in Canada

1 List compiled from area-specific search using iMapBC (2018) and does not include exotic or introduced species including Brook Trout, Largemouth Bass, Pumpkinseed, Walleye, and Yellow Perch.
2 B.C. Conservation Data Centre 2018
3 DFO 2018
4 Cutthroat Trout populations previously documented in LALR include both Coastal and Westslope (Yellowstone) Cutthroat Trout. Westslope Cutthroat Trout were introduced into small headwater lakes in the Arrow Lakes region (B.C. MWLAP 2004) and do not represent populations listed under the *Species at Risk Act.*
5 Arrow Lakes Reservoir component of the Columbia River population of White Sturgeon.

Habitat preferences and species descriptions are provided below for the Project's target species (i.e., Bull Trout, Kokanee Salmon, and Rainbow Trout [*Oncorhynchus mykiss*]), as well as for White Sturgeon (*Acipenser transmontanus*), which are included due to their cultural, social, and biological significance in B.C.

White Sturgeon

The Columbia River population of White Sturgeon within the Arrow Lakes Reservoir is considered endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2012a). The population's estimated size, in 2005, consisted of 52 adults (COSEWIC 2012a). The population is known to overwinter in the Beaton Reach area near the Hugh Keenleyside Dam and Big Eddy, near Revelstoke, and spawn near Revelstoke (DFO 2014). Spawning activity is low and does not occur annually (Hildebrand

and Hildebrand 2014). Critical habitat is confirmed for late juvenile rearing and adult feeding (Moderate degree of use) in the Narrow Burton Reach of the Arrow Lakes Reservoir, located upstream of the Project area (DFO 2014). The Narrow Burton Reach is also suspected to provide Critical habitat (Low degree of use) for early juvenile rearing (DFO 2014). The extent of critical habitat defined in the Narrow Burton Reach (DFO 2014) identified by DFO does not extend downstream to the Project area.

Preferred adult White Sturgeon feeding areas in the Arrow Lakes Reservoir comprise depths greater than 10 m, while juvenile rearing habitats tend to comprise depths greater than 5 m and are used from mid-June to mid-August (COSEWIC 2012a). Juvenile habitat is typically characterized as low velocity, deep-water features that are often associated with tributary confluences in large backwaters, sloughs, and side channels (DFO 2014). Sub-adults (over 2 years) are often found in deep-water habitats, adjacent to reaches with heavy flow over sand and fine gravels. According to Hawkes and Tuttle (2016) White Sturgeon are not likely to utilize habitat located east of the Highway 6 bridge at the confluence of Burton and Caribou creeks. Set-line sampling in 1998 and 1999, specifically targeting White Sturgeon in Burton Flats immediately north of the Project area (in the zone of inundation), resulted in no White Sturgeon being captured or observed, despite 3,852 hook hours of effort (RL&L 1999).

Due to the limited probability of occurrence of White Sturgeon in the Project area, their habitat preferences, and the location of the Project outside critical habitat for the species, it was not considered as a target species for this assessment.

Bull Trout

A cold-water species, Bull Trout are frequently referenced as having the most sensitive and complex habitat requirements among trout and char species in western North America (Mackay et al. 1997). Overall, Bull Trout require habitat that is cold, clean, complex, and connected (COSEWIC 2012b). Generally, Bull Trout are found in water with temperatures below 18 degrees Celsius (°C) but most commonly in habitat with water temperatures below 12°C.

This species spawns in the late summer to early fall and require flowing water to spawn (McPhail 2007). Females excavate redds (i.e., gravel nests) in coarse gravel substrates near cover, generally near groundwater upwelling. Spawning and egg incubation require clean (i.e., unembedded) gravels and cobble substrates (2 millimetres [mm] to 256 mm) and groundwater inflow (Stewart et al 2007, Roberge et al 2002, Evans et al. 2002).

Migration to spawning areas typically commences in July; however, in the Arrow Lakes Reservoir, migration of adfluvial Bull Trout commences as early as April (Hawes and Drieschner 2013). Migration to spawning habitat in Burton Creek is likely limited to the lower-most kilometres of the watercourse due to the high gradient and a deep bedrock canyon (Decker and Hagen 2007). Similarly, suitable spawning habitat in Caribou Creek is limited to its lower-most 6 km, and a naturally occurring barrier located approximately 4 km upstream from the reservoir is presumed to be an impediment during low flows in August and September (Decker and Hagen 2007). Bull Trout spawning data from Burton Creek is provided in **Figure 3**.

Specific to the LALR population, Bull Trout spawning activity commences when water temperatures drop below 9°C, often in mid-September, and ceases when temperatures fall below 5°C in November (McPhail 2007, Hawes and Drieschner 2013). Spawning habitat is low in velocity (<0.9 metres per second [m/s]) and shallow (<1 m) (COSEWIC 2012b), typically characterized by run and glide habitats (McPhail 2007).

Incubation occurs over the early winter when water temperatures are generally between 2°C and 4°C. Hatching is anticipated to occur in January and February, while emergence generally occurs in early April to late May (Hawes and Drieschner 2013). Juveniles spend two to three weeks near their emergence location and then move to side channels and low-velocity areas for the remainder of the year, using substrate as a primary cover source (COSEWIC 2012b). As juveniles mature, they seek deeper pools associated with large, woody debris in lower-tributary reaches (ASRD and ACA 2009). Lakeward migration in adfluvial populations of Bull Trout in Arrow Lakes Reservoir typically occurs at year 3+ (Clark and Telmer 2008).

As juveniles develop into adults, their diet shifts from invertebrates to more piscivorous food sources (McPhail 2007). Adfluvial adults appear to remain in deep water during the day and move to shallow, littoral areas at night for foraging.

Kokanee Salmon

Kokanee Salmon are freshwater, resident Sockeye salmon. Within the Arrow Lakes Reservoir, Kokanee Salmon typically spawn after reaching the age of 4 (Lindsay 1994). Spawning typically occurs in late August to early October (Hawes and Drieschner 2013), and like other salmonids, females chose the spawning location on sites with gravel substrates and sub-gravel flow with velocities less than 1 m/s and water depths less than 0.40 m (McPhail 2007). Some Kokanee Salmon spawn on beaches with upwelling or subsurface flow, although beach spawning typically occurs in depths less than 10 m (McPhail 2007). In these locations, if substrates are too large for redd-building females, they may clean the substrate only rather than building a traditional redd, allowing the eggs to fall between large gravels and cobbles. Like Sockeye Salmon, Kokanee Salmon die following spawning.

Reservoir levels and adequate stream flows did not impede Kokanee Salmon staging and migration in Burton and Caribou creeks in a study from 2010 to 2012 (Hawes and Drieschner 2013). In 2012, high Kokanee Salmon spawning use was also observed in gravel outwash deposited in the upper drawdown zone near Burton and Caribou creeks (Hawes and Drieschner 2013). Kokanee Salmon escapement data (collected during spawning migrations in the Burton and Caribou creek watersheds) are provided in **Figure** 4.

Kokanee Salmon spawning in LALR tributaries occurs between 4°C and 15°C. Kokanee Salmon eggs typically incubate from 39 days to 140 days (September to March), and fry emerge from March to May (Hawes and Drieschner 2013). Where spawning occurs within the drawdown zone, developing Kokanee Salmon are especially vulnerable to stranding (Hawes and Drieschner 2013). Upon emergence, fry migrate downstream to a nursery lake or reservoir (McPhail 2007). Fry typically spend several weeks feeding in littoral zones before moving offshore to deeper areas mid-summer. Littoral zones are used more regularly once Kokanee Salmon fry reach a size threshold for increased predation risk. Adult Kokanee Salmon reside in offshore habitats and can exhibit crepuscular (twilight) foraging migrations.

Rainbow Trout

In Arrow Lakes Reservoir, Rainbow Trout begin migrating to spawning habitats when water temperatures rise above 5°C in April to May, and spawn during early May and late June, when water temperatures range between 6°C and 9°C (Hawes and Drieschner 2013). Recorded water temperatures in Caribou and Burton creeks indicate that conditions may be suitable for Rainbow Trout spawning in early March (Hawes and Drieschner 2013). This unique temperature trend suggests that Rainbow Trout near the Project area may begin migrating earlier than in other regions of Arrow Lakes Reservoir.

Rainbow Trout are redd builders and generally spawn in glide habitat with small gravel (2 mm to 26 mm) and velocities of between 0.3 m/s and 0.7 m/s (McPhail 2007, Raleigh et al 1984). Incubation occurs until early July, and fry emergence occurs from mid-June to early September in Arrow Lakes Reservoir (Hawes and Drieschner 2013).

Lakeward migration of adfluvial populations of Rainbow Trout typically occurs in the first summer or early fall, when fish stay approximately 2 m–5 m offshore (McPhail 2007). Adult Rainbow Trout typically stay below the 18°C isotherm in lakes and are not usually found offshore in large, oligotrophic lakes.

2.0 METHODS

2.1 Aquatic Habitat Characteristics and Fish Community

Prior to conducting the assessment's field-based components, the Project team completed a desktop review of the Project's design and available existing habitat and fish use information. Historically documented fish presence information was derived from publicly available literature and fish inventories (iMapBC 2018). Aerial imagery of the Project area from 2004, 2005, 2007, and 2011 was reviewed (Google Earth 2018). Existing literature and imagery were reviewed and interpreted to define habitat features, including wetted widths, water depths, substrate composition, primary channel geomorphic units, and cover amount (i.e., overhanging vegetation, woody debris, instream vegetation, boulder, undercut banks, and depth), relative to the Project's design.

In spring (May 8, 9, and 10) and summer (July 6 and 7) 2018, the Project team conducted field-based sampling of aquatic habitat and fish communities to support presumptions made during the desktop review about habitat suitability and learn more about habitat potential and fish use during the drawdown (spring) and inundation (summer) periods, respectively. During the spring site visit, the Project team quantified habitat characteristics of lotic (watercourse) and lentic (ponded areas in the drawdown area within the Project's proposed footprint) habitat. During the summer site visit, the team made generalized observations about habitat conditions (e.g., depth and cover for fishes) in the Project area during the inundation period.

2.1.1 Spring Site Visit

During the spring site visit, the Project team measured channel and wetted widths, water depth, and water velocities at seven randomly selected transects (**Table 3**) within two channelized drainages that conveyed flow in a northerly direction (transect location information is provided in **Figure 6**). In addition, the team evaluated substrate composition at each transect location and estimated substrate embeddedness as either Low, Moderate, or High, based on methods outlined in Alberta Transportation (2001). The Project team also recorded bank height, shape, stability and composition, and approach grades at each transect and measured gradients using a clinometer. They also referenced percent slope and generalized riparian width, stream shading, and vegetation types (e.g., grasses, shrubs, deciduous or coniferous) near each of the channels.

Water quality information was measured (i.e., temperature, conductivity, pH, and dissolved oxygen concentration [DO]) daily within each channelized section using a multiparameter SmartTroll handheld water quality meter; the same parameters were also measured in the aggregate pond. Water quality monitoring location information is provided in **Figure 6**.

