BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

LAKE KOOCANUSA

HIGH LEVEL ASSESSMENT OF A PROPOSED DAM

FINAL DRAFT

PROJECT NO.: 0466001 DATE: November 19, 2020

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November 19, 2020
Project No.: 0466001

Kathy Eichenberger, Executive Director
Ministry of Energy, Mines and Petroleum Resources
PO Box 9314, Stn Prov Govt
Victoria, BC V8W 9N1

Dear Kathy,

Re: Lake Koocanusa, High Level Assessment of a Proposed Dam – FINAL DRAFT

BGC is pleased to provide the Ministry of Mines, Energy and Petroleum Resources with the following FINAL DRAFT report. The report details an assessment of a proposed dam on Lake Koocanusa, in southeastern British Columbia. If you have any questions or comments, please contact the undersigned at 604-629-3850.

Yours sincerely,

BGC ENGINEERING INC.
per:

Hamish Weatherly, M.Sc., P.Geo.
Principal Hydrologist

EXECUTIVE SUMMARY

The Libby Dam is a 129 m high concrete gravity dam located on the Kootenay River near Libby, Montana. The dam was completed in 1973 and was first filled in 1974, inundating the Kootenay River valley to form the 145 km long Koocanusa Reservoir (Lake Koocanusa). Canadian residents and water users are affected by changes in the Libby Dam operations that affect reservoir water levels, as nearly half (70 km) of the reservoir extends into southeastern British Columbia. Downstream residents in BC are also impacted by changes in outflow magnitude or timing from Libby Dam, as the Kootenay River flows north from Libby Dam back into Canada near Creston, BC and the south end of Kootenay Lake.

The Libby Dam was initially operated to optimize flood control and hydropower generation, but changes in the schedule of releases were implemented to benefit downstream fisheries in 1993, and to a greater extent in 2002 to meet new legal requirements under the US Endangered Species Act, resulting in less water released in the winter and higher spring and summer outflows. The three main operational regimes are:

- 1973 to 1992 (Early FC): Standard Flood Control regime with operation of the dam driven almost exclusively by flood control and power generation.
- 1993 to 2002 (Standard FC): Standard Flood Control regime continues, and flood control remains a top priority. However, maintaining in-stream flow needs for downstream fisheries has a higher priority than power operations. During this period, discharge ramping rate[1] restrictions were also adopted in the late 1990's.
- 2003 to Present (VARQ FC): Variable Flood Control regime is adopted. With this regime there are higher flood control curves for most water conditions, although flood control remains a top priority. Operations for downstream fisheries continues to have higher priority than operations for power.

Unlike the three other BC dams built under the Columbia River Treaty (CRT) – the Mica Dam, Hugh Keenleyside Dam, and Duncan Dam – the CRT does not require that operation of the Libby Dam be coordinated jointly by the US and BC. The Libby Coordination Agreement, ratified in 2000 and valid until 2024, stipulates that the US Army Corps of Engineers can operate Libby Dam consistent with US fisheries objectives and that the Canadian Entity (BC Hydro) may compensate itself for losses from the VARQ operations using storage draft in Arrow Reservoir and through exchanges with the Bonnieville Power Administration.

Canadian residents and water users have expressed concern regarding the impact of operational changes on late spring and summer water levels in Lake Koocanusa. Therefore, they have proposed construction of a dam across Lake Koocanusa in BC, directly upstream of the US

[1] Discharge ramping is defined as the alteration of discharge in a stream channel resulting from the operation of a hydroelectric facility. Under Early FC, flow releases from Libby Dam were ramped up and down very rapidly, a practice that was detrimental to fish species and that had a negative impact on bank erosion.

border, to maintain the reservoir level at or above an elevation of 2440' (743.7 m) ideally from May through September. BGC Engineering Inc. (BGC) was retained by the Ministry of Energy, Mines, and Petroleum Resources (MEMPR) to evaluate the impacts of the VARQ FC operations on reservoir level, assess the impacts of the proposed dam, and provide a high-level cost estimate. The impacts of the proposed dam were evaluated for two scenarios: maintaining the reservoir at or above El. 2440' either: (A) throughout the year and (B) only during the prime recreation season of late May through September.

BGC used hydrologic and snowpack data from Canadian and US agencies to evaluate the effects of the operational changes over time on water levels in Lake Koocanusa during the recreation season. Reservoir levels are lowest in the winter and spring and peak in July or August for all operational regimes. The largest differences between the operational regimes occur in the spring when the reservoir level is low prior to the onset of the freshet, though small differences also exist in the summer months (July-September). Compared to Standard FC (1993-2002) the average reservoir level under the current operational regime (VARQ FC) is:

- 26 feet (8 m) higher in May
- 10 feet (3.2 m) higher in June
- 3.5 feet (1.1 m) higher in July
- 2.8 feet (0.85 m) lower in August
- 4.8 feet (1.5 m) lower in September.

