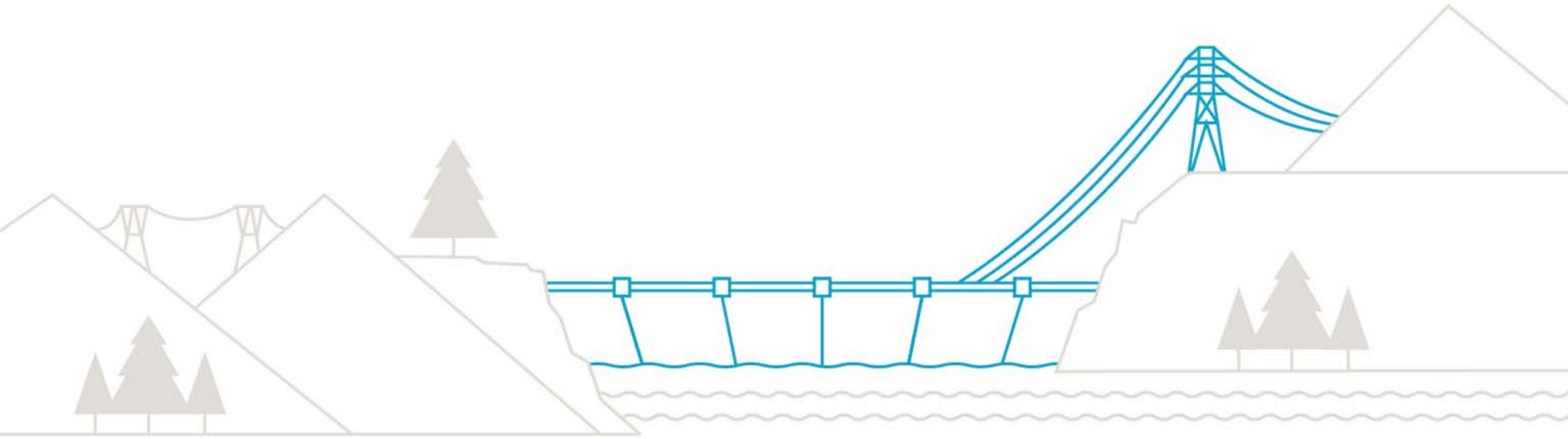
Columbia Water Use Plan Update to CBRAC



December 4, 2017

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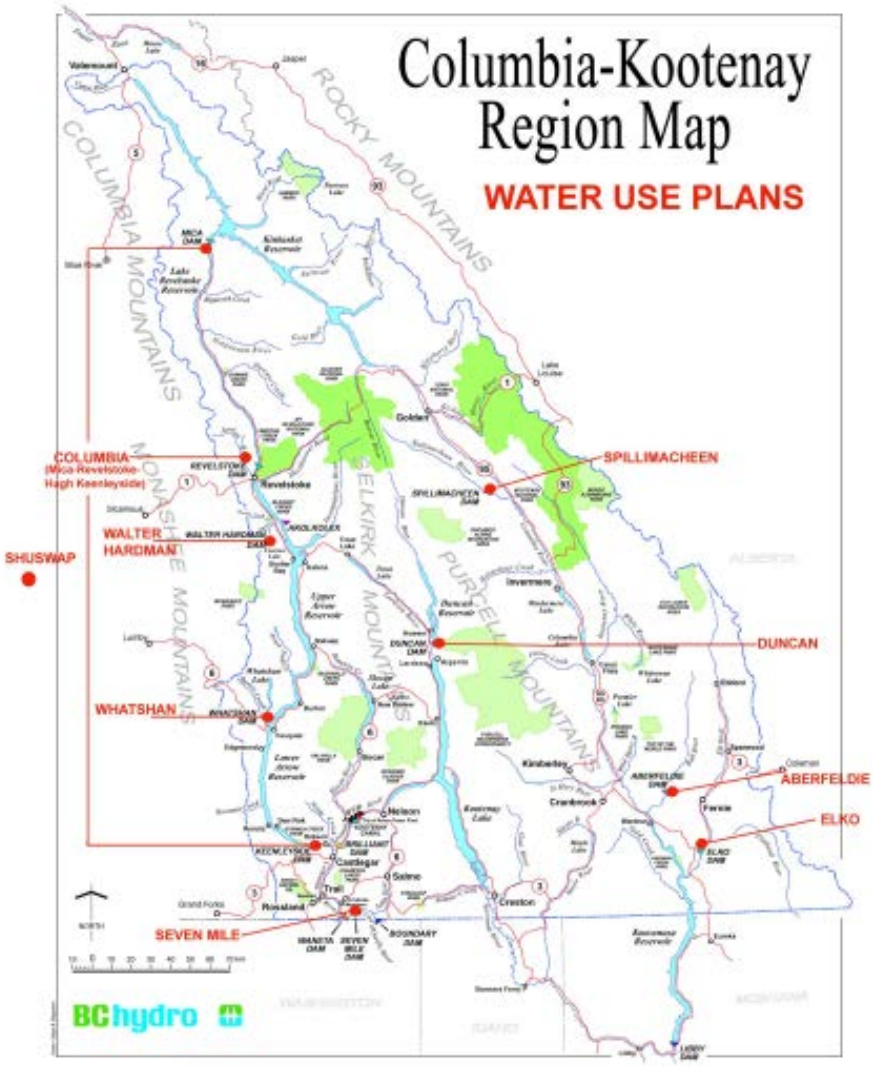
Columbia Water Use Plan Update

