Eagle Creek Feasibility Assessment: Improving Kokanee Access to Spawning Habitat in Eagle Creek (2016 - 2017)

FWCP COL-F17-F-1456

Prepared for:

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Prepared with financial support from the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and the public who work together to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams.

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syilx Okanagan Nation Alliance

Executive Summary

Eagle Creek is a major tributary to the Lower Arrow Lakes section of the Columbia River and contains important sport species such as Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*), and Kokanee (*Oncorhynchus nerka*). There is approximately 4.3 km of stream available for spawning Kokanee before arriving at a 2 m falls, but access is impeded in the lower reaches of due to reservoir management from downstream Hugh L. Keenleyside Dam. Members of the Edgewood community have expressed interest in rehabilitation work on the creek to improve Kokanee access to spawning habitat, but there is minimal information regarding the upstream stability.

The ONA's main goal for this project was to determine the feasibility of improving Kokanee access in Eagle Creek, potentially through construction of habitat enhancement features. This goal is consistent with the FWCP *Columbia Action Plan* (2012); specifically the first goals of the *Large Lake Action Plan* (2012) and *Streams Action Plans* (2012). The Feasibility Assessment Area begins at Eagle Creek's confluence with the Arrow Lakes Reservoir (at the time of low pool) and extends approximately 2.6 km upstream to the Worthington Road Bridge. A brief review was conducted to determine history, ownership and water rights within the study area. A site visit occurred on August 2016 to observe habitat conditions during Kokanee migration and spawning. All results are based on observations in the field and pre-existing knowledge of experienced professionals. Stream features were used to characterize stream morphology and to understand the origins and dynamics of channel sediment.

The Feasibility Assessment Study Area was delineated into six different Management Zones (MZ). MZ 1 (lower drawdown zone) is subject to low water levels, braiding and lateral movement which may be addressed by installing habitat structures to define a distinct channel within the drawdown zone. MZ 2 (upper drawdown zone) contains obstacles that impede Kokanee access due to deposition of materials which can be addressed similarly by installing habitat structures to improve channel definition. MZ 3 (braided, but stable area) is subject to some erosion and is a stabilizing aggraded section likely from sources of historical significance. MZ 4 (narrow stable section) does not have any obvious issues, but monitoring should occur to identify any issues in the zone that may occur due to treatments in the other zones. MZ 5 (log jam) contains an obstruction that is aggrading upstream reaches (MZ 6) and is increasing risk of channel avulsion. Mitigation of upstream flooding and avulsion risk can be undertaken by gradually removing pieces of the log jam over 2+ years to improve sediment conveyance and allow upstream Kokanee access. During the assessment, two heavy machine access points were identified which would provide access to all management zones.

Recommendations resulting from this feasibility assessment include (but aren't limited to) installing habitat structures to improve Kokanee access to through the drawdown zone and upstream spawning habitat, concurrent with a multi-year sediment monitoring program to further understand material movement in Eagle Creek. Installing habitat structures in conjunction with monitoring will improve conditions for Kokanee access. Implementing habitat improvements will also provide the citizens of Edgewood and local stewardship groups a sense of progress while addressing upstream concerns.

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Acknowledgements

This project was made possible with funding from the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and the public who work together to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams.

I would also like to acknowledge Lorne Davies from Geostream Environmental Consulting for his valuable interpretation and site assessment contributions; Kevin Schiller from Misty Ridge Contracting for his local knowledge, enthusiasm, and valuable observations; Edgewood community members Brian Ewings, Mike Flintoff and Crystal Spicer, for their valuable local knowledge, input, and feedback on the project, and Amy Duncan from the Okanagan Nation Alliance for report review, field support and guidance.

Introduction

Eagle Creek is a major tributary to the Lower Arrow Lakes section of the Columbia River. This watershed has an area of 108.1 km^2 in the Christina Range of the Monashee Mountains and includes the Interior Cedar-Hemlock and Engelmann Spruce - Subalpine Fir Biogeoclamatic Zones. Originating in the headwaters of Mount Scaia, Eagle Creek extends 22 km to the Lower Arrow Lakes Reservoir just south of Edgewood, British Columbia (BC) approximately 65 km north west of Castlegar, BC (Fig 1).

Eagle Creek is a fish bearing stream supporting sport fish such as Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*), and Kokanee (*Oncorhynchus nerka;* Dobson Engineering Ltd 1997, Sebastian et al. 2000, Trumbley Environmental Consulting Ltd 2001). Approximately 4.3 km of stream is available for spawning Kokanee in Eagle Creek before arriving at a 2 m falls, though Bull Trout may pass this obstacle for a total of 9.3 km of stream habitat (Seaton 1978, Lindsay and Seaton 1978).