Discharge within each of channels was measured concurrently with the collection of other habitat parameter information. At each transect, the channel's wetted width was separated into 0.5-m bins, consecutively established to span the wetted width. At the mid-point of each bin, the average depth and velocity (i.e., at 60% depth) was measured using a Swoffer Model 2100 Current Velocity Meter. The resulting bin values were summed to determine the discharge at the transect. Discharge values collected at the downstream most transect within each channel were presumed to represent the greatest potential value and so are referenced exclusively in subsequent tables and sections.

The Project team identified primary channel geomorphic units (CGU) and other unique features (e.g., islands) over the extent of each channelized drainage (i.e., from the source point or inflow from culvert crossing under Highway 6). Within each CGU, the team quantified the type and amount of cover for fish (i.e., overhanging vegetation, woody debris, instream vegetation, boulder, undercut banks and depth). The team also recorded areal extents and approximate orientations of all ponded areas.

Table 3 Habitat parameter collection information, spring 2018.

Habitat Parameter	Method/Instrument	Location	Unit of Measure	Date of Collection
Channel width	Visual observation, measuring tape	7 randomly selected transects[a]	m	May 8–9, 2018
Wetted width	Visual observation, measuring tape	7 randomly selected transects[a]	m	May 8–9, 2018
Channel depth	Visual observation, measuring tape	7 randomly selected transects[a]	m	May 8–9, 2018
Water velocity, discharge	Swiffer 2100 velocity meter	7 randomly selected transects[a]	Velocity; m/s Discharge: m^3/s	May 8–9, 2018
Water quality (temperature, turbidity, dissolved oxygen, conductivity)	SmartTroll handheld water quality meter	Downstream most transects within each channel	Temperature: °C Turbidity: NTU Dissolved Oxygen: mg/L Conductivity: µS/cm	May 8–9, 2018
Substrate composition and embeddedness	Visual observation, estimation	7 randomly selected transects[a]	Composition: None, trace, sub-dominant, dominant Embeddedness: Low, Moderate, High	May 8–9, 2018
Bank height, shape and composition	Visual observation, measuring tape	7 randomly selected transects[a]	Height: m Shape: sloping, vertical, undercut Composition: dominant/sub-dominate (estimation)	May 8–9, 2018
Channel geomorphic units	Visual observation, measuring tape	Length of channelized section per channel	m	May 8–9, 2018
Cover for fish	Visual observation, measuring tape	Within each˚ CGU where present	None, trace, dominant, sub-dominant	May 8–9, 2018
Gradient	Visual observation, clinometer	Randomly selected transects	%	May 8–9, 2018
Riparian width, stream shading and vegetation type	Visual observation, measuring tape	Length of channelized section per channel	Width: m Shading: % of canopy cover Vegetation type: grasses, shrubs, deciduous, coniferous	May 8–9, 2018

Notes: µS/cm – microsiemens per centimetre; m^3/s – cubic metres per second; mg/L – milligrams per litre; NTU - nephelometric turbidity units;

1. Refer to **Figure 6** for locations.

The Project team sampled fish communities in the channelized drainages as well as in ponded areas (where conditions warranted) during the spring site visit. Depending on location and method used, sampling for fish occurred on May 8, 9, and 10, 2018. Backpack electrofishing (SmithRoot LR-24 – 200 V; 35 Hertz [Hz]; 4.0 milliseconds [ms]) was used to sample the full extent of Channel 1 as well as within some of the ponded areas, where depth permitted. Minnow trapping (gee-type, baited with cat food) was used to supplement sampling effort in some of the ponded areas and Channel 1, while it was used exclusively in other ponds and in Channel 2 where conditions precluded electrofishing. Simple arc-seine sets (net dimensions: 30 m length; 1.8 m height; 6.4 mm mesh size) were conducted with radius lengths of 10 m and 12 m within the littoral zone of the aggregate pond. Backpack electrofishing (SmithRoot LR-24 – 200 V; 35 Hz; 4.0 ms) and minnow trapping (as in other ponded areas) supplemented sampling in the littoral zone of the aggregate pond. Location information for each sample method type is provided in **Figure 6**.

Sampling of fish communities occurred in accordance with Scientific Fish Collection Permit #CB18-290857, issued by the Ministry of Forest, Lands and Natural Resource Operations, Kootenay – Boundary Region.

2.1.2 Summer Site Visit

All habitat features previously observed during the spring site visit were inundated at the time of the summer site visit (July 6 and 7, 2018). As a result, habitat characteristic observations during the summer site visit were limited to the collection of water quality information (water temperature) and generalized evaluations about fish cover and feeding habitat. At approximately 10:00 on July 7, 2018, the Project team collected water temperature at a near-shore (shallow) location in the area of the Project's shallow wetland A1 and from mid-depth in the area of Project shallow wetland A4. Characterization of fish cover and feeding habitat was not quantified; instead, it was generalized based on collective observations made of the inundated Project area.

The Project team sampled fish communities during the summer site visit under an amended Scientific Fish Collection Permit #CB18-290857. Sampling effort types included arc-seine netting, fyke netting, backpack electrofishing, and overnight minnow trapping efforts. Location information for all sampling effort types is included in **Figure 7**.

Arc-seine sampling consisted of multiple simple arc sets in littoral zones, with the assistance of an oar propelled inflatable pontoon boat, as described by Hahn, Bailey, and Ritchie (2007). Dimensions of the seine net were 30 m (length) by 1.8 m (height) and its mesh diameter was 3 mm.

The fyke net (4 m in length) comprised 3-mm mesh netting, with a 1 m x 1.8 m rectangular gate opening (oriented with opening facing downslope) and three internal hoop components, with a final upstream ring-trap gate measuring 10 cm. The fyke net's wing panels were customized with 1.8-m-high seine netting to span the wetted width of the set location and were set for overnight effort between July 6 and 7, 2018. Backpack electrofishing (SmithRoot LR-24 – 220 V; 30 Hz; 4.0-5.0 ms) was conducted on July 6, 2018 in shallow habitat, immediately upslope from the fyke net.

Given considerable water depths in much of the Project area (>2 m), sampling within deep-water areas was limited to pelagic minnow trap sets (gee-type traps) baited with cat food.

2.1.3 Habitat Suitability

The Project team assessed the potential for fish habitat within the Project area (i.e., specific to the Project's target species) based on observed and interpreted aquatic habitat characteristics resulting from this assessment's desktop analysis and spring and summer site visits. Potential ratings of fish habitat suitability were defined as follows:

- **Preferred:** habitat that is rare, highly productive, sensitive, or vital in sustaining CRA fisheries, or any species at risk or of management concern.
- **Suitable:** habitat that is important to the fish population for spawning, feeding, rearing, wintering, and migration; however, it is not deemed to be critical to a specific population.
- **Marginal:** habitat characterized by low productive capacity that contributes marginally to fish production, including habitat that is not available year-round to fish due to natural permanent barriers.
- **Unsuitable:** no suitable habitat present for a specific fish species life history stage.

The Project team assigned habitat potential ratings with reference to observed and interpreted habitat characteristics, and with context to each species' preferred requirements for each of the following life stages: spawning, rearing, adult feeding/foraging, and overwintering. Preferred requirements were established based on habitat suitability values documented in literature. Habitat suitability values considered for this Project and specific to its target species are provided in **Appendix C**. In addition to quantified field observations referenced against documented preferred conditions, final assigned suitability ratings were also subject to some discretion and professional judgement of the Qualified Environmental Professional (QEP; Greg Eisler).

2.2 Fish Stranding Risk Assessment

2.2.1 Fish Stranding Risk Rating Tool

A risk-rating tool for fish stranding (tool) was developed for the assessment (**Table 4**). As with other similar tools (e.g., Hanson and Nadeau 2010), the tool for this Project was developed based on the acknowledgement that potential fish stranding in the proposed wildlife enhancement features does not necessarily indicate mortality (i.e., survival following isolation may be possible). As a result, the tool was developed to assess the risk of stranding only.

Table 4 Fish stranding risk assessment tool for the Burton Flats Wildlife Enhancement Project.

Criterion	Risk Category					
	None (0)	Low (1)	Low to Moderate (2)	Moderate (3)	Moderate to High (4)	High (5)
Design Plan and Reservoir Levels						
Wetland area (m^2)	-	<1,000	1,000–2,000	2001–3000	3001–4000	>4000
Wetland depth (m)	-	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
% of days inundated from April to October	-	<20	20–40	40–60	60–75	>75
Fish Presence and Significance						
Fish presence (historical and field-verified)	None	–	–	Adults only	Juveniles only	All life stages
Conservation status – Provincial	No Status or Exotic	–	–	Yellow or Unknown	Blue	Red
Conservation status – Federal[1]	None	Not at risk	Candidate	Special Concern	Threatened	Endangered
Habitat Suitability						
Spawning suitability if coinciding with inundation	Unsuitable	-	Marginal	-	Suitable	Preferred
Spawning timing relative to inundation	Inundation does not coincide with staging/ spawning or no spawning habitat present	-	Inundation coincides with staging/ spawning and outmigration/ emergence	-	Inundation coincides with staging/ spawning/ outmigration but not emergence	Inundation coincides with staging/ spawning but not emergence
Juvenile rearing suitability at inundation	Unsuitable	-	Marginal	-	Suitable	Preferred
Adult feeding/foraging suitability at inundation	Unsuitable	-	Marginal	-	Suitable	Preferred

Note: Either COSEWIC or *Species at Risk Act* (SARA) listing status can be used.

A series of criteria was identified as critical parameters for considering the potential for risk stranding. These criteria span considerations relevant to the proposed footprint characteristics, inundation timing and duration, habitat availability and potential use, fish species presence, and the conservation status of target species. Each criterion is assigned an individual rating or score, in increasing importance from 0 and 5, for each target species. The sum of the criteria scores (out of a potential 50) determines the perceived relative risk of stranding. A risk index was established to provide a benchmark for risk indices and comparison between species. The index is dependent on a three-tiered scoring system with High, Moderate, or Low indices being defined (**Table 5**).

Table 5 Risk index ratings and associated risk of fish stranding.

Risk Index[1]	Risk of Fish Stranding
>35	High
26 - 35	Moderate
≤25	Low

Notes: 1 Risk index as taken from fish stranding risk rating tool (**Table 4**).

It is expected that these criteria and associated rating schemes will remain relevant should changes to the Project's detailed or updated feasibility designs be necessary, although re-evaluation of risk scorings may be needed if subsequent design changes occur (i.e., relative to KWL 2018).

2.2.2 Criteria Rationale

The above criteria were selected and rated based on the following rationale:

Wetland Area

Based on similar rationale to Hanson and Nadeau (2010), an increase in the design option's wetland area (m^2) is considered a greater perceived potential risk of fish stranding because fish are more likely to access the wetland.