Agenda

- Brief Regional WUP Overview
- Selection of Physical Works and Monitoring Studies to illustrate scope, issues, and learnings:
    - Arrow Wildlife Physical Works
    - Kinbasket Revegetation Physical Works
    - Lower Columbia River Mountain Whitefish monitoring studies
    - Lower Duncan River Kokanee monitoring

Regional Water Use Plans



WUP	Monitoring studies	Physical Works
Aberfeldie	1	3
Columbia	62	45
Duncan	17	4
Elko	3	0
Seven Mile	2	0
Shuswap	4	1
Spillimacheen	3	1
Whatshan	4	2
Walter Hardman	6	2

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Columbia WUP Background

Consultative Committee Process 2001 to 2004

- 1998 Water Use Plan Guidelines
- Representatives from First Nations, agencies, municipal government, industry and local stakeholders
- Seven meetings plus technical subcommittee meetings
- Multiple objectives (8) using a structured decision-making process, performance measures and modeling. For example:
    - Culture & Heritage: *Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities*
    - Aquatic Resources: *Maximize abundance, diversity, and condition of wild, indigenous fish stocks in the Columbia River system*
    - Wildlife and Vegetation: Maximize wildlife abundance and diversity in the Columbia River system.

Columbia WUP Background

Columbia WUP approved by Comptroller of Water Rights (CWR) January 2007

- No operational changes for Kinbasket Reservoir (KIN)
- Year-round minimum flow at Revelstoke (REV)
- Soft operational constraints on Arrow Reservoir (ARR)
- Commitment to attempt to negotiate flows for Mountain Whitefish (MWF) and Rainbow Trout (RBT) for Lower Columbia River (LCR)

Columbia WUP Background

Order amended for Revelstoke 5 August 2007

- Delayed implementation of 5 kcfs minimum flow from REV dam from Fall 2010 to coincide with In-Service Date of REV 5
- Five new monitoring studies and bank erosion protection works
- Changes to existing studies and physical works to incorporate potential effects of 5-unit operations

Order amended for Mica 5/6 in August 2010

- Four new monitoring studies and changes to three existing studies to assess potential effects of 6-unit operations

Arrow Wildlife Physical Works (Mgmt Plan 7)

Columbia 2007 Conditional Order Clauses 4.a. and 7.a.

Upon review of wildlife habitat feasibility studies…physical works to improve conditions for nesting and migratory birds and wildlife within the drawdown zone of Revelstoke Reach…and Arrow Reservoir.