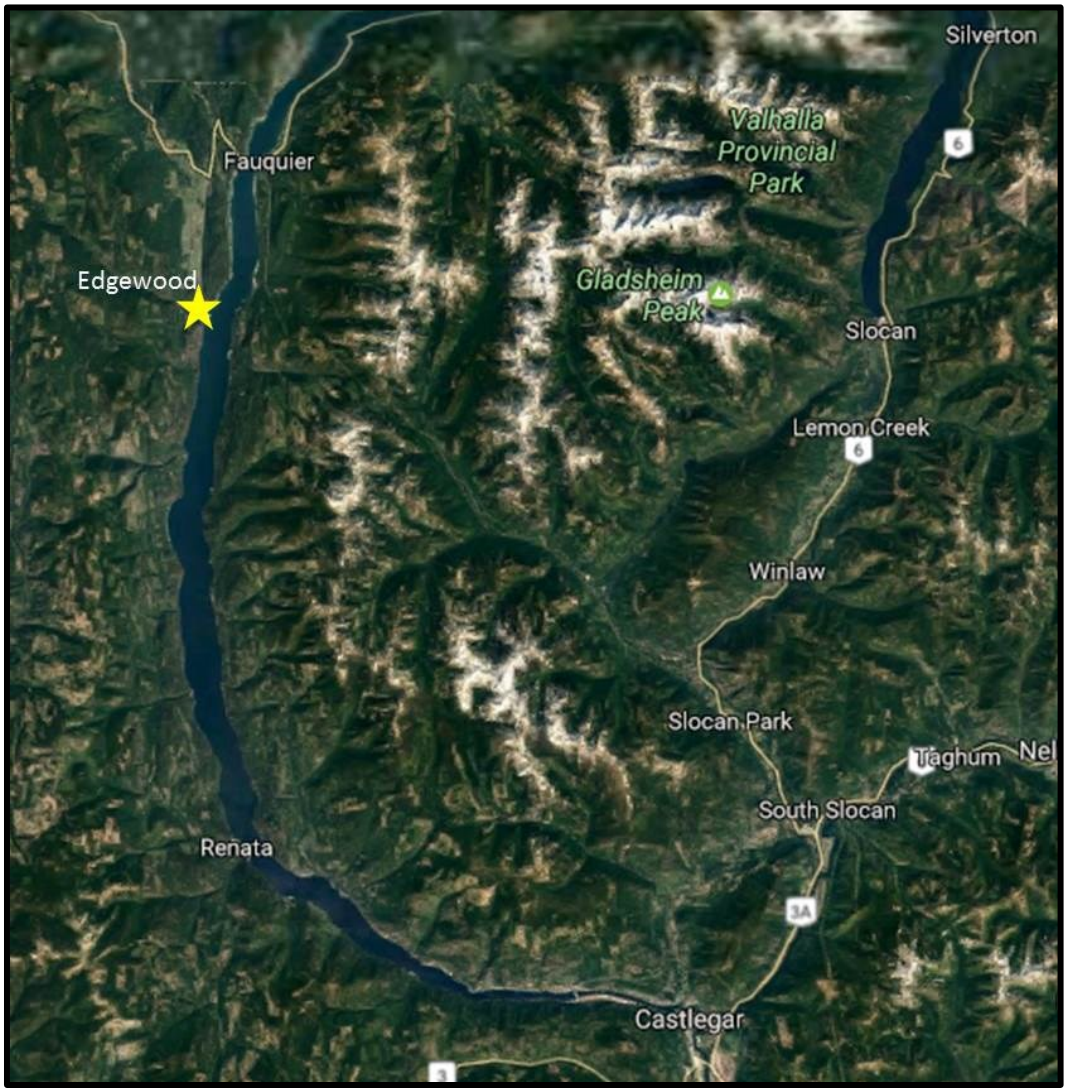

Figure 1. Location of Edgewood (yellow star) in relation to Castlegar, BC (created by Evan Smith using map data 2016, Google).

Kokanee access is impeded in the lower reaches of Eagle Creek during low water levels due to reservoir management. Four hundred forty Kokanee were found in Eagle Creek during the annual Kokanee count in 2016 compared to zero Kokanee in 2015 (Steve Arndt, pers. comm.). Kokanee numbers peaked in 2008 at 4,088 Kokanee but are consistently under 500 Kokanee (2007, 2009 – 2013, 2015-2016 data; Steve Arndt, pers. comm.). The reason for low Kokanee spawning numbers has been attributed to braiding and low stream flows in the drawdown zone (Hawes and Drieschner 2013; Fig 2). Because of its potential for fish habitat, access issues and public interest, habitat improvement treatments have been recommended (Dykeman 1980, Hawes and Drieschner 2013).

Members of the Edgewood community have expressed interest in having rehabilitation work performed on the creek to improve Kokanee access to spawning habitat. However, available information on Eagle Creek is primarily fish-oriented, so knowledge of stream morphology, sedimentation and stability in the upper reaches of the stream is limited. To improve the success of a future project, the Okanagan Nation Alliance (ONA) proposed to undertake a feasibility assessment of Eagle Creek to fill knowledge gaps and assess whether a rehabilitation project focused on Kokanee access would be successful considering stream morphology, sediment supply, and upstream stability risk.

This project is consistent with the Fish and Wildlife Compensation Programs *Columbia Basin Plan* (2012), specifically the goals of the *Large Lakes Action Plan* (2012) and *Streams Action Plan* (2012) which include maintaining a productive and diverse aquatic ecosystem. The *Large Lake Action* (2012) plan specifically lists Kokanee status as one of seven “status indicators” and identifies the possibility of increasing opportunities for Kokanee fishing in the Upper and Lower Arrow Lakes. Kokanee habitat restoration is also listed as a first priority action in Appendix B of the *Streams Action Plan* (2012).