Wetland Depth

Based on similar rationale as Hanson and Nadeau (2010), increased mean water depth (m) of the design option's wetland features is considered a greater perceived potential risk of fish stranding because fish are more likely to access the footprint. Habitat preferences by different species and life stages for variable water depths are considered in the habitat suitability criteria.

Percentage of Days Inundated

Based on similar rationale as Hanson and Nadeau (2010), increased percentage of the time (of year) in which the design option's wetland features are inundated is considered to create more available time for fish to access the feature, thereby increasing the perceived potential risk of fish stranding. This criterion incorporates pool elevations, relative inundation levels, and operating regimes, which are provided by KWL (2017). Operating Regime 3 has been the most common regime used over the last 15 years.

Fish Presence (Historical and Field Verified)

Species presence in the approximate areas of the wetland feature was determined, with special consideration given to those life stages more vulnerable to stranding (i.e., those more susceptible to stranding are rated higher than those less prone to gradual dewatering). Species presence in this report was determined using the desktop investigation and updated following field verification.

Federal and Provincial Conservation Status

Consideration of the stranding potential for species that are rare or otherwise of conservation concern was based on the provincial and federal conservation status of each target species. Species of limited conservation concern were rated lower than those of elevated concern.

Spawning Suitability if Coincides with Inundation

Habitat suitability for spawning (specific to the spawning period of the target species if that timing or staging coincides with inundation) was rated as Preferred, Suitable, Marginal, or Unsuitable. Habitat suitability of each rating was based on potential ranges of values associated with several parameters (e.g., substrate, depth, water temperature) that influence spawning fish habitat potential. The value of these ranges for individual parameters was informed by peer reviewed literature defining species-specific habitat preferences (**Appendix C**), and the assignment of suitability ratings was conducted by a QEP (Mark Fjeld) with experience conducting fish and fish habitat assessments.

Spawning Timing Relative to Inundation

To increase the weighting associated with eggs and alevin having a relatively higher risk of stranding (as compared to fry, juveniles, and adults), the timing of spawning and emergence relative the inundation period was compared and scored, reflecting the highest risk when spawning coincides with inundation, but not emergence.

Juvenile Rearing Suitability at Inundation

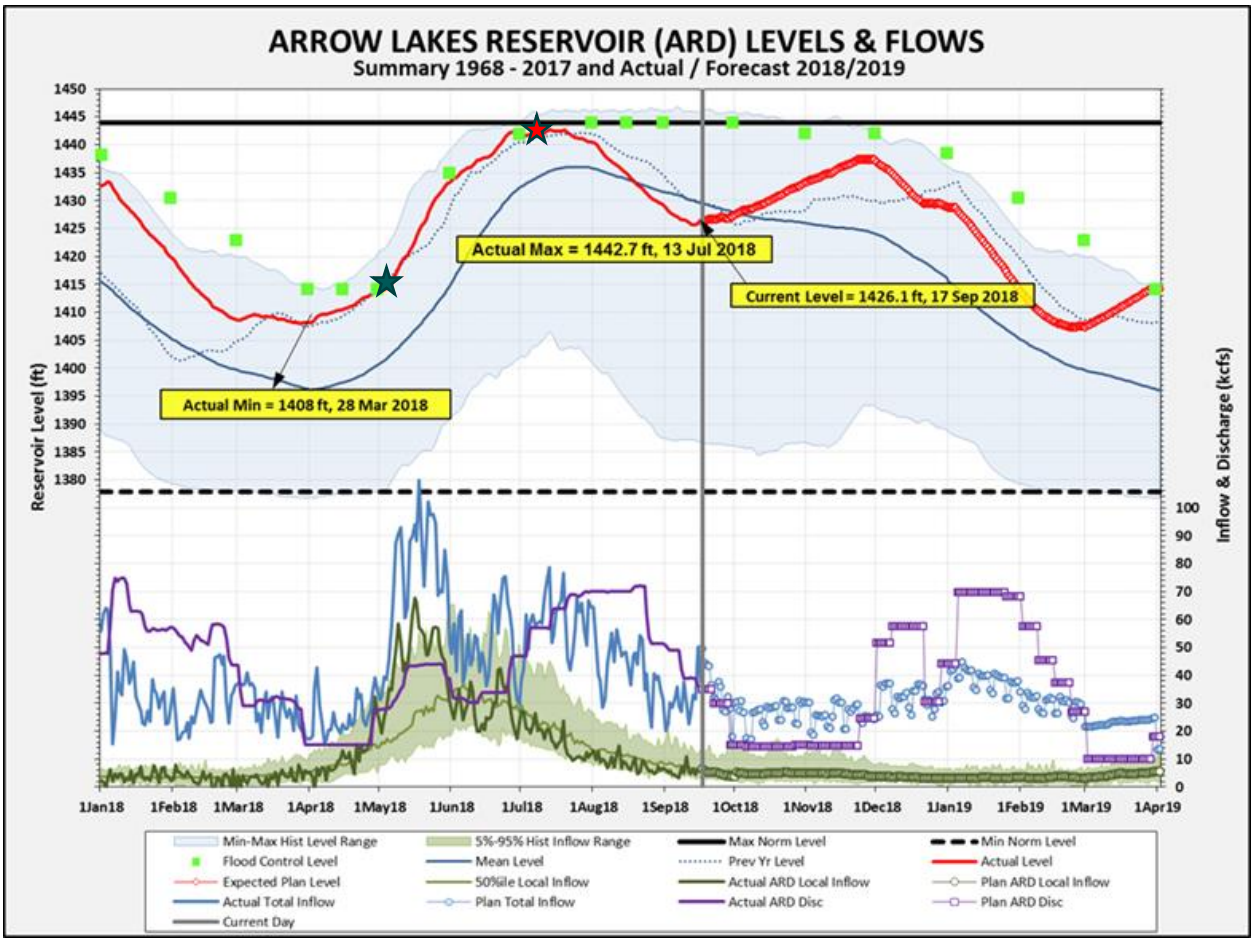
Habitat suitability for rearing juveniles was rated as Preferred, Suitable, Marginal, or Unsuitable, and was based on the presumption of potential for juveniles to initially select wetland features due to their uniqueness or suitability for the life stage. As with Spawning Suitability evaluation (above), ratings were based on potential ranges of suitability of various habitat parameters (e.g., cover, temperature) that influence rearing habitat potential, and were referenced to species-specific peer-review literature (**Appendix C**). Habitat suitability was determined by a QEP (Mark Fjeld) with experience conducting fish and fish habitat assessments.

Adult Feeding/Foraging Suitability at Inundation

Habitat suitability for feeding/foraging adults was rated as Preferred, Suitable, Marginal, or Unsuitable and was associated with the potential for adults to select the wetland features due to their potential support for the species' feeding and foraging life stages. As with Spawning Suitability and Juvenile Rearing Suitability evaluation (above), ratings were based on potential ranges of suitability of various habitat parameters (e.g., cover, velocity) that influence adult feeding habitat potential. Values used to establish the ranges (and therefore range suitability) were defined with reference to species-specific peer-review literature (**Appendix C**). Habitat suitability was determined by a QEP (Mark Fjeld) with experience conducting fish and fish habitat assessments.

3.0 RESULTS

Following the assessment's desktop review of the aquatic habitat characteristics and fish community in the Project area, the Project team completed spring and summer field site visits to update the understanding of fish habitat potential and use with reference to the proposed wetland features. The timing of the field visits was strategic, as it was intended to enable data collection to coincide with drawdown (spring) and inundation (summer) periods of the LALR. **Figure 5** illustrates the actual and predicted elevations within the LALR during the spring and summer season (inclusive of peak drawdown and inundation periods), when the assessment's field sites visits were conducted.



Source: Kong 2018

Notes: Water levels during the May 8–10 2018 spring site visit (denoted by blue star) ranged between 1415.7 ft. and 1419.0 ft. ASL.

Water levels during the July 6–7 2018 summer site visit (denoted by red star) ranged between 1441.3 ft. and 1441.6 ft. ASL

Figure 5 Water level within Lower Arrow Lakes Reservoir at the time of spring and summer sampling visits, 2018.

Given the unique conditions encountered during the two field site visits, wide ranging observations resulted, and differing fish habitat and population sampling efforts were warranted. For clarity, fish habitat potential and use results are described independently, by season, below. Results from the assessment's desktop analysis are referenced in each seasonal interpretation, when appropriate. Lotic habitat that was encountered within the Project area (i.e., during the spring visit), provided the opportunity to detail the associated seasonal watercourse habitat information. This information is summarized in **Appendix A**.

Although habitat parameters and their potential value to target species differed between the assessment's field-based components, the overall assessment of fish habitat suitability and, therefore, fish stranding risk resulted from interpretation of data from all desktop and field-based components. The resulting collective risk assessments are discussed below (Section 3.3) and are detailed in **Appendix B**.

3.1 Aquatic Habitat Characteristics and Fish Community – Spring 2018

Two converging channels were present in the Project area during the drawdown period in 2018 (**Figure 6**). These channels were defined during the May 8–10, 2018 site visit as Channel 1 and Channel 2. Given that most of the flow in both Channel 1 and Channel 2 was sourced from Burton Creek (i.e., via surface or subsurface flow), both channels were identified as side channels of Burton Creek. Water quality parameters in both channels were suitable for fishes known to occur in the area, as water temperatures were low (<6.0°C) and DO were high (>11 milligrams per litre [mg/L]) (**Table 6**). In comparison, water temperature was relatively increased, while DO was decreased in the aggregate pond.

Table 6 Water quality data collected in the Project area, spring 2018.

Location[1]	Date/Time	Water Quality Parameter			
		Temperature (°C)	DO (mg/L)	Conductivity (µs/cm)	pH
Aggregate pond	May 8, 2018/ 10:48	17.5	9.54	186.2	7.88
Channel 1	May 8, 2018/ 10:27	5.2	12.54	58.8	7.57
Channel 2	May 8, 2018/ 10:04	5.8	12.22	64.8	7.47
Channel 2	May 8, 2018/ 16:03	8.3	11.55	64.6	7.62
Channel 2	May 9, 2018/ 09:36	5.0	12.02	61.7	6.77
Channel 1	May 9, 2018/ 09:40	4.6	12.43	55.9	6.93
Channel 2	May 9, 2018/ 16:10	5.5	12.00	59.3	7.54
Channel 2	May 10, 2018/ 08:02	4.94	11.96	36.7	7.51

Notes: µS/cm – microsiemens per centimetre

1 – coordinates of sampling locations are provided in **Figure 6**.