Background: Columbia Consultative Committee

- Focus on riparian and wetland habitat due to high overall diversity in these areas and potential effects of reservoir operations.
- Holding levels at 1427ft (435m) until mid July was not feasible under the Columbia River Treaty.
- Physical works recommended to mitigate inundation effects of nesting bird habitat.

Arrow Wildlife Physical Works (Mgmt Plan 7)

Feasibility: Wildlife Physical Works Committee

- 44 sites in Revelstoke Reach identified by the Consultative Committee evaluated in 2008.
- Early feasibility and consultation with the Wildlife Physical Works Committee narrowed the selection down to 8 sites using biological and operational criteria.

Early Design Phase

- Several of the sites were eliminated due to safety concerns (proximity to airport), potential impacts to fish (impeding passage to tributaries or entrapment), and high uncertainty in ecological benefits.
- Proceeded with Site 6A Airport Slough erosion control and Site 15A Cartier Bay.

Arrow Wildlife Physical Works (Mgmt Plan 7)

Airport Slough Wetland Erosion Protection (Site 6A)

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Arrow Wildlife Physical Works (Mgmt Plan 7)

Airport Slough Wetland Erosion Protection (Site 6A)

- Erosion from reservoir operations, Revelstoke discharge, and overflow drainage created a115 metre-long Y-shaped channel.
- Filled the east arm of the erosion channel with rip-rap to prevent drainage of the Airport Slough wetland in 2013.
- 2016 post-works monitoring assessment indicates good integration with floodplain.

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Arrow Wildlife Physical Works (Mgmt Plan 7)

Cartier Bay Wetland (CLBWORKS30A - Site 15A)

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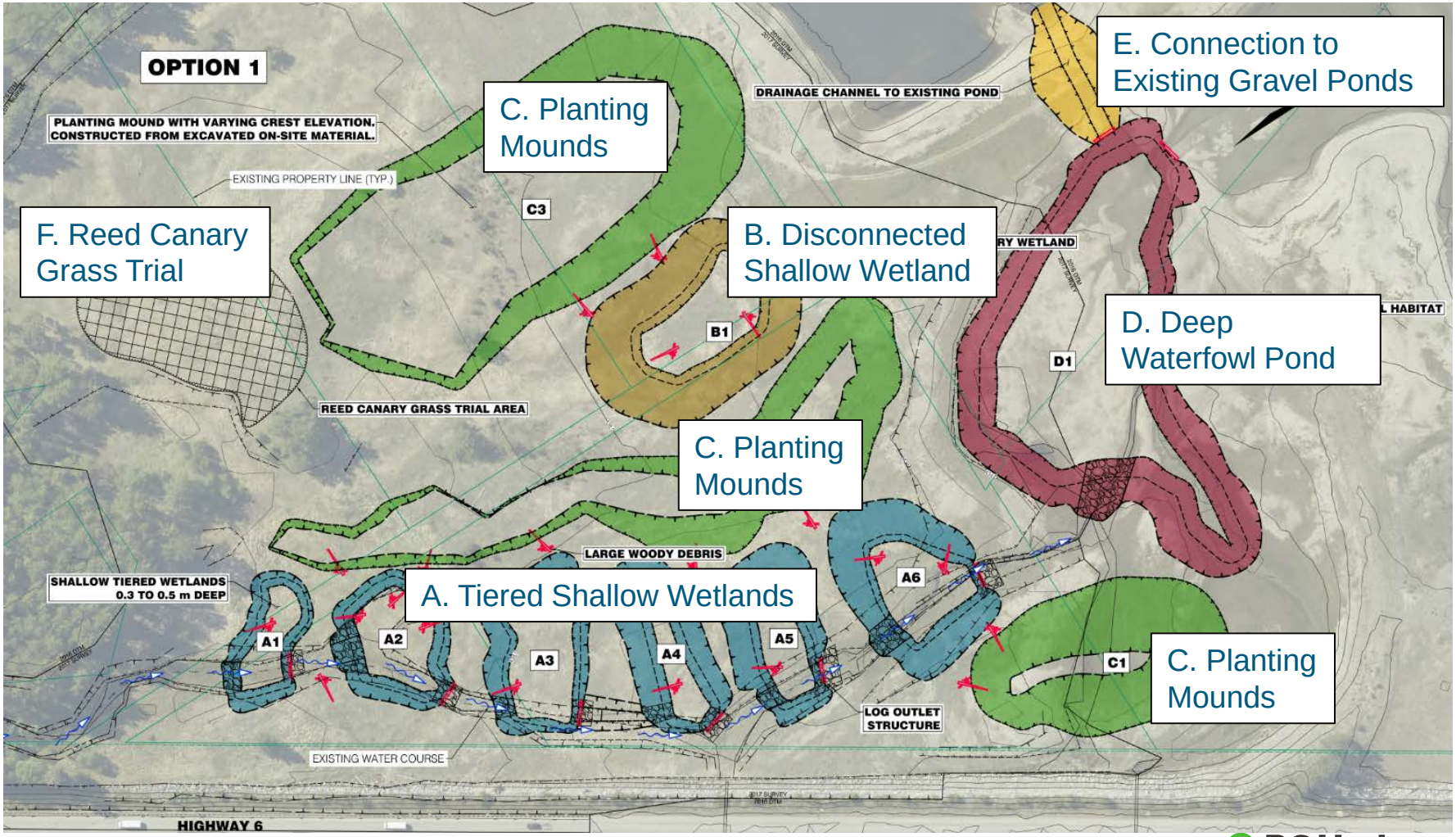
Arrow Wildlife Physical Works (Mgmt Plan 7)