Figure 2. (A) An upstream view of Eagle Creek flowing through the Lower Arrow Lakes Reservoir's drawdown zone with low water depth and minimal habitat value. (B) Downstream view of Eagle Creek braiding and fanning within the drawdown zone to the Lower Arrow Lakes Reservoir (photos by Evan Smith, Okanagan Nation Alliance, August 2016).

Goals and Objectives

The ONA had one main goal for the Eagle Creek Feasibility Study:

Goal 1: Determine the feasibility of installing habitat structures in Eagle Creek to increase Kokanee access.

> Objective 1 – Observe stability indicators (erosion and deposition patterns) from the Worthington Road Bridge in Edgewood downstream to the confluence with Arrow Lakes Reservoir to understand potential upstream risks.
>
> Objective 2 – Identify drawdown zone sediment composition and its potential to support habitat structures.
>
> Objective 3 – Identify access points for machinery to conduct instream work.

Study Area

The study area is located at the end of Lakeshore Avenue in the community of Edgewood approximately 65 km northwest of Castlegar, BC. The Feasibility Assessment Area begins at Eagle Creek's confluence with the Arrow Lakes Reservoir (at the time of low pool) and extends approximately 2.6 km upstream to the Worthington Road Bridge (Fig 3). This area was targeted because of:

1) Known Kokanee access limitations through the drawdown zone,
2) Potential for habitat improvements to address the apparent lack of low flow channel definition and instream cover,
3) Locally established environmental stewardship groups with an vested interest in Eagle Creek,
4) Good site access, and
5) Risk from upstream sediment transport factors which may render future habitat structures ineffective.

Due to the lack of a defined low flow channel, the drawdown zone fans out during low water resulting in meandering and subsequent shallow sections of water that ultimately impede Kokanee access. During high water (full pool, April-June) the drawdown zone is inundated, limiting the establishment of vegetation and floating material that could be used for cover (trees, driftwood). Therefore the addition of habitat structures could deliver needed cover and holding areas while helping define the creek through the drawdown zone providing a deeper overall channel depth improving Kokanee access.

Unlike the drawdown zone, the upper reaches are unaffected by changing reservoir levels. They are proposed to be surveyed due to the absence of information regarding the stream stability. Air photo interpretation indicates localized erosion, though there is no definitive cause. The area will be assessed for stability and opportunity for possible rehabilitation projects to reduce risk of possible influence on any proposed downstream structures.

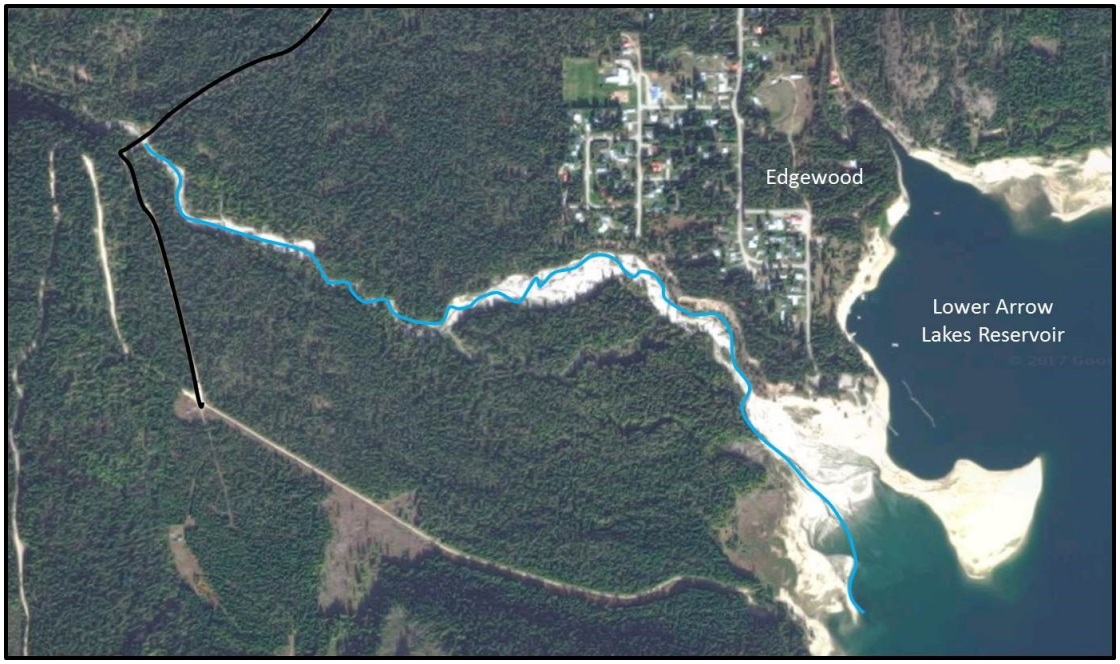

Figure 3. (Blue) Feasibility Assessment Area located at the Worthington Road Bridge downstream to Eagle Creek's confluence with the Arrow Lakes Reservoir (at low pool). (Black) Worthington Road marking the upstream boundary of the Feasibility Assessment Area (created by Evan Smith using map data 2016, Google).