Years with low reservoir levels have occurred during all operational regimes and typically coincide with anomalously low snowpack in the region. The snowpack in 2019 was the lowest recorded since the initiation of VARQ FC in 2002, and the resulting reservoir level in July and August was the sixth lowest since infilling of the reservoir in 1974.

Hydrologic studies that account for regional climate change project that high elevation regions throughout southeastern British Columbia, including the headwaters of the main tributaries to Lake Koocanusa, will experience increases in snowpack. The timing and seasonality of flows are also anticipated to change within the region, with increased winter and spring discharge due to earlier snowmelt and more frequent rain-on-snow events (Schnorbus, Werner, & Bennett, 2014; Farjad, Gupta, & Marceau, 2016). Projections from the Pacific Climate Impacts Consortium (PCIC) show that inflows to Lake Koocanusa from its three largest tributaries are projected to increase by 5.5% during the freshet (i.e., the peak snowmelt period) from April 1-July 31 between the years 2050 and 2095. However as anticipated the timing of the peak flows is projected to shift earlier, with the greatest increases in flow occurring in April and May. Flows are projected to decrease in June through October.

Based on reservoir levels during VARQ operations since 2003 ,the proposed dam would increase the reservoir level an average of 45% of the days during the main recreational season from mid-May to the end of September. Table E-1 summarizes the number of days that reservoir levels were elevation 2440' from mid-May to end of September. Results are shown for an average year, a wet year and dry year. The associated rise in reservoir level that would be attained with the proposed dam is also summarized in Table E-1. The largest gain in reservoir levels would occur for mid-May to end of June.

Table E-1. Summary of how the proposed dam would have impacted reservoir levels during past VARQ operations (2002-2019).

Time Period	Average Year		Wet Year		Dry Year	
	# days below 2440’	WL Below 2440’ (ft)	# days below 2440’	WL Below 2440’ (ft)	# days below 2440’	WL Below 2440’ (ft)
May 15-31	16	24	17	28	17	25
June 1-14	12	14	14	9.9	14	18
June 15-30	8.5	8	0	0	16	15
July 1-14	3	5.8	0	0	14	7.2
July 15-31	2	0.8	0	0	12	1.2
August 1-14	0	0	0	0	0	0
August 15-31	0.5	0.1	0	0	0	0
Sept 1-14	2.5	2.2	0	0	0	0
Sept 15-30	4	3.8	0	0	0	0

There are a number of boat launches and docks around the reservoir, which are useable at different levels. Table E-1 shows that improved access to these recreation facilities would be most improved at the start of the recreation season, from mid-May to end of June. The impact would be less pronounced the remainder of the recreation season, with the exception of dry years.

Within Canada, Kokanee account for 98% of the recreational harvest of Lake Koocanusa. In most years, the reservoir is not fully fishable until about El. 2435' (742.2 m) because of high sediment concentrations from the slowly submerging mudflats. This elevation is typically reached in mid-June. Kokanee move out of the reservoir in early September, resulting in a 2-month season that can support up to 25,000 angler-days/year. Fishing opportunities in Canada would be improved on average by 1-month with the proposed dam.

Overall, the data indicates that maintaining a reservoir level of 2440’ year-round or during the prime recreation season only would improve the viability of recreation on the Canadian portion of the reservoir, resulting in improved recreation for local residents, as well as increased tourism and other economic benefits for the area. Reservoir shoreline aesthetics are also generally more pleasing at higher, and more stable reservoir levels for watercraft within Canada may also be improved due to the higher reservoir levels. However, the opposite would be true on the US side of the reservoir.

The proposed dam is anticipated to negatively affect navigation, hydroelectric power generation, and flood management, if the reservoir level was maintained at a minimum elevation of 2440’ year-round. These negative impacts largely disappear if the high reservoir level is only maintained during the prime recreation season of late May through September.

Estimated costs for the proposed dam were assessed with empirical formula and have a wide range with a minimum estimate of $80 million to a maximum of $1.1 billion. The lower end of the range is likely conservatively low in this particular case. Project specific aspects that would likely increase cost that may not be included in the empirical formula include:

- Navigation lock
- Fish passage (which is much harder to provide with such widely fluctuating water levels, especially if the upstream level is going to fluctuate)
- Site geology constraints
- Construction accessibility
- CRT, BC Utilities Commission (BCUC), public, and First Nations consultation.