Cartier Bay Wetland (CLBWORKS-30A – Site 15A)

- Collapsed wooden box culvert in the old railbed that bisects the reservoir was threatening to drain Cartier Bay.
- Filled in with rip rap in 2016 maintaining existing footprint of Cartier Bay wetland.

Lower Arrow Wildlife Physical Works: Burton Design Overview



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Revegetation Physical Works (Mgmt Plan 2)

Columbia 2007 Conditional Order Schedule A Clause 1.a.

In lieu of operational constraints on Kinbasket Reservoir… a reservoir-wide planting program to enhance sustainable vegetation growth within the drawdown zone of Kinbasket Reservoir to benefit fish, wildlife, aesthetics, dust control, and recreation.

Revegetation Physical Works (Mgmt Plan 2)

Kinbasket Revegetation (CLBWORKS-1)

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Revegetation Physical Works (Mgmt Plan 2)

Kinbasket Revegetation (CLBWORKS-1)

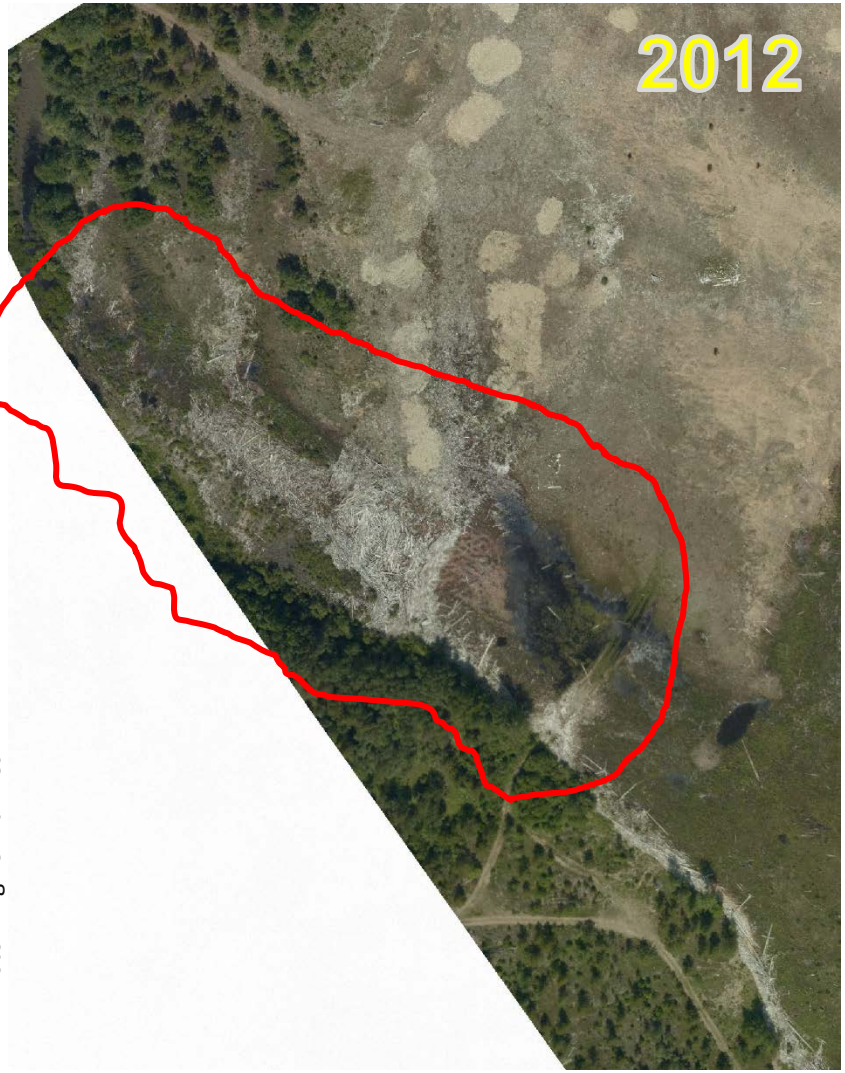
Photo: Virgil C. Hawkes

- Sedge seedling survival from early plantations is < 5% as of 2016; live stakes had 100% mortality.
- Modified approach to revegetation in Kinbasket in favour of small-scale pilot revegetation techniques.
- Revegetation successes and failures are being evaluated under CLBMON-35 Plant Response to Inundation.

Kinbasket – Bush Arm Km 88 Sedges

- Planted in 2013
- More mature sedge stock in a site selected for ecological suitability
- 74% survival rate as of 2015