Methods

Before visiting the site, a brief review was conducted to determine history, ownership and water rights. A site visit was then conducted on August 26th 2016 by a Geoscientist (Lorne Davies P.Geo., Geostream Environmental Consulting), Fish Biologist (Michael Zimmer, R.P.Bio., Okanagan Nation Alliance), Fish Technician (Evan Smith, Okanagan Nation Alliance) and a Heavy Machine Operator/Tree Faller (Kevin Schiller, Misty Ridge Contracting). The entire 2.6 km of the Feasibility Assessment Study Area was investigated. All results are based on observations in the field and the pre-existing knowledge of experienced professionals. Observed stream features (gradient, bankfull and wetted widths, depths, dominant substrate, instream cover availability, riffles, pools, vegetation etc.) were used to estimate stream morphology, characteristics and origins of deposited sediment. Stream characteristics above the Worthington Bridge were assessed via aerial photographs and local knowledge due to difficult access and time constraints.

Results and Discussion

During the preliminary investigation prior to the site visit, two landslides were noted via air photo high up in the watershed. The cause and date of these slides is unknown. One water license holder was found within the Feasibility Assessment Study Area. If future work is to continue, this water license holder will be notified prior to any work taking place. The land in the drawdown zone is owned in part by BC Parks, Crown and BC Hydro, but it is unlikely BC Hydro property will be accessed for future habitat structure construction as it is outside the area recommended for treatments. For maps associated with the preliminary investigation on Eagle Creek see Appendix A.

Approximately 2.6 km of Eagle Creek was ground-assessed to document stream morphology, sediment, and upstream stability characteristics. It was determined the creek could be separated into six different management zones based on the findings of the desk-top and field assessments. (Fig. 4).

Figure 4. Eagle Creek management zones and features: (Yellow) Management Zone 1 - lower drawdown zone, (Blue) Management Zone 2 - upper drawdown zone, (Red) Management Zone 3 - laterally unstable section, (White) Feature - old stream beds, (Green) Management Zone 4 - narrow stable section, (Black Star) Management Zone 5 - log jam, (Orange) Management Zone 6 - aggregated section (created by Evan Smith using map data 2016, Google).

Management Zone (MZ) 1 is the lower drawdown zone. This zone is prone to lateral stream movement across the drawdown zone and stream bifurcation while the substrate is mostly sand and finer material (Davies 2016; Fig 5). Access for Kokanee is very limited in this zone due to shallow water and minimal cover. Substrate in MZ 1 may be suitable to support habitat structures but construction is only recommended after monitoring the effects of treatments in MZ 2.

Figure 5. A representation of bifurcation and sediment size in Eagle Creeks lower drawdown zone where the stream channel is prone to lateral migration (photo by Evan Smith, Okanagan Nation Alliance, 2016).

MZ 2 is the upper drawdown zone which is also prone to lateral stream migration and has been identified as a deposition zone for larger material (Davies 2016). Access for Kokanee is limited by shallow water, minimal cover, and barriers cause by material deposition (Fig. 6). The substrate in this zone is larger than MZ1 and will also support habitat structures which will confine the stream to a more natural width to depth ratio, to promote scouring which will deepen the channel and reduce deposited material in the stream. The substrate in this zone is similar to Deer Creek, where habitat structures have already been created (Smith and Zimmer 2016), and have been determined to be sufficient to support habitat structures.

Figure 6. Deposited material in MZ 2 which impedes Kokanee access to the upper reaches of the stream (photo by Evan Smith, Okanagan Nation Alliance, August 2016).

MZ 3 is the laterally unstable section. The stream in this zone is bifurcated and appears to shift from side to side increasing the wetted width over time (Davies 2016). There is a large amount of material in this zone as seen in the satellite image of Fig 4. It was originally thought material was being transported from upstream and deposited in this zone due to its lower gradient, which would have put downstream habitat structures at-risk of being buried. However, inspection of the zone indicated the material is a result of lateral erosion and is stabilizing (i.e. not moving downstream at an elevated rate). The bank material is made up of fluvial deposits (indicated by rounded rocks) which are less stable than glacial deposits (angular rocks and till) making them more susceptible to erosion (Fig. 7). When the bank is eroded, the rounded substrate falls into the stream but is not readily transported downstream due to its size. Therefore downstream structures are at minimal risk of being buried by upstream materials, which was previously thought (notwithstanding a catastrophic flow event). Approximately 40 - 60 Kokanee were observed in this zone during the field visit.

Figure 7. (A) Example of bed material found throughout MZ 3. (B) The river right bank of Eagle Creek reveals the bank material as fluvial deposits (rounded rock eroded by fluvial processes in the bank soil), a characteristic of stream banks in MZ 3 (Photos by Evan Smith, Okanagan Nation Alliance, August 2016).

MZ 4 is the Narrow stable section upstream of MZ3. Its higher gradient may explain why it is more stable than MZ 3 as bank materials are similar in both zones (Fig. 8). Approximately 5 – 10 Kokanee were observed in this zone during the field visit and may have been in the process of spawning.