Flow in Channel 1 resulted predominantly from a braided channel of Burton Creek upstream of Highway 6, which was subsequently conveyed under Highway 6 via a single corrugated steel, closed-bottom culvert. Additional flow from Channel 2 (see below) converged with Channel 1, approximately 220 m downstream from this culvert outlet. Channel 1 was well defined throughout its length, from the culvert outlet to its confluence with the LALR. A modest gradient resulted generally in shallow conditions, and habitat morphology in Channel 1 was dominated by riffle units and shallow (<0.5 m deep) run habitat. Substrate, which primarily consisted of coarse elements (gravel and cobble), was moderately embedded. Though a unique and potentially valuable spawning habitat (riffle) was identified near Transect 3 (**Figure 6**), in general, cover for fishes was limited in type and amount. Where cover was observed, it resulted primarily from turbulence and turbidity, as depth (>1.0 m), instream and near-stream features, and woody debris occurred rarely. Banks were largely sloping in nature, of low (0.2 m) to moderate (0.9 m) height, and generally moderately unstable due to their fine and small, gravel-dominated compositions.

Flow in Channel 2 resulted from a collection of overland runoff from areas toward the southern extent of the Project area, groundwater seepages along the embankment of Highway 6, and nearly indiscernible flow exiting a second culvert crossing of Highway 6 (i.e., south of the culvert outlet providing flow in Channel 1). Although the assessment's desktop analysis originally interpreted this channel as originating further south, investigations in this upslope area in spring 2018 confirmed this reach being devoid of defined or continuous channels. Continuous scour (i.e., channel definition) in Channel 2 was first observed during the spring site visit immediately downslope of the culvert outlet. Although scour and channel definition further increased with downstream distance from this location, the channel maintained a modest width (i.e., <1.6 m wide) over its course, until its confluence with Channel 1. As with Channel 1, banks of Channel 2 were small, comprising gravels and fines, and were moderately unstable. Cover for fishes was limited largely to instream and near-stream vegetation (grasses and sedges).

Burton Flats Wildlife Enhancement
Burton Flats, British Columbia

Spring Habitat and Fish Sampling Locations

Pond 4
1014m²
Pond 3
367m²
Pond 1
70m²
Pond 2
12m²
Pond 6
80m²
Pond 5
156m²
AGGREGATE POND
TRANSECT 1
D1
TRANSECT 2
TRANSECT 5
TRANSECT 3
Pond 8
299m²
Pond 9
52m²
C1
Pond 7
269m²
TRANSECT 4
CHANNEL 1
TRANSECT 6
A6
HWY 6
Burton Creek
C4
B1
A5
CHANNEL 2
TRANSECT 7
A4
C3
C2
A3
A2
A1
REED CANARY GRASS

Transect/Water Quality Sampling Locations

Transect ID	Easting	Northing	UTM Zone
Transect 1	435932	5536906	11
Transect 2	436017	5536850	11
Transect 3	436128	5536853	11
Transect 4	436126	5536781	11
Transect 5	436014	5536847	11
Transect 6	436017	5536754	11
Transect 7	436022	5536650	11
Channel 1 (Water Quality)	436122	5536769	11
Channel 2 (Water Quality)	436029	5536672	11
Aggregate Pond (Water Quality)	435959	5536884	11

Fish Sampling Locations

Sampling Method	Date	Easting	Northing	UTM Zone
arc-seining	2018-05-08	435785	5536923	11
electrofishing	2018-05-08	435785	5536923	11
electrofishing	2018-05-08	435650	5536828	11
electrofishing	2018-05-08	435729	5536855	11
electrofishing	2018-05-08	435649	5536851	11
electrofishing	2018-05-08	435657	5536867	11
electrofishing	2018-05-08	435959	5536884	11
minnow trapping	2018-05-08	435785	5536923	11
minnow trapping	2018-05-08	435650	5536828	11
minnow trapping	2018-05-08	435649	5536851	11
minnow trapping	2018-05-08	435657	5536867	11
minnow trapping	2018-05-08	435676	5536904	11
minnow trapping	2018-05-08	435723	5536833	11
minnow trapping	2018-05-08	435729	5536855	11
minnow trapping	2018-05-09	436060	5536801	11
minnow trapping	2018-05-09	436143	5536819	11
minnow trapping	2018-05-09	435966	5536790	11
minnow trapping	2018-05-09	436018	5536834	11

Legend

- Arc-Siene Fishing Location
- Channel
- Electrofishing Location
- Minnow Trap Location
- Potential Rainbow Trout Spawning Habitat
- Water Quality Monitoring Location

Phase I

- Deep Waterfowl Pond
- Habitat and Planting Mounds
- Primary Shallow Wetland
- Reed Canary Grass Trial Area
- Secondary Wetlands

Phase II

- Connection to Existing Ponds and Reservoir
- Deep Waterfowl Pond
- Habitat and Planting Mounds
- Primary Shallow Wetland
- Reed Canary Grass Trial Area
- Secondary Wetlands

Site Features

- Transect Line
- Fish Sampling Area - By Backpack electrofisher
- Approximate Site Boundary
- Fish Sampling Location
- Log Outlet Sill Structure
- Potential Cobble at Inlet & Outlet

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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989445-01	Production Date: December, 2018	Figure 6

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In addition to identifying lotic habitat, the Project team encountered multiple isolated ponds within or near the Project area during the spring site visit (**Figure 6**). The aggregate pond was present during the drawdown period in 2018, as were six relatively smaller ponds in the northwestern extent of the Project area. The Project team visited these ponds (Ponds 1, 2, 3, 4, 5, and 6) during the spring site visit to increase fish sampling opportunities; these sites served as proxy sampling sites for the larger and much deeper aggregate pond where comprehensive sampling effort was precluded by conditions. In addition, the Project team encountered three small and shallow ponds further east within the Project area (Ponds 7, 8, and 9), which were also disconnected from the flowing drainages (Channel 1 and Channel 2). While much smaller and shallower in comparison to other waterbodies, these ponds were considered in the sampling of fish communities as naturally occurring representatives of the Project's proposed wetlands. Dimensions of the ponds investigated in spring 2018 are provided in **Table 7**.

In general, the isolated ponds (other than the aggregate pond) offered limited value to fish, especially the Project's target species. Each lacked complexity, suitable flow, adequate depth, and available cover. A single exposed gravel bar/shoal was exposed near Transect 3 (**Figure 6**) (but outside the wetted width of the channels and ponds) during the spring site visit.

Table 7 Summary of dimensions of ponds encountered in the Project area, spring 2018.

Pond #	Pond Dimensions		
	Width (m)	Length (m)	Depth*(m)
Aggregate pond	80	90	>2 m
1	6	15	<1 m
2	5	3	<1 m
3	17	25	<1 m
4	20	40	1-2
5	5	20	<0.5 m
6	5	10	<0.5 m
7	6	45	<0.5 m
8	15	25	<0.5 m
9	4	14	<0.5 m

Note: * = estimated

The Project team encountered a total of 79 fish, resulting from five species (or genera), during the spring site visit (**Table 8**). Although the majority of the fish captured were coarse species (i.e., non-sportfish), juvenile Rainbow Trout were captured in both Channel 1 and Channel 2 and a juvenile Mountain Whitefish was captured in Channel 1. The relative abundance of fish captured during the spring site visit, as described by catch-per-unit effort (CPUE) for each of the methods used, was notably low in all sampling locations. No fish were captured in 6 of the 10 ponds sampled, a result that was not unexpected given the relatively limited depth of these ponds and their lack of suitability for many fish species. Largest CPUE values resulted from Channels 1 and 2 and Pond 5.

Caution should be applied when interpreting the CPUE value associated with sampling of the aggregate pond. Given this pond's depth and comparatively increased potential to support fish year-round (as compared to other ponds encountered during the spring site visit), fewer fish were encountered than expected during the 2018 spring site visit. Specific details related to sample methods, locations, and date are provided in **Figure 6**.

Table 8 Summary of fish community sampling, spring 2018.

Channel or Pond #	Effort and Capture Information		
	Method(s) Used (Effort)	Number of Fish Captured (spp.)/Life Stage	CPUE by method
Channel 1	backpack electrofishing (1,245 seconds)	1 (Mountain Whitefish) / juvenile 1 (Rainbow Trout) / parr 1 (Sculpin spp.) / fry	0.24 fish/100 seconds
Channel 2	minnow trap (54.5 hours)	6 (Rainbow Trout) / fry	0.11 fish/hour
Aggregate pond	arc seine (113 m^2) backpack electrofishing (130 seconds) minnow trap (212.5 hours)	0 0 2 (Sculpin spp.) / fry	0 fish/m^2 0 fish/100 seconds <0.01 fish/hour
Pond 1	backpack electrofishing (300 seconds) minnow trap (52 hours)	1 (Northern Pikeminnow) / juvenile) 1 (Sculpin spp.) / fry	0.33 fish/100 seconds 0.019 fish/hour
Pond 2	backpack electrofishing (79 seconds) minnow trap (52 hours)	0 0	0 fish/100 seconds 0 fish/hour
Pond 3	backpack electrofishing (267 seconds) minnow trap (52 hours)	0 1 (Northern Pikeminnow) / fry 1 (Sucker spp.) / fry	0 fish/100 seconds 0.38 fish/hour
Pond 4	minnow trap (78.6 hours)	0	0 fish/hour
Pond 5	minnow trap (102.9 hours)	1 (Northern Pikeminnow) / fry 63 (Sucker spp.) / fry	0.62 fish/hour
Pond 6	backpack electrofishing (96 seconds) minnow trap (52 hours)	0 0	0 fish/100 seconds 0 fish/hour
Pond 7	minnow trap (27.9 hours)	0	0 fish/hour
Pond 8	minnow trap (13.9 hours)	0	0 fish/hour
Pond 9	minnow trap (13.9 hours)	0	0 fish/hour

Fish habitat suitability ratings, based on initial interpretations from available information from the desktop analysis and field-based sampling during the spring site visit, are summarized for Bull Trout, Kokanee Salmon, and Rainbow Trout in **Appendix A.** Note, some of the ratings for the fall spawning target species (Bull Trout and Kokanee Salmon) resulting from the spring site visit were considered at the time of assignment to be interim, and they were updated following the assessment's summer site visit.

In general, the Project area is anticipated to provide Marginal spawning habitat for Rainbow Trout due to the limited flow and depth in Channel 1 and 2, the general absence of habitat complexity, and lack of cover. However, it is noted that habitat in Channel 1 may provide passage for Rainbow Trout migrating further upstream into Burton or Caribou creeks.

Due to the lack of connectivity, none of the ponds within or near the Project area except the aggregate pond is anticipated to provide wintering habitat for any of the target species. Given the shallow depth of most of the ponds and the lack of connectivity, it was also presumed that elevated water temperatures and dewatering during the remaining dewatering period would limit survival of any naturally stranded fish.