Canoe Reach Debris Removal and Exclusion



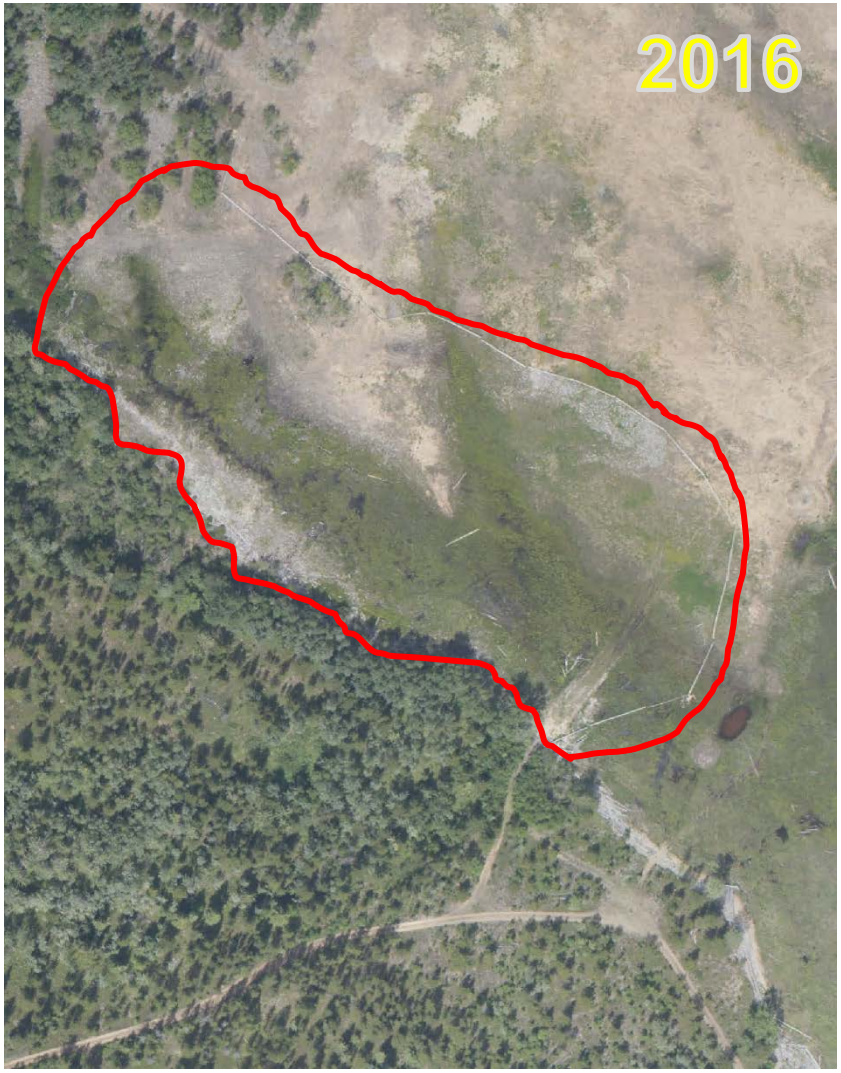


Photo: Virgil C. Hawkes

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Exclusion of debris accumulation

Valemount Peatland natural regrowth (one year post works)

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Bush Arm Causeway Debris mounds and ponds

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Bush Arm Causeway Debris mounds and ponds