Figure 8. MZ 4 at low flow (photo by Evan Smith, Okanagan Nation Alliance, August 2016).

MZ 5 is a log jam located approximately 2.1 km upstream of Arrow Lakes Reservoir (560 m downstream of the Worthington Road Bridge, Fig. 9). By retarding flows at freshet, this log jam may be the cause of lateral erosion in MZ 3. This log jam is thought to be the result of landslides/debris torrents farther up the watershed (as seen on satellite imagery). Over the years it continues to collect debris growing in size and continuing to impede flows and sediment migration. This log jam also has the potential to be fish barrier as no fish were observed upstream.

Figure 9. Two meter high, channel spanning log jam (MZ 5) located approximately 2.1 km upstream of the Arrow Lakes Reservoir with Lorne Davies (Geostream Environmental Consulting) and Kevin Schiller (Misty Ridge Contracting) standing on top for scale (photo by Evan Smith, Okanagan Nation Alliance, August 2016).

Located between the log jam and Worthington Bridge is MZ 6, an aggraded section of Eagle Creek. Here an estimated 10,000– 20,000 m^3 of sediment has been deposited causing the stream bed to be higher than the stream bank (Davies 2016; Fig. 10A). A quick analysis was done on the previously mentioned landslides higher in the watershed and it was found this substrate could be a result of those landslides (Davies, pers. comm.). The log jam prevents substrate from moving farther downstream, resulting in continued deposition of material every year, causing elevation of the streambed. Old channels, large cut banks, and other erosion was observed in MZ 6 and can also be attributed to the log jam holding back sediment during freshet transport, causing deposition and lateral erosion (Fig. 10B). The height differential between upstream and downstream channel bed was 2 m, likely the reason no Kokanee were observed in MZ 6 in 2016. No upstream Kokanee observations were also confirmed by others (FLNRO pers comm 2016).

Figure 10. (A) An example of heavy aggradation found throughout MZ 6 thought to be a result of a downstream log jam. (B) Eroded banks found in MZ 6 thought to be caused by lateral erosion resulting from stream retardation from the downstream log jam (photo by Evan Smith, Okanagan Nation Alliance, August 2016).

A summary table has been included in Appendix B describing each MZ's specific issue and any recommended treatments. Many issues with Eagle Creek have been identified through this feasibility assessment; we see indications that upstream risk does not preclude an effort to improve Kokanee access treatments, such as adding habitat structures in the drawdown zone. The sediment transport complexity of Eagle Creek presents its challenges, but also provides a unique opportunity for creative stream habitat improvements in support of Kokanee access.

We recommend installing habitat structures in MZ 2 within the Eagle Creek drawdown zone using natural channel design principals to mimic analogous wetted and bank-full width conditions as assessed in MZ 4. Sinuosity should attempt to replicate upstream reaches with consideration to parent creek-bed material and channel slope by using the radius of the curvature of the channel and dominant channel characteristics in the drawdown zone. The stream itself should be designed to mimic a riffle-pool system in order to provide habitat associated with resident Kokanee spawning and rearing requirements (Hogan and Ward 1997). Structures consisting of boulders and large-woody debris anchored by large rock can be used to define a bank-full channel and structure for escape cover; which is otherwise absent in the drawdown zone. These methods were used with early indications of success in the Deer Creek drawdown zone (Smith and Zimmer, 2016). Once treatment in MZ 2 is complete, MZ 1 should be monitored for any resulting hydrological changes. If Kokanee access remains impeded in MZ 1 then treatment should continue into this zone.

A phased approach should be considered when removing the log jam (MZ 5). In conjunction with treatment in MZ 2, sections of the log jam should be removed annually to gradually improve downstream sediment migration and reduce upstream aggradation while minimizing risk for further detrimental debris accumulation and resultant erosion and avulsion risk.

Three locations were identified as possible heavy machine access points (Schiller, pers. comm.). However, due to concerns of damage to white-tail deer habitat and possible increased hunter access into the area, only two locations are being considered (Fig. 11; Schiller, pers. comm.). These locations provide access to recommended treatment sites with minimal tree removal. Since the channel is over widened in MZ 3 and MZ 6 there is plenty of area for a machine to travel down without disturbing vegetation and minimal instream disturbance. An excavator size 325 or 330 is recommended for the work considering size of material, reach requirements, and cost effectiveness (Schiller, pers. comm.). A danger tree assessment may also be required while working in MZ 3, 5, and 6 with heavy machinery (Schiller, pers. comm.). Local BC Parks staff are supportive of the works (Mike Flintoff pers comm.), and regional staff have has also been briefed on the potential and interest in fish habitat improvements in the Eagle Creek drawdown zone (Chris Price, pers comm.)

Figure 11. (Stars) Access points for heavy machinery off of Worthington Road (top left) and Boat Launch Road (bottom right). (Red Line) Old access road with little vegetation suitable for excavator use that provides access to MZ 2 and 3 without entering the stream bed (created by Evan Smith using map data 2016, Google).