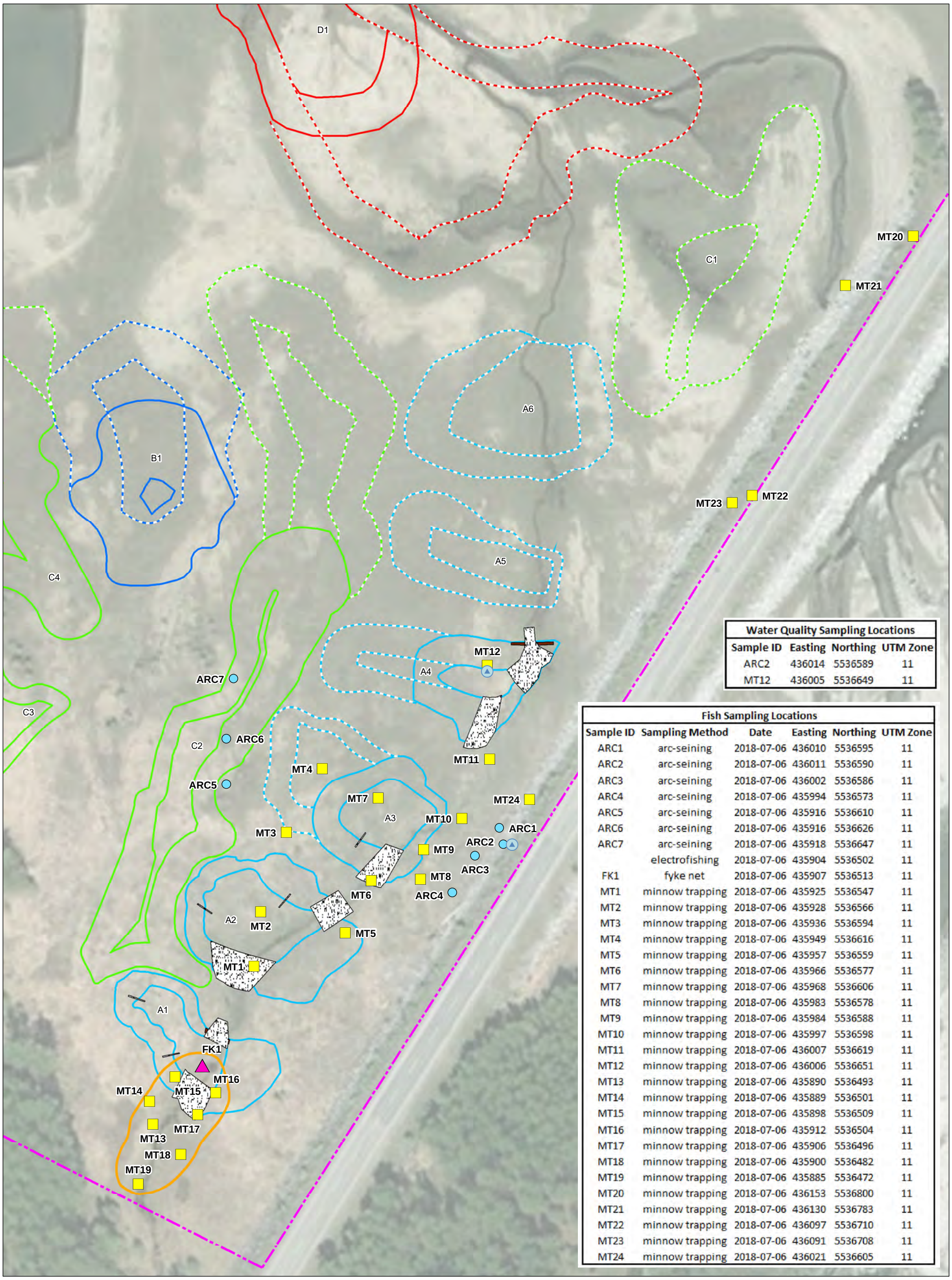
3.2 Aquatic Habitat Characteristics and Fish Community – Summer 2018

The timing of the summer site visit (July 6 and 7, 2018) coincided with the peak water levels within the LALR. As a result, the entire Project area and the aggregate pond and ponds 1, 2, 3, 4, 5, 6, 7, 8 and 9 were submerged. No lotic characteristics were discernible, as aquatic habitat within and adjacent to the Project area was exclusively lacustrine. Flooded terrestrial and emergent vegetation were present at the southern fringes of the Project area, while water depths exceeded 3 m in more lentic areas, where the Project's shallow wetlands are proposed, and increased to more than 5 m in the location of the Project's proposed deep waterfowl pond (D1). Considerable aquatic vegetation was visible under the water surface, even in the Project area's deepest locations.

Limited exposed gravels/cobbles were observed adjacent to terrestrial (partially flooded) areas in the northwestern fringes of the Project site. Given the elevation of the observed exposed cobbles relative to anticipated water levels, these seasonal shoals will likely be inaccessible to fish during the spawning period for Kokanee Salmon in Burton and Caribou creeks. Exposed gravels observed near Transect 3 (**Figure 6**) during the spring site visit were not visible during the summer site visit; however, it is anticipated that exposed coarse substrate at lower elevations (e.g., near the deep waterfowl pond) may provide Kokanee Salmon spawning habitat, similar to that noted in 2012 (Hawes and Drieschner 2013). Elevated water temperatures were observed on July 7, 2018, ranging between 19.7°C in near-shore areas, to 18.5°C in deeper areas, which exceeded the optimal thermal regime for Kokanee Salmon and Bull Trout (**Appendix C**).

The abundance of aquatic vegetation and the availability of large riprap elements in the flooded area along the eastern embankment of Highway 6 provided abundant fish cover, rearing, and feeding opportunities. The Project team observed several schools of rearing and feeding juvenile fishes (e.g., Mountain Whitefish), and on multiple occasions displaced larger-bodied fish (unidentified species) while wading or floating through the area.

Fish community sampling methods used during the summer site visit included arc seine, fyke trapping, backpack electrofishing, and baited minnow trapping at multiple locations within the Project area (**Figure 7**). Eight simple arc sets were completed using an oar-propelled pontoon boat and on-shore anchor points. Set locations were strategic, with priority placed on each being at or adjacent to preferred cover elements (e.g., instream vegetation and riprap).



Water Quality Sampling Locations

Sample ID	Easting	Northing	UTM Zone
ARC2	436014	5536589	11
MT12	436005	5536649	11

Fish Sampling Locations

Sample ID	Sampling Method	Date	Easting	Northing	UTM Zone
ARC1	arc-seining	2018-07-06	436010	5536595	11
ARC2	arc-seining	2018-07-06	436011	5536590	11
ARC3	arc-seining	2018-07-06	436002	5536586	11
ARC4	arc-seining	2018-07-06	435994	5536573	11
ARC5	arc-seining	2018-07-06	435916	5536610	11
ARC6	arc-seining	2018-07-06	435916	5536626	11
ARC7	arc-seining	2018-07-06	435918	5536647	11
	electrofishing	2018-07-06	435904	5536502	11
FK1	fyke net	2018-07-06	435907	5536513	11
MT1	minnow trapping	2018-07-06	435925	5536547	11
MT2	minnow trapping	2018-07-06	435928	5536566	11
MT3	minnow trapping	2018-07-06	435936	5536594	11
MT4	minnow trapping	2018-07-06	435949	5536616	11
MT5	minnow trapping	2018-07-06	435957	5536559	11
MT6	minnow trapping	2018-07-06	435966	5536577	11
MT7	minnow trapping	2018-07-06	435968	5536606	11
MT8	minnow trapping	2018-07-06	435983	5536578	11
MT9	minnow trapping	2018-07-06	435984	5536588	11
MT10	minnow trapping	2018-07-06	435997	5536598	11
MT11	minnow trapping	2018-07-06	436007	5536619	11
MT12	minnow trapping	2018-07-06	436006	5536651	11
MT13	minnow trapping	2018-07-06	435890	5536493	11
MT14	minnow trapping	2018-07-06	435889	5536501	11
MT15	minnow trapping	2018-07-06	435898	5536509	11
MT16	minnow trapping	2018-07-06	435912	5536504	11
MT17	minnow trapping	2018-07-06	435906	5536496	11
MT18	minnow trapping	2018-07-06	435900	5536482	11
MT19	minnow trapping	2018-07-06	435885	5536472	11
MT20	minnow trapping	2018-07-06	436153	5536800	11
MT21	minnow trapping	2018-07-06	436130	5536783	11
MT22	minnow trapping	2018-07-06	436097	5536710	11
MT23	minnow trapping	2018-07-06	436091	5536708	11
MT24	minnow trapping	2018-07-06	436021	5536605	11

Legend

- Fyke Trap Location
- Minnow Trap Location
- Arc-Siene Fishing Location
- Water Quality Monitoring Location

Phase I

- Deep Waterfowl Pond
- Habitat and Planting Mounds
- Primary Shallow Wetland
- Reed Canary Grass Trial Area
- Secondary Wetlands

Phase II

- Connection to Existing Ponds and Reservoir
- Deep Waterfowl Pond
- Habitat and Planting Mounds
- Primary Shallow Wetland
- Reed Canary Grass Trial Area
- Secondary Wetlands
- Fish Sampling Area - Backpack Electrofisher
- Approximate Site Boundary
- Log Outlet Sill Structure
- Potential Cobble at Inlet & Outlet

Notes

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2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Burton Flats Wildlife Enhancement
Burton Flats, British Columbia

Summer Habitat and Fish Sampling Locations

989445-01	Production Date: December, 2018	Figure 7

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A total of 645 fish, resulting from eight species (or genera), were captured during the summer site visit in 2018 (**Table 9**). No sportfish or target species were captured, and the largest fish captured was 123 mm (fork-length), a juvenile Northern Pikeminnow (*Ptychocheilus oregonensis*). In addition to the fish captured during the summer site visit, three other fish (some estimated to be >400 mm in length) were observed but evaded capture. Minnow trapping yielded the highest CPUE of the methods employed and resulted in the greatest diversity in catch composition.

Table 9 Summary of fish community sampling, summer 2018.

Effort and Capture Information		
Method(s) Used (Effort)	Number of Fish Captured (spp.)/Life Stage	CPUE by Method
backpack electrofishing (1,800 seconds)	2 (Lake Chub) / juvenile 3 (Redside Shiner) / juvenile	0.28 fish/100 seconds
minnow trap (413.5 hours)	465 (Redside Shiner) / various 36 (Lake Chub) / various 1 (White Sucker) / juvenile 1 (Northern Pikeminnow) / juvenile 1 (Prickly Sculpin) / unknown	1.22 fish/hour
fyke net (15.5 hours)	2 (Peamouth Chub) / adult 1 (Lake Chub) / juvenile 1 (Longnose Dace) / juvenile 1 (Longnose Sucker) / juvenile 1 (unidentified)	0.39 fish/hour
arc seine (452 m^2)	124 (Redside Shiner) / various 5 (Lake Chub) / various 1 (Sculpin spp.) / juvenile	0.30 fish/m^2

Spawning data from Burton and Caribou creeks (BC Hydro Environmental Field Services, Columbia. 2018. pers. comm., **Figure 3** and **Figure 4**) confirm that habitat upstream from the Project area is important to Kokanee Salmon and Bull Trout. However, the absence of lotic habitat and limited exposed shoals within the Project area decrease its suitability for spawning by these species. The flooded conditions in the Project area were likely preferable to several coarse fishes known to occur in the LALR. However, the elevated water temperatures observed during the summer 2018 site visit (and low DO), which are presumably chronic throughout the inundation period, are expected to discourage regular use by target species of all life stages in all but the deepest parts of the Project area (e.g., aggregate pond). Similarly, limited water depth and low DO in isolated pools (except potentially in the aggregate pond) are expected to result in Unsuitable wintering conditions for most fish in much of the Project area. Suitable wintering conditions within the aggregate pond is presumed

A summary of habitat potential ratings for the target species, including desktop analysis and field observations from the spring and summer 2018 site visits, is provided in **Table 10**. Habitat potential ratings in this table supersede those in **Appendix A**, which represented conditions assessed only during the spring site visit and specific to lotic habitats observed.