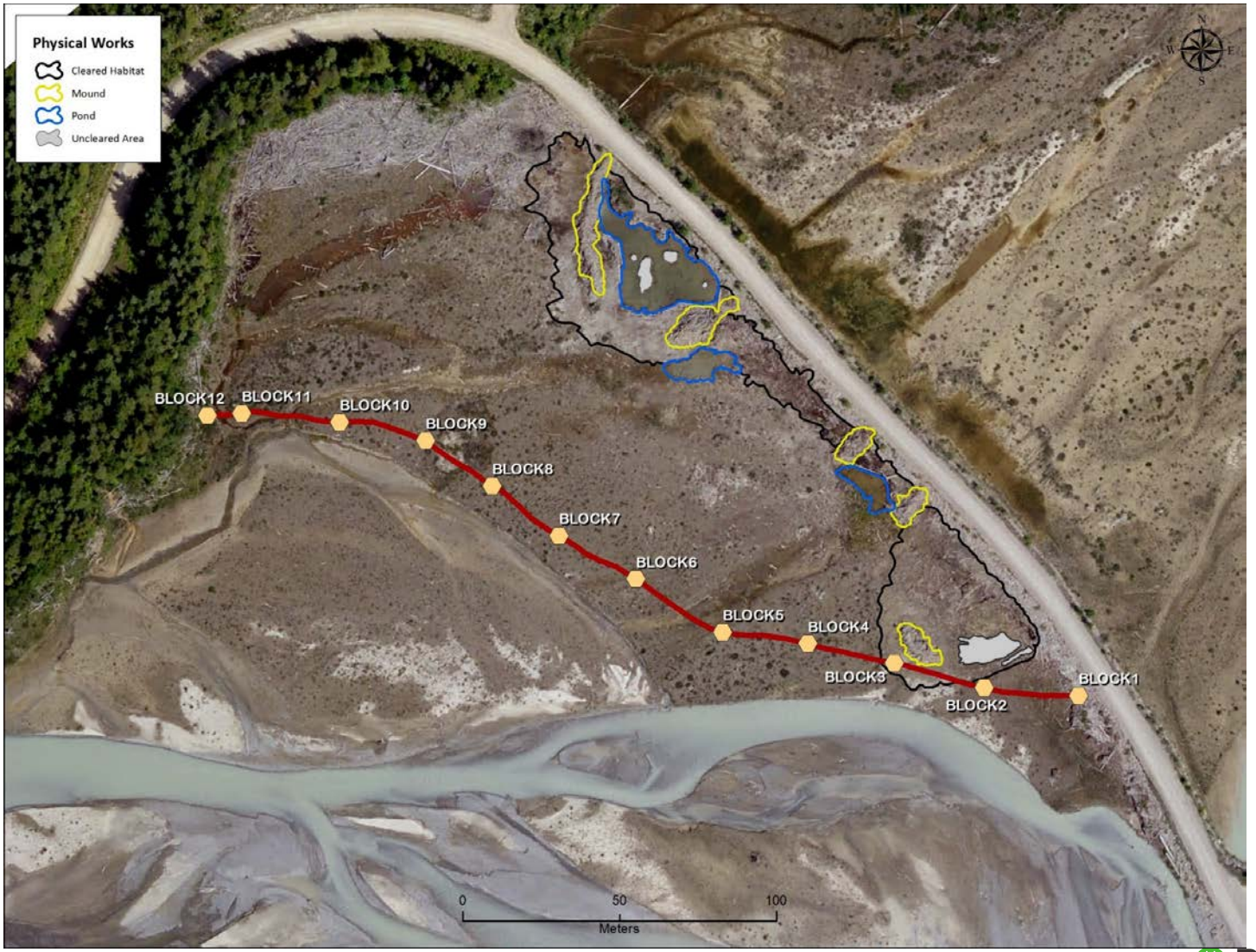

Photo: Virgil C. Hawkes

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Lower Columbia River Fish (Mgmt Plan 8)

CLBMON-47 LCR Mountain Whitefish Spawning

Monitor the spawning locations of whitefish in the lower