Lorne Haggert, A resident of Edgewood, indicated there was a side channel man-made dam used as a deflection device approximately 200 – 300 meters upstream of the Worthington Road Bridge (Schiller pers. com.). He mentioned this structure is in need of rip-rap repair and maintenance, which could be completed in conjunction with other future projects on Eagle Creek.

Recommendations

It is important to adopt a watershed based view when dealing with a system as dynamic as Eagle Creek. The following recommendations were based on Davies (2016; Appendix C) and the ONA, to mitigate risk to future habitat structures in the drawdown zone and to further increase our understanding of processes in Eagle Creek:

- Conduct a complete literature review including a more in-depth investigation of historic conditions using historic aerial photographs, forestry records, and information from BC Hydro and the Regional District.

- Implement a sediment monitoring program to better understand:
    a. Sediment deposition rates and patterns in the drawdown zone.
    b. Rates of lateral erosion/avulsion in the drawdown zone.
    c. Sizes and volume of sediment being moved downstream in the lower sections of Eagle Creek (particularly with respect to the log jam deposit).

- Investigate existing landslides and stream channels and calculate the amount of potential material that is or could be moved downstream

- Construct habitat structures in the drawdown zone in conjunction with sediment monitoring to improve Kokanee access to the upstream reaches.

- Engage local stewardship groups throughout any planned habitat improvement projects

- Visit and evaluate the extent of maintenance/repair required on the man-made deflection structure located 200 – 300 m above the Worthington Road Bridge mentioned by Lorne Haggert, and carry out repairs in conjunction with MZ 6 activities if possible.

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APPENDIX A: EAGLE CREEK BACKGROUND INFORMATION

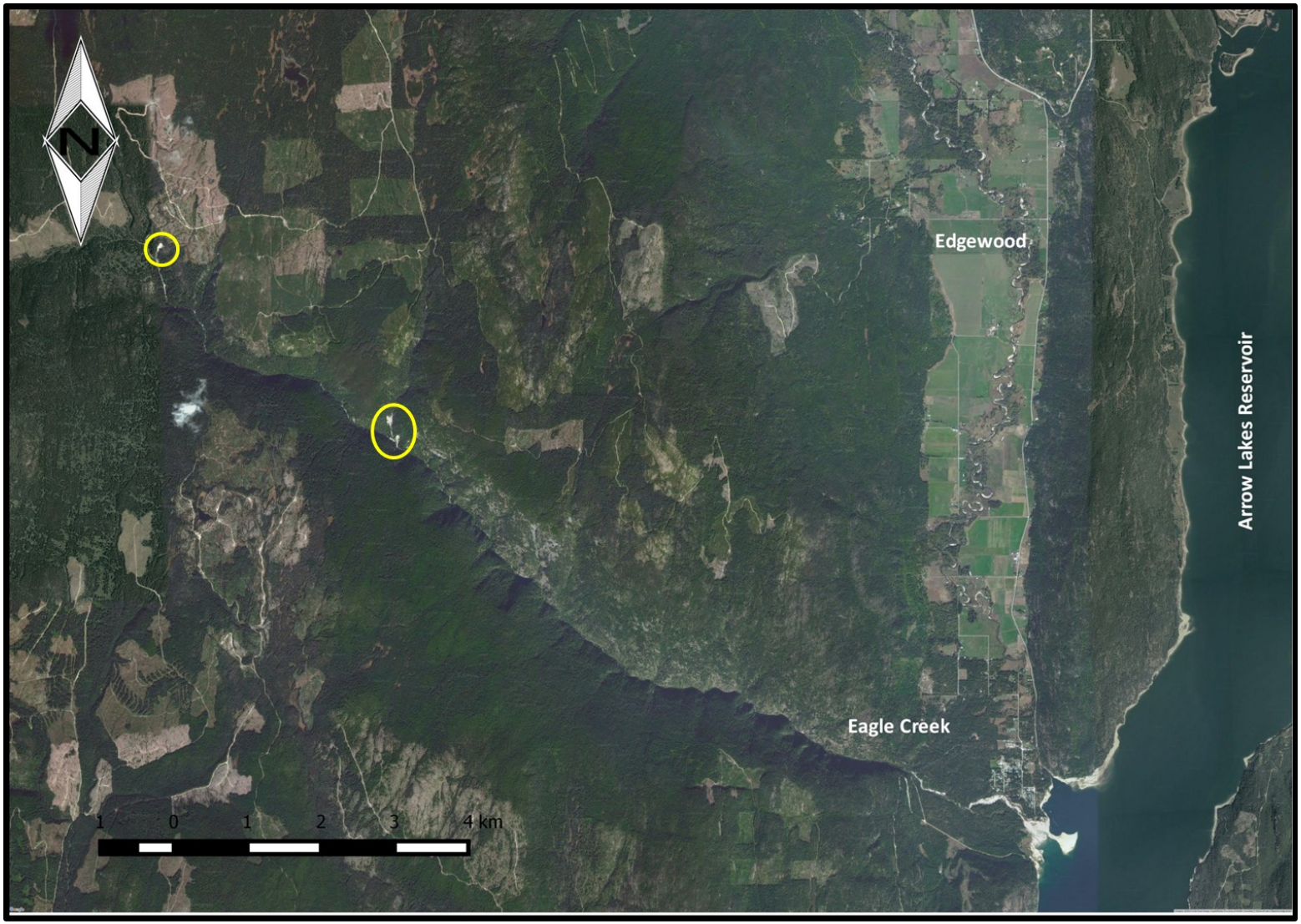

Figure 12. Overview of Eagle Creek watershed. (Yellow) Landslides that have occurred on Eagle Creek, the cause and date of which is undetermined (created by Evan Smith using map data 2017, Google).