Table 10 Summary of fish habitat potential ratings for the target species within the Project area.

Fish Species	Fish Habitat Potential Rating			
	Spawning	Rearing	Wintering	Adult Feeding
Bull Trout	Marginal[1]	Marginal	Unsuitable[2]	Suitable
Kokanee Salmon	Marginal	Marginal	Unsuitable[2]	Marginal
Rainbow Trout	Marginal	Marginal	Unsuitable[2]	Suitable

Notes: 1 Rating is based on presumption of similar flows during future fall spawning seasons as observed during the spring 2018 site visit.

2 Rating reflects conditions anticipated in much of the Project area, excluding the aggregate pond.

3.3 Fish Stranding Risk Assessment

The risk indices for each target species within the context of the Project's design are provided in **Table 11, Table 12**, and **Table 13.** The complete risk assessments, including ratings for each criterion, are provided in **Tables B-1**, **B-2**, **and B-3** in **Appendix B.** All wetlands associated with the preferred design pose a Low risk of fish stranding for Bull Trout, except the deep waterfowl pond (D1), which poses a Moderate risk of fish stranding for the species (**Table 11**). The risk of Kokanee Salmon and Rainbow Trout stranding in the Project design's feature D1 also rated as Moderate (**Table 12** and **Table 13**).

Table 11 Summary of fish stranding risk indices for Bull Trout in the Project area.

Design/Feature		Design Plan and Reservoir Levels	Fish Presence and Significance	Habitat Suitability	Total Score
Design 1	A1	4	7	6	17
	A2	6			19
	A3	6			19
	A4	6			19
	A5	7			20
	A6	7			20
	B1	8			21
	D1	14			27

Note: Colour coding of the Total Score column indicates risk rating as Low (green), Moderate (yellow), or High (red).

Table 12 Summary of fish stranding risk indices for Kokanee Salmon in the Project area.

Design/Feature		Design Plan and Reservoir Levels	Fish Presence and Significance	Habitat Suitability	Total Score
Design 1	A1	4	6	11	21
	A2	6			23
	A3	6			23
	A4	6			23
	A5	7			24
	A6	7			24
	B1	8			25
	D1	14			31

Note: Colour coding of the Total Score column Indicates risk rating as Low (green), Moderate (yellow), or High (red).

Table 13 Summary of fish stranding risk indices for Rainbow Trout in the Project area.

Design/Feature		Design Plan and Reservoir Levels	Fish Presence and Significance	Habitat Suitability	Total Score
Design 1	A1	4	7	6	17
	A2	6			19
	A3	6			19
	A4	6			19
	A5	7			20
	A6	7			20
	B1	8			21
	D1	14			27

Note: Colour coding of the Total Score column indicates risk rating as Low (green), Moderate (yellow), or High (red).

4.0 CONCLUSIONS AND RECOMMENDATIONS

Low potential stranding risks were identified for each of the target species for most Project design features. The highest potential stranding risk (i.e., Moderate), based largely on habitat conditions encountered during site visits and with reference to habitat suitability values, was identified for each target species through completion of Phase 2) for the design's D1 feature (deep waterfowl pond). Compared to the other Project features, this component represents the greatest wetted areas and water depths, and is also located at the lowest elevation, which results in a greater percentage of time inundated relative to the higher-elevation wetland features and a lower percentage of time isolated. The design features located at higher elevations have comparatively smaller wetted areas and water depths, but higher percentages of time isolated.

Specific to Kokanee Salmon, a Moderate peak risk of stranding within the deep waterfowl pond (D1) (**Table 12**) resulted primarily from Marginal ratings for habitat suitability for multiple life stages (e.g., rearing and feeding) (**Table B-3** in **Appendix B**) and a conservative evaluation of the potential for spawning on exposed substrates nearest the mouth of Burton and Caribou creeks (e.g., near the northern edge of the Project area). A High risk score was also assessed (**Table B-3 in Appendix B**), again conservatively, for the potential of inundation to influence spawning success (emergence survivorship) due to inundation overlapping with the timing of spawning and staging, but with the drawdown period coinciding with the timing of fry emergence.

It is reasonable to expect that Suitable habitat potential exists for adult Bull Trout feeding within the Project area during inundation, particularly within the deep-water areas (e.g., where D1 is proposed) (**Table B-3** in **Appendix B**) where temperatures and DO are likely to remain within the species' preferred ranges. While a Marginal rating was assigned for the potential of Bull Trout spawning in the Project area, this rating was largely based on a conservative presumption of surface flows being similar to those observed during the spring site visit. Observations of adult Bull Trout at the confluence of Burton and Caribou creeks in September 2009 (Hawes and Drieschner 2013) corroborate this presumption, and while conditions may vary between years, the regular presence of the species during the spawning period cannot be precluded. Regardless, since the typical period of peak inundation (July) does not overlap with staging or spawning periods for the species, there is a perceived Low overall risk (i.e., other than within the D1 feature) of the Project resulting in stranding during or immediately following the spawning season.

The presence of multiple juvenile Rainbow Trout within the Project area during the drawdown period suggests rearing fish are either present at the onset of inundation or migrate into channelized sections of the drawdown zone. Further, Marginal spawning habitat (**Table B-3** in **Appendix B**) and the connectivity provided by the channelized drainages (present during drawdown periods) to more valuable spawning habitat in Burton and Caribou creeks suggest that adults may also be present in the Project area as the inundation period begins (May). As the inundation period reaches its peak (early July), however, elevated water temperatures, particularly in the littoral (or otherwise shallow) areas, suggest juveniles or adults of the species would not commonly occur in shallow sections of the inundated area. This assertion is supported by the absence of the species in the captured population during the summer site visit. As with Kokanee Salmon and Bull Trout, the greatest potential for the species to be present during inundation is most likely to be associated with deep-water areas (e.g., D1 and aggregate pond).

In addition to the target species, the potential exists for stranding of coarse species, particularly given the suitability and confirmed use by several forage fishes within inundated areas of the Project footprint. Although coarse fish are not included as target species, the potential for stranding of coarse species is likely higher than the target species and should be considered during future regulatory consultations or Project planning.

This interim risk of stranding at the deep waterfowl pond and other wetland features is likely to be increased after completion of the Project's Phase 1 and before completion of Phase 2, when many of the features are constructed to interim dimensions but are not be connected to other Project features, aggregate pond, or LALR by Project-designed drainage channels or potential grading. Future expansion is proposed during Phase 2 and includes potential connections between shallow wetlands (A1, A2, A3, A4, A5, and A6) and D1, as well as the designed channel connection between D1 and the aggregate pit (and eventually LALR) downslope slope. If Phase 2 occurs as conceptualized, connectivity is expected to provide the wetlands upslope from D1 with continuous flow and egress potential to the deep waterfowl pond, while also providing connectivity for fish from D1 to the aggregate pond and/or the LALR. Based on the results of the assessment's field site visits, the proposed drainage connections and/or grading to facilitate drainage proposed as part of Phase 2 will be critical in limiting the potential for final stranding of all fishes.

Based on the results of the desktop and field-based components of this assessment and a comprehensive review of the detailed design for the Project's Phase 1 and updated feasibility designs for the Project's Phase 2 (KWL 2018), the following mitigation measures are proposed to reduce the potential for fish stranding:

- Design 1 (Drawing C-102, KWL 2017) includes one feature of the wetland with a Moderate risk of stranding, while Design 2 (Drawing C-103, KWL 2017) included two features of the wetland with a Moderate risk of stranding (based on previous desktop analysis) (Hemmera and Nupqu 2018). Based on this assessment, Design 1 remains the preferred option over Design 2 from the perspective of reducing the risk of fish stranding.
- Construction of lower elevation wetlands is not recommended (e.g., D1) until DFO can confirm that the Project will not result in Serious Harm to fish.
- Should access across lotic habitat be required during construction, temporary crossing structures should be installed and removed as appropriate.
- The drainage channels associated with the deep waterfowl pond (D1) and the existing aggregate pond(s) should be constructed simultaneously. Alternatively, if construction of the drainage channels is not completed during the same Phase as D1 (and D1 becomes inundated), fish salvage should be considered in context to the level of risk of stranding and logistical feasibility. The confirmed presence of several fish species in the Project area, including juvenile Mountain Whitefish and Rainbow Trout, supports this recommendation. Similarly, an interim drainage channel/connecting system or grading should also be included between the shallow wetland features (A1, A2, A3 and A4) and deeper habitat (e.g., D1) during Phase 1 of the Project to enable egress of non-target fish species encountered (and possibly others) during the summer site visit. It is understood that maintaining connectivity (grading of existing substrate) between inlet and outlet features of shallow wetland features (e.g., A3, A4) will be at the direction of the on-site engineer during construction (KWL 2018). However, emphasis should be placed on retaining connectivity through this area during construction, or detailed designs for connectivity should be established prior to construction. Maintaining connectivity will be important in sustaining egress routes for non-target fish species during the inundation period.

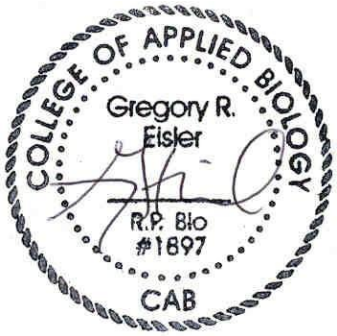
- Given the aggregate pond(s)'s considerable depth, areal extent, consistent presence, and seasonal inundation without connection during drawdown periods, it is reasonable to expect multiple life stages of several species (including target species) through the winter season, particularly if water quality parameters remain suitable; therefore, an additional site visit (winter season) might be useful, subject to approval by BC Hydro and DFO, and weather permitting. Collection of water quality information (e.g., water temperature and DO) from the aggregate pond(s) will supplement the understanding of habitat potential for isolated habitats within the drawdown zone. Opportunistic fish sampling methods (e.g., gill netting, angling, underwater/ice videography) could also confirm fish presence and inform the potential for fish survival in the Project area during the winter.
- A fall habitat and fish community sampling visit is recommended after completion of the works. Timing a site visit to coincide with Bull Trout and Kokanee Salmon spawning periods would provide corroborating evidence for the presumed limited spawning potential of these species.
- The Fisheries Act will likely be revised under Bill C-68 before Phase 1 of the Project is implemented. Although the legislation is currently with the Senate and awaiting Royal Assent, proposed changes could be implemented before the end of 2018. It is recommended that the Project's preferred design (through Phase 2) be finalized so that BC Hydro can conduct a self-assessment for the potential for Serious Harm to fish habitat. Alternatively, changes under the proposed Fisheries Act may further limit future Project design considerations, and additional mitigation specific to the avoidance of alteration or destruction of fish habitat may be necessary.
- It is recommended that monitoring for potential fish stranding be implemented as part of the interim evaluation of Phase 1 of the Project (i.e., following construction of Phase 1 and prior to construction of Phase 2). Results of the monitoring program will help inform potential remedial needs for wetland modification or enhanced connectivity between the features and the LALR. Interim monitoring results may validate limited habitat suitability interpretations for the Project's target species but could also assist in evaluation of fish passage potential at feature inlet and outlet structures (not included as part of this assessment).
- Monitoring of potential stranding is also recommended following Phase 2, at 1, 3, and 5-year intervals post-completion. Monitoring after construction of Phase 2 should occur in spring, during the drawdown period.