Columbia River using detailed topographic surveys to improve the effectiveness of the whitefish flow regime (Columbia 2007 Order, Schedule E, Clause 2.f.)

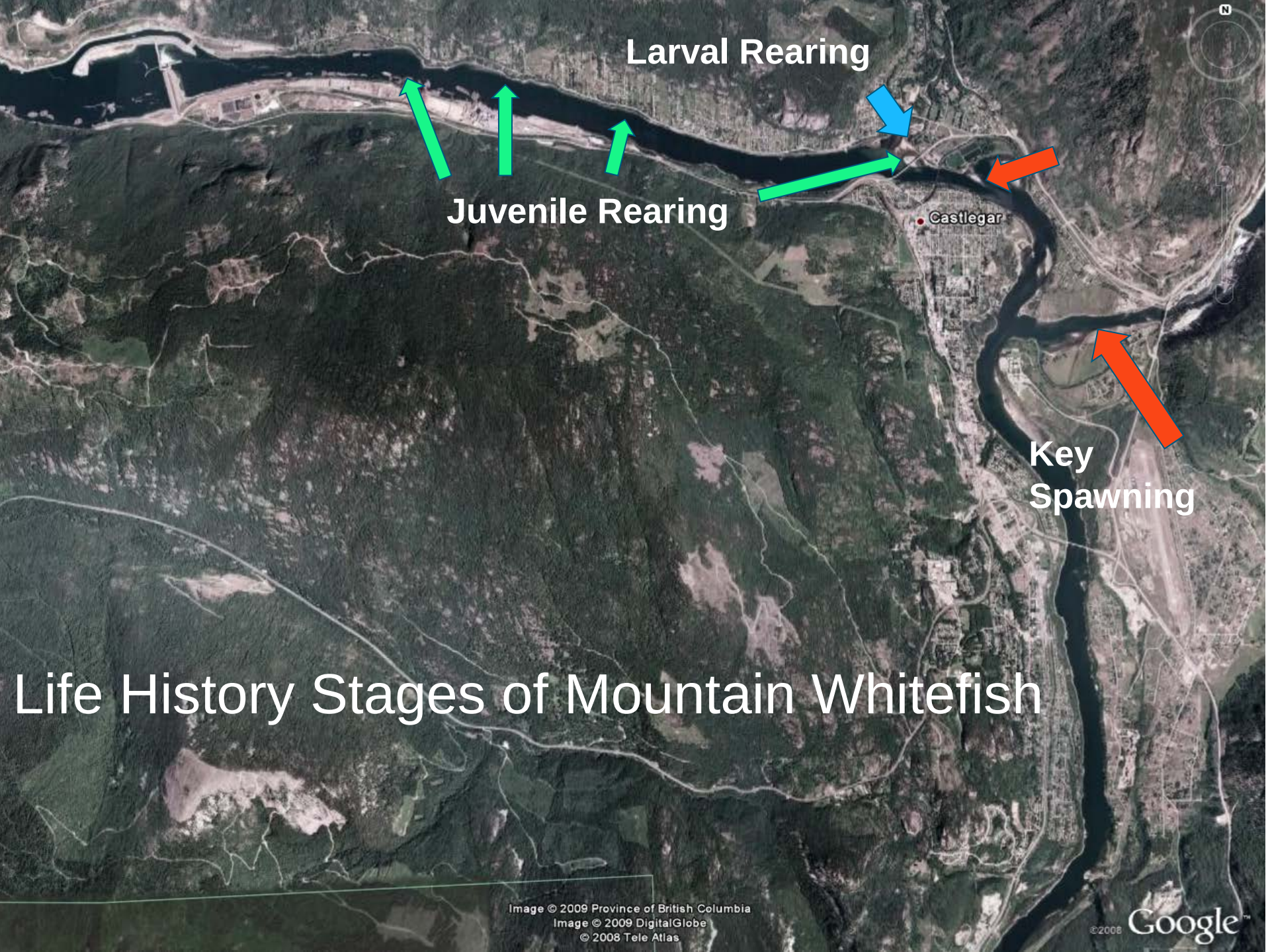
CLBMON-48 LCR Mountain Whitefish Egg monitoring & Life History