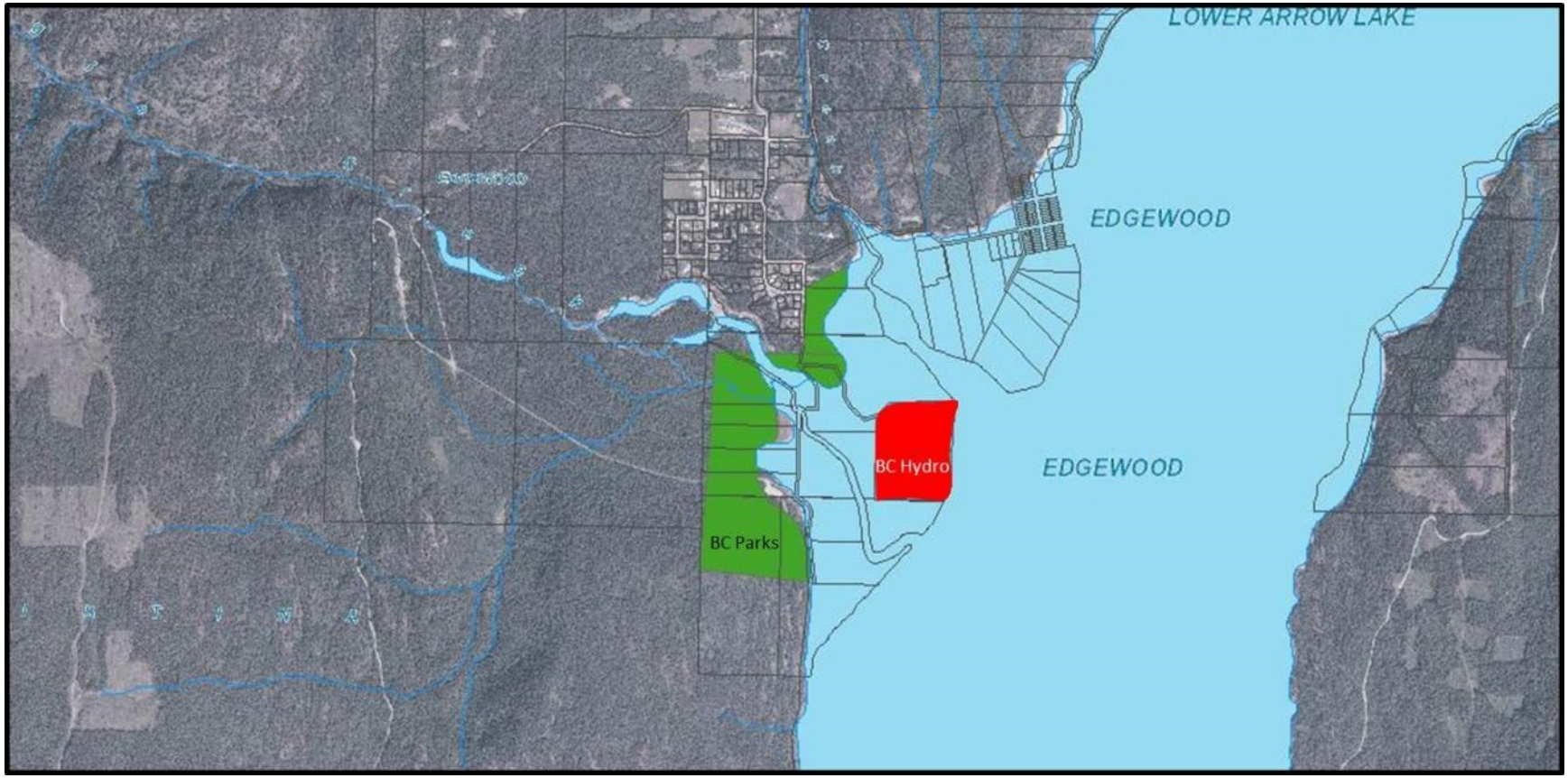

Figure 13. Property ownership map in the drawdown zone of Eagle Creek. (Green) BC Parks land. (Red) BC Hydro Land. (Clear) Crown Land (created by Evan Smith using map data 2017, Regional District of the Central Kootenays).

APPENDIX B: SUMMARY OF EACH MANAGEMENT ZONES ISSUES AND SOLUTIONS TO MITIGATE RISK TO POSSIBLE DOWNSTREAM STRUCTURES

Table 1. A Summary of issues within each Management Zone (MZ), their designated risk to potential downstream habitat structures, and associated solutions to mitigate the risks based a site visit on August 26th 2016.