5.0 CLOSING

Information provided above, and the appendices below detail the aquatic habitat potential and risk rating for the proposed Project area near Burton Flats. All information contained within this report and its appendices should be considered in context of the Project designs that were current at the time of the assessment (KWL 2018) and field conditions and species' conservation status that coincided with site visits in 2018. If there are any questions related to the information provided in this report, please contact the undersigned.

Report prepared by:

Hemmera Envirochem Inc.



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APPENDIX A

Site Atlases – Channels, Spring 2018 Site Visits, Photographs

Watercourse (Site#):	Burton Creek (Channel 1)
Habitat Survey Length (# transects):	390 m (5)
Least Risk Window:	July 15 – August 15
Watershed Code / Waterbody ID:	300-690200 / 163604

Field Crew:	M.Fjeld; N. Morrison
Survey Date:	May 8-10, 2018
Stream Order:	4
UTM (Zone 11U):	436125E, 5536773N

Flow Regime	Seasonal
Bankfull Width (m): Mean, Range	4.0, 3.0-5.4
Wetted Width (m): Mean, Range	3.9, 3.1-4.5
Depth (m): Mean, Range	0.15, 0.0-0.29
Stream Gradient (%)	2.0
Embeddedness	Moderate
Discharge (m^3/sec.)	0.18
Native Channel Width (m)	N/A

Bank Conditions	Left Bank	Right Bank
Bank Shape	Sloping	Sloping
Bank Texture	Fines / Sm. Gravel	Fines / Sm. Gravel
Bank Height (m): Mean, Range	0.3, 0.09-0.90	0.2, <0.01-0.38
Grade of Approach Slopes (%)	1-14	1-14
Riparian Area Width (m)	2-10	2-10
Riparian Vegetation Types	Grasses	Grasses
Stream Shading	<5%	

Substrate Composition	Amount
Organics	None
Fines (<2 mm)	Trace
Small Gravel (2-20 mm)	Subdominant
Large Gravel (21-65 mm)	Subdominant
Cobble (66-250 mm)	Dominant
Boulder (>250 mm)	Trace

Water Quality Parameters	
Water Temperature (°C)	5.8
pH	7.47
Dissolved Oxygen (mg/L)	12.22
Conductivity (µS/cm)	65
Turbidity (NTU)	13.6

Habitat	Length (m)	%
Pool 1 (depth > 1.0 m)	-	-
Pool 2 (depth 0.75-1.0 m)	1	<1
Pool 3 (depth <0.75 m)	-	-
Run 1 (>1.0 m)	-	-
Run 2 (0.75-1.0 m)	-	-
Run 3 (<0.75 m)	273	70
Flat 1 (> 1.0 m)	-	-
Flat 2 (0.75-1.0 m)	-	-
Flat 3 (<0.75 m)	-	-
Riffle	117	29
Backwater	-	-
Rapid	-	-
Other	-	-

Cover Types	Amount
Boulders	Trace
Undercut Banks	None
Overhanging Vegetation	None
Woody Debris	Trace
Depth	Subdominant
Stain/Turbulence	Dominant
Instream Vegetation	Subdominant
Other	-
Other	-
Other	-
Other	-
Other	-
Total Cover	Low

Fish Habitat Potential

Target Species	Spawning Rating	Rearing Rating	Wintering Rating	Adult Feeding Rating
Bull Trout	Marginal*	Suitable	Unsuitable	Marginal
Rainbow Trout	Marginal	Suitable	Unsuitable	Marginal
Kokanee Salmon	Unsuitable	Marginal	Unsuitable	Unsuitable

*** - Rating is based on presumption for the potential for similar flows to occur during fall spawning season.**

Fish species previously documented (within Burton Creek upstream from Highway 6): Bull Trout, Kokanee, Rainbow Trout (iMap BC, 2018).

Additional Habitat Comments

The site Channel 1 was defined as occurring between a culvert outlet (conveying flow from Burton Creek) on the west side of Highway 6 and the Lower Arrow Lakes Reservoir. Flow in Channel 1 was joined by that from a second drainage (Channel 2 as defined by this assessment) near transect 3. Channel 2 resulted from groundwater seepages observed south of Channel 1, in the vicinity of a second culvert under Highway 6. In addition, several ponded areas were observed in the vicinity of the Project Area, none of which had connectivity to the Lower Arrow Lakes Reservoir at the time of site visit.

Habitat within Channel 1 is dominated by shallow run (R3) and riffle habitat units. Substrate, although comprised of gravels and cobbles predominantly was moderately embedded. Suitable spawning substrate (relatively unembedded gravels) was observed near transect 3, within riffle habitat.

Photo 1: Upstream view at T5 (near culvert outlet) (May 8, 2018).

Photo 2: View of Rainbow Trout captured within Channel 1 (May 8, 2018).

Photo 3: Upstream view at T1 (near outlet to Lower Arrow Lakes Reservoir) (May 9, 2018).

Photo 4: Downstream view at T1 (near outlet to Lower Arrow Lakes Reservoir) (May 9, 2018).

Photo 5: Downstream view at T4 (near confluence with Channel 2) (May 8, 2018)..

Photo 6: Downstream view at T4 (May 8, 2018).

Watercourse (Site#):	Burton Creek (Channel 2)
Habitat Survey Length (# transects):	300 m (2)
Least Risk Window:	July 15 – August 15
Watershed Code / Waterbody ID:	300-690200 / 163604

Field Crew:	M.Fjeld; N. Morrison
Survey Date:	May 8-10, 2018
Stream Order:	4
UTM (Zone 11U):	435985E, 5536594N

Flow Regime	Seasonal
Bankfull Width (m): Mean, Range	1.0, 1.0-1.1
Wetted Width (m): Mean, Range	1.3, 1.1-1.5
Depth (m): Mean, Range	0.05, 0.05-0.18
Stream Gradient (%)	2.0
Embeddedness	High
Discharge (m^3/sec.)	0.02
Native Channel Width (m)	N/A

Bank Conditions	Left Bank	Right Bank
Bank Shape	Sloping	Sloping
Bank Texture	Fines / Sm. Gravel	Fines / Sm. Gravel
Bank Height (m): Mean, Range	0.1, 0.07-0.18	0.1, 0.08-0.17
Grade of Approach Slopes (%)	1-14	1-14
Riparian Area Width (m)	2-10	2-10
Riparian Vegetation Types	Grasses	Grasses
Stream Shading	<5%	

Substrate Composition	Amount
Organics	None
Fines (<2 mm)	Dominant
Small Gravel (2-20 mm)	Subdominant
Large Gravel (21-65 mm)	Trace
Cobble (66-250 mm)	Trace
Boulder (>250 mm)	Trace

Water Quality Parameters	
Water Temperature (°C)	5.2
pH	7.57
Dissolved Oxygen (mg/L)	12.54
Conductivity (µS/cm)	59
Turbidity (NTU)	13.1

Habitat	Length (m)	%
Pool 1 (depth > 1.0 m)	-	-
Pool 2 (depth 0.75-1.0 m)	-	-
Pool 3 (depth <0.75 m)	-	-
Run 1 (>1.0 m)	-	-
Run 2 (0.75-1.0 m)	-	-
Run 3 (<0.75 m)	210	70
Flat 1 (> 1.0 m)	-	-
Flat 2 (0.75-1.0 m)	-	-
Flat 3 (<0.75 m)	-	-
Riffle	20	7
Backwater	-	-
Rapid	-	-
Non-Defined Channel	70	23

Cover Types	Amount
Boulders	Trace
Undercut Banks	None
Overhanging Vegetation	None
Woody Debris	Trace
Depth	None
Stain/Turbulence	Dominant
Instream Vegetation	Trace
Other	-
Other	-
Other	-
Other	-
Other	-
Total Cover	Low

Fish Habitat Potential				
Target Species	**Spawning Rating**	**Rearing Rating**	**Wintering Rating**	**Adult Feeding Rating**
Bull Trout	Unsuitable	Marginal	Unsuitable	Unsuitable
Rainbow Trout	Unsuitable	Marginal	Unsuitable	Unsuitable
Kokanee Salmon	Unsuitable	Marginal	Unsuitable	Unsuitable

Fish species previously documented (within Burton Creek upstream from Highway 6): Bull Trout, Kokanee Salmon, Rainbow Trout (iMap BC, 2018).

Additional Habitat Comments

The site Channel 2 was defined during the spring site visit as encompassing a section of non-defined channel (wet ground) which provides overland drainage towards a collection area for a culvert outlet (conveying flow from Burton Creek) on the west side of Highway 6. Downslope of the culvert outlet, flow was organized within a marginally defined channel and conveyed to a confluence with Channel 1.

Habitat within Channel 2, where channel definition was discernible, was comprised of shallow run and marginally defined riffle units.

Photo 1: Downslope view upslope from section of non-defined channel (May 8, 2018).

Photo 2: View of channelization downstream from culvert outlet (May 8, 2018).

Photo 3: Downslope view of culvert outlet within non-defined channel section (May 8, 2018).

Photo 4: View of culvert outlet under Highway 6 (May 8, 2018).

Photo 5: Upstream view at T6 (near confluence with Channel 1) (May 8, 2018).

Photo 6: Downstream view at T6 (near confluence with Channel 1) (May 8, 2018).