Monitor the whitefish life history, including spawning and egg mat sampling in the lower Columbia River to establish the effectiveness of the whitefish flow regime on egg survival, juvenile recruitment, and adult populations (Columbia 2007 Order, Schedule E, Clause 2.g.)

Lower Columbia River Fish (Mgmt Plan 8)

Mountain Whitefish (MWF) High level learnings

- Whitefish spawning commences in mid November, peaks in mid January and ends in February.
- Key spawning areas are Kootenay and CPR Island; secondary areas are Tin Cup and Kinnaird Rapids.
- Boulders/cobbly substrate is preferred.
- Egg Loss Model predicts mortality based on eggs dewatered and review of the model is underway.
- Only one Tier 3 (40-60% mortality) egg loss in the past 24 years in 2012. No signal detected in subsequent monitoring of juvenile MWF.
- Second Tier 3 flow occurred in 2016/2017 peak spawning and we will monitor any effects on juvenile MWF in 2019.


Larval Rearing
Juvenile Rearing
Castlegar
Key
Spawning
Life History Stages of Mountain Whitefish
Image © 2009 Province of British Columbia
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Duncan WUP Background

Duncan WUP approved by Comptroller of Water Rights (CWR) December 2007

- Minimum flow year round.
- Reservoir elevation target of full pool in August (peak recreation period and to maintain min flows for fish).
- Target Flow Protocol at confluence of Duncan and Lardeau Rivers.
- Ramping rates.
- Physical works and monitoring studies

Duncan Water Use Plan

DDMMON-4 Lower Duncan River Kokanee Spawning

Monitor kokanee spawning in Lower Duncan River in order to evaluate flow release benefits (Duncan 2007 Order, Clause 6.a.)

High level learnings

- Kokanee spawning late August to early November.
- Peak spawning estimated between Sept 28 to Oct 7.
- Emergence is late December to early February (2-3 months earlier than Lardeau or Meadow Creek).
- Abundance estimates have been low for the past 3 years.
- Third year of flow trials was implemented in 2017 to reduce flows a few days earlier in Sept to avoid peak spawning and to sustain a higher overall flow (target 100cms).

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