Zone	Description	Problem	Risk to Structures	Solution
MZ1	Lower drawdown zone	• Over widened, Laterally diffused, Kokanee access issues due to shallow water depth and stream bifurcation	Low	• Stabilize lateral movement using habitat structures • Increase depth by defining single, low-flow channel using habitat structures • Monitor effectiveness
MZ2	Upper drawdown zone	• Over widened, Laterally diffuse • Obstructions to Kokanee Access due to sediment deposition and over-widened channel	Low	• Stabilize lateral movement using habitat structures • increase depth by defining single, low-flow channel using habitat structures • Monitor effectiveness
MZ3	Cobble-Boulder dominated, over widened	• Over widened and aggraded section • Erosion of stream banks	Medium	• Monitor
MZ4	Narrow stable section	None Apparent	Low	• Monitor when conducting upstream work
MZ5	Log Jam	• Interrupts stream flow which causes aggradation in MZ6 • High risk of channel avulsion above logjam in MZ 6	Medium	Gradually remove log jam which will: • Reduce aggradation in MZ 6 decreasing the amount of debris deposited. • promotes natural channel definition upstream and downstream
MZ6	Aggraded section	• Deposition of material caused by the log jam resulting in lateral flow and bank erosion • Imminent avulsion risk	Medium	• Remove log jam to reduce aggradation in this zone to promote degradation and channelization • Monitor

APPENDIX C: Technical Memo By Lorne Davies P.Geo., Geostream Environmental Consulting

Geostream Environmental Consulting
101-1865 Dilworth Drive, Suite #614
Kelowna, BC V1Y 9T1

Okanagan Nation Alliance
Castlegar, BC

Attention: Evan Smith;

Re: Summary Report - Eagle River Field Trip – August 26, 2016

A reconnaissance field trip on the lower 2 kms of Eagle Creek (near Edgewood, BC) took place August 26, 2016 with Michael Zimmer R.P. Bio. (Okanagan Nation Alliance), Evan Smith (Okanagan Nation Alliance), Lorne Davies, P.Geo. (Geostream Environmental Consulting) and Kevin Schiller (Misty Ridges Contracting Ltd.). Members of the Edgewood Rod and Gun Club were present for part of the morning.

The main observations of the field trip were:

a. 500 m aggraded section below bridge downstream to debris jam
    i. Abandoned stream channel on north side of creek (review of historic aerial photographs will help better understand when channel shifted course, could have occurred in conjunction with landslide (sediment wedge behind debris jam).
    ii. Sediment wedge higher than stream banks.
    iii. Rough estimate of sediment volume 10-20,000 m^3.
    iv. Large eroding cutbank in this section of creek as well.
b. Narrower 350 m section below debris jam.
c. 900 m laterally unstable section down to mouth of creek
    i. Section of north side of creek has been riprapped (don't know when)
    ii. South streambank has a lack of fines; sediment sizes same as those within the stream channel (same as natural north side stream bank.)
    iii. Appears creek has shifted from side to side, widening the wetted width.
    iv. Sediment was up to 60 cm (b-axis). There were some larger lag boulders (1.1 m).
    v. The creek has also bifurcated – water flowing along both banks.
    vi. Abandoned stream channels were present to the south (I did not see them)
d. Upper draw down zone – single channel
    i. The draw down zone is like an alluvial fan, subject to the stream channel moving from one side to another.
    ii. This is a depositional zone. It appears larger material is deposited in the upper section of the drawdown zone.
e. Lower draw down zone – braided channel
    i. This section is more laterally unstable as indicated by the finer textured material.

Office review:

1. A watershed assessment was completed in 1998 – logging was high in one sub-basin. Five landslides were identified.
2. Google earth shows that there has been more logging in the watershed.
    a. There has also been additional landslides that may be associated with logging and the debris jam observed below the bridge.
3. Historical photos (1970) from the Arrow Lakes Historical Society shows the lower section of Eagle Creek was cleared of vegetation (and appears to have been re-contoured). The full extent of the work is unknown.
4. There is a berm upstream of the bridge to prevent flooding of Edgewood.
5. BC Hydro reports.

Recommendations

1. Collate and summarize existing information (historical aerial photographs, forestry, BC Hydro, Regional District).
2. Assess upstream landslides and stream channels (watershed conditions). How much sediment is being moved downstream or could be coming downstream.
3. Determine the relationship between width, depth, slope, velocity, grain-size for the lower sections of Eagle Creek (and drawdown zone).
4. Implement a sediment monitoring program to better understand:
    a. Sediment deposition rates and patterns in the drawdown zone.
    b. Rates of lateral erosion/avulsion in the drawdown zone.
    c. Rates of stream bank erosion in the lower sections of Eagle Creek.
    d. Sizes and volume of sediment being moved downstream in the lower sections of Eagle Creek (particularly with respect to the debris jam deposit).
5. Implement stream enhancement works to help accelerate the natural stabilization processes that are taking place (with respect to the disturbances associated with human activities).

This summarization is based on the limited assessment of the office material and field investigations. New conclusions maybe result as more information is collected and knowledge gained.

Thank you.

Lorne

Lorne Davies, P.Geo.