APPENDIX B
Fish Stranding Risk Assessment

Table B–1 Stranding Risk Assessment Tool for the Burton Flats Wildlife Enhancement Project – Design Plan and Reservoir Levels

Wetland	Total Score	Criteria	Risk Category					
			None (0)	Low (1)	Low to Moderate (2)	Moderate (3)	Moderate to High (4)	High (5)
A1	4	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75
A2	6	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75
A3	6	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75
A4	6	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75
A5	7	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75
A6	7	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75
B1 – disconnected	8	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>65
D1	14	Wetland area (m^2)	–	<1000	1000–2000	2001–3000	3001–4000	>4000
		Wetland depth (m)	–	<0.50	0.50–0.70	0.71–1.0	1.01–1.50	>1.50
		% of days inundated	–	<20	20–40	40–60	60–75	>75

Table B–2 Stranding Risk Assessment Tool for the Burton Flats Wildlife Enhancement Project – Fish Presence and Significance

Target Species	Total Score	Criteria	Risk Category					
			None (0)	Low (1)	Low to Moderate (2)	Moderate (3)	Moderate to High (4)	High (5)
Bull Trout	7	Fish presence (historical and field verified)	None	–	–	Adults only	Juveniles only	All life stages
		Conservation status – Provincial	No Status or Exotic	–	–	Yellow or Unknown	Blue	Red
		Conservation status – Federal[1]	None	Not–at–risk	Candidate	Special Concern	Threatened	Endangered
Kokanee	6	Fish presence (historical and field verified)	None	–	–	Adults only	Juveniles only	All life stages
		Conservation status – Provincial	No Status or Exotic	–	–	Yellow or Unknown	Blue	Red
		Conservation status – Federal[1]	None	Not–at–risk	Candidate	Special Concern	Threatened	Endangered
Rainbow Trout	7	Fish presence (historical and field verified)	None	–	–	Adults only	Juveniles only	All life stages
		Conservation status – Provincial	No Status or Exotic	–	–	Yellow or Unknown	Blue	Red
		Conservation status – Federal[1]	None	Not–at–risk	Candidate	Special Concern	Threatened	Endangered

Table B–3 Stranding Risk Assessment Tool for the Burton Flats Wildlife Enhancement Project – Habitat Suitability

Target Species	Total Score	Criteria	Risk Category					
			None (0)	Low (1)	Low to Moderate (2)	Moderate (3)	Moderate to High (4)	High (5)
Bull Trout	6	Spawning suitability if coincides with inundation	Unsuitable	–	Marginal	–	Suitable	All life stages
		Spawning timing relative to inundation	Inundation does not coincide with staging/ spawning Or no spawning habitat present	–	Inundation coincides with staging/ spawning and outmigration/ emergence	–	Inundation coincides with staging/ spawning/ outmigration but not emergence	Inundation coincides with staging/ spawning but not emergence
		Juvenile rearing suitability at inundation	Unsuitable	–	Marginal	–	Suitable	Important
		Adult feeding/Foraging suitability at inundation	Unsuitable	–	Marginal	–	Suitable	Important
Kokanee	11	Spawning suitability if coincides with inundation	Unsuitable	–	Marginal	–	Suitable	All life stages
		Spawning timing relative to inundation	Inundation does not coincide with staging/ spawning Or no spawning habitat present	–	Inundation coincides with staging/ spawning and outmigration/ emergence	–	Inundation coincides with staging/ spawning/ outmigration but not emergence	Inundation coincides with staging/ spawning but not emergence
		Juvenile rearing suitability at inundation	Unsuitable	–	Marginal	–	Suitable	Important
		Adult feeding/Foraging suitability at inundation	Unsuitable	–	Marginal	–	Suitable	Important
Rainbow Trout	6	Spawning suitability if coincides with inundation	Unsuitable	–	Marginal	–	Suitable	All life stages
		Spawning timing relative to inundation	Inundation does not coincide with staging/ spawning **OR** no spawning habitat present	–	Inundation coincides with staging/ spawning and outmigration/ emergence	–	Inundation coincides with staging/ spawning/ outmigration but not emergence	Inundation coincides with staging/ spawning but not emergence
		Juvenile rearing suitability at inundation	Unsuitable	–	Marginal	–	Suitable	Important
		Adult feeding/Foraging suitability at inundation	Unsuitable	–	Marginal	–	Suitable	Important

APPENDIX C
Habitat Suitability Tables

Rainbow Trout

	Spawning				Rearing			
Physical Habitat	Preferred	Suitable	Marginal	Unsuitable	Preferred	Suitable	Marginal	Unsuitable
Substrate type	Small gravel (small gravel)	Gravel, cobble (gravel)	Some Gravel but dominated by fines	Silt, rock	Gravel	Boulder	Cobble, fines	Silt
Substrate size (mm)	2-16 (1-5)	2-256 (<2-16)	<2-16 (65-256)	<2; >400	17-64	256-400	<2; 65-256	<2
Depth (m)	0.15-1.0 (0.1-0.2)	1.0-2.0 (0.2-0.4)	2.5 (0.4-0.7)	(>0.8)	0.5-0.8		0.3-0.5;0.8-1	<0.3; >2.0
Embeddedness	Unembedded	Low	Moderately	Highly, algae covered	Unembedded	Low	Moderately	Highly, algae covered
Velocity (m/s)	0.3-0.7 (0.3)	0.2-0.3; 0.7-0.9 (0.2-0.5)	0.1-0.2; 0.9-1.0 (0.1-0.2; 0.5-0.7)	<0.1; >1 (<0.1; >-0.8)	0.1-0.3		Moderate	Fast
Cover	Abundant OHV	Moderate cover	Sparse cover	No cover	Abundant WD, cobble/boulder	UC, OHV	Moderate cover	No cover
Habitat type	Downstream end of pool, upstream of riffle	Run of small tributaries; lake inlet/outlet	Flat	Lakes with no inlets/outlets	Deep pool, snye	Stream margins, run	Cobble shoal, flat	Rapid

pH Tolerance: 6.5 – 8

Optimal H_20 Temp: 12 – 18 º C
Lethal H_20 Temp: >24 º C

Optimal DO: 7-9 mg/L
DO Tolerance: >3 mg/L

	Feeding				Overwintering			
Physical Habitat	Preferred	Suitable	Marginal	Unsuitable	Preferred	Suitable	Marginal	Unsuitable
Substrate type	Gravel, sand	Sand, cobble	Cobble; fine only	Muck, detritus	Gravel, sand	Sand, cobble	Cobble; fines only	Muck, detritus
Substrate size (mm)	<2-64	<2; 65-256	65-256; <2	<2	<2-64	<2; 65-256	65-256; <2	<2
Depth (m)	1.0-3.0		0.8->5.0	<0.5	>2.0 **(>0.6)**		1.0	<1.0
Embeddedness	Unembedded	Low	Moderately	Highly, algae covered				
Velocity (m/s)	0.2-1.0		Moderate	High	Low		Moderate	High
Cover	Abundant BL, WD	UC, OHV	Moderate cover	No cover	Abundant BL, WD	BL, WD	Moderate cover	No cover
Habitat type	Pool, riffle	Run	Side channel, Snye, flat	Rapid	Deep pool, snye	Moderate depth pool	Moderate or deep run, low velocity	High velocity run

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Bull Trout

	Spawning				Rearing			
Physical Habitat	Preferred	Suitable	Marginal	Unsuitable	Preferred	Suitable	Marginal	Unsuitable
Substrate type	Gravel	Gravel, cobble	Gravel, sand	Silt, muck, detritus	Cobble, boulder	Cobble	Gravel	Silt, muck, detritus
Substrate size (mm)	2-64	2-256	<2-256	<1	64-400	64-256	2-64	<1
Depth (m)	0.4	0.2-0.6	0.1-0.8	<0.1, >1.0	<0.5	<0.8	<1.0	>2.0
Embeddedness	Unembedded	Low	Moderately	Highly, algae covered	Unembedded	Low	Moderately	Highly, algae covered
Velocity (m/s)	0.3-0.5	0.2-0.6	0.3-0.7	<0.1, <1.0	<0.2	<0.4	0.4-0.6	>0.9
Cover	WD, BL, OHV	UC, BL	OHV	No cover	WD, OHV	UC, BL	OHV	No cover
Habitat type	Areas with upwelling, downstream end of pool, head of riffle	Moderate depth pool or run	Riffle	Flat	Pool, snye	Run	Run/boulder garden	Flat, rapid

pH Tolerance: 7.6 – 8.8

Optimal H_20 Temp: >14 ° C
Lethal H_20 Temp: >20 ° C

Optimal DO: >6.5 mg/L
DO Tolerance: >4 mg/L

	Feeding				Overwintering			
Physical Habitat	Preferred	Suitable	Marginal	Unsuitable	Preferred	Suitable	Marginal	Unsuitable
Substrate type	Gravel, cobble,	Boulder, gravel, cobble	Boulder, rock	Silt, muck, detritus	Gravel, cobble	Boulder, gravel, cobble	Boulder	Silt, muck, detritus
Substrate size (mm)	25-256	2-400	>256	<1	25-150	2-400	256-400	<1
Depth (m)	1.0-3.0	1.0-2.0	2.0	>0.2	1.0-3.0	0.8-2.0	0.5-1.5	<0.75
Embeddedness	Unembedded	Low	Moderately	Highly, algae covered	n/a	n/a	n/a	n/a
Velocity (m/s)	0.1-0.2	0.2-0.3	0.3-0.5	>0.7	0.2		0.5	>1.0
Cover	BL, DP	WD, OHV	IV, UC	No cover	DP			
Habitat type	Deep pool or run	Moderate depth pool or run	Run, riffle	Rapid, flat	Deep pool or run	Moderate depth pool or run	Shallow pool or run	Flat

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Kokanee Salmon

	Spawning				Rearing (April – June emergence)			
Physical Habitat	Preferred	Suitable	Marginal	Unsuitable	Preferred	Suitable	Marginal	Unsuitable
Substrate type	Small gravel	Gravel	Gravel, cobble	Silt, organics	Large gravel, cobble		Small gravel, sand	Silt
Substrate size (mm)	2-16	2-64	2-256	<2	17-256		<2-16	<2
Depth (m)	0.3-0.6	0.2-0.8	0.8-1.0		<2			
Embeddedness	Unembedded	Low	Moderately	Highly, algae covered	Kokanee Salmon migrate to lakes immediately.			
Velocity (m/s)	0.1-0.2 (with upwelling)	0.45-0.65 (without)	0.2-0.8 (without)	>1.0	<0.15			High
Cover	n/a	n/a	n/a	n/a	UC, WD	Littoral vegetation, BL		No cover
Habitat type	DS end of pool, US of riffle, areas w/groundwater upwelling	Riffle, run	Pool, riffle	Lakes with no inlets or outlets	Littoral zones of lakes, snye, side channel			

pH Tolerance: Unknown

Optimal H_20 Temp: 11 – 15 ^{o} C
Lethal H_20 Temp: >18 ^{o} C

Optimal DO: >6.5 mg/L
DO Tolerance: >4 mg/L

	Feeding				Overwintering			
Physical Habitat	Preferred	Suitable	Marginal	Unsuitable	Preferred	Suitable	Marginal	Unsuitable
Substrate type	Kokanee Salmon are crepuscular foragers in lakes.				Kokanee Salmon overwinter in lakes.			
Substrate size (mm)								
Depth (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Embeddedness	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Velocity (m/s)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cover	DP, darkness				DP			
Habitat type	Pelagic zone; meta and hyperlimnion; hypolimnion when resting				Lakes			

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