As such, the cost of dam construction is likely in excess of $400 million. In addition, annual operation and maintenance (O&M) costs for the dam are expected to vary varied from 0.14% to 0.35% of the final dam cost. Assuming a construction cost estimate of $400 million, annual O&M costs could then vary between $560,000 and $1,400,000.

A dam at El. 2440’ would be regularly submerged during the summer and fall months (on average between 5 to 6 months of the year). A standard earthfill dam could not be built to withstand near annual submergence without significant reinforcement, which would incur additional costs. The alternative is that the dam would need to be built to the same crest elevation as Libby Dam. A unique engineering solution would also be required for the dam spillway due to the backwater effects from Libby Dam (i.e., flows would need to be able to be conveyed both from upstream to downstream of the dam and from downstream to upstream).

If a decision is made to continue investigating the possibility of a dam, then preliminary design work on the dam would be needed to obtain a more accurate construction cost estimate. As part of this process, a number of key questions will need to be answered, as these could affect the business case for the project. For example:

- What are the Canadian legal and regulatory hurdles for this project?
- Which Canadian agency would be the “owner” of the dam? And who would pay for it?
- Would the US agree to such a Canadian dam proposal?
- How would the US Libby operating regime be adjusted in reaction to Canada’s operation of a dam at the Canada-US border?

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LIMITATIONS

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1.0 INTRODUCTION

1.1. Background

The Columbia River Treaty (CRT) is an agreement between the United States and Canada to develop and operate dams and reservoirs to provide regulated flows on the Columbia and Kootenay rivers to optimize flood control and power generation in both countries. BC Hydro was appointed as the Canadian entity under the CRT and the US entity is Bonneville Power Administration (BPA) and the US Army Corps of Engineers (USACE). Under the terms of the CRT, BC Hydro built and now operates the Mica, Hugh Keenleyside and Duncan Dam projects. The Treaty also permitted the US to construct Libby Dam and the associated Koocanusa Reservoir, which extends approximately 70 km into BC. In return for the dams constructed in Canada, Canada received an up-front payment for the flood control benefits up to 2024 as well as one-half of the annual additional power generation benefits the US could realize at the downstream US projects on an on-going basis (BC Hydro, 2013). These proceeds are received by the Province of BC.

Libby Dam is a concrete gravity dam located on the Kootenay River[2] approximately 66 km from the Canadian border, in Montana, US The 129 m high dam was completed in 1973 and was first filled in 1974, inundating the Kootenay River to form the 145 km long Koocanusa Reservoir (Lake Koocanusa). Canada's CRT-specified benefits from Libby Dam include downstream power generation and flood risk management on the Lower Kootenay River, Kootenay Lake, and the Columbia River. There are also recreation benefits (and costs) related to the Koocanusa Reservoir on both sides of the border – these are retained by the country in which they occur, and are neither specified in, nor controlled by, the CRT. The CRT does not require that operation of the Libby Dam be coordinated jointly by the US and BC; however, it does require for coordination of the three BC dams (Mica, Hugh Keenleyside and Duncan) between the CRT Entities.

Until 1992, the USACE operated Libby Dam in a manner that was optimal for power generation and flood control in both countries. In 1993, the USACE, responding to US fisheries regulatory agency concerns about white sturgeon, bull trout, and downstream salmon, began to operate Libby in a manner designed to benefit downstream salmon passage and sturgeon spawning, with less water released from Libby during the fall and winter and more water released during the spring and summer. This operation resulted in power losses, including additional spill and reduced seasonal value, at downstream Canadian hydropower plants on the Kootenay River system (Penfold, 2012). Canada objected to this unilateral operating change, but the dispute was set aside with the signing of the Libby Coordination Agreement (LCA).

In return for Libby Dam operations that meet US regulatory requirements for fish, the LCA gives Canada the flexibility to self-compensate for its Kootenay River power value losses. Canada has

[2] The Kootenay River is referred to as the Kootenai River in the US For consistency the Canadian spelling is used throughout the present assessment.

the option to release water from the Arrow Lakes Reservoir and receive the resulting incremental power generated at US federal plants during periods of high power value. Canada returns the power to the US during times of lower power value, with the value difference being the net compensation to Canada. Canada also obtained some non-power benefits, including more favourable Treaty requirements on Arrow discharges during January, which benefits mountain whitefish spawning, and an option to exercise an Arrow-Libby "storage swap" agreement when beneficial to Canada. This "storage swap" agreement has been used in several years to improve recreational conditions on Koocanusa Reservoir (Penfold, 2012). The 'Coordination Agreement' does not bring the operations decisions for Libby Dam under the coordination process between the Entities for the three Treaty dams in BC.

In response to a 2000 court ordered biological opinion under the Endangered Species Act, the USACE temporarily (and unilaterally) changed the operation of the Libby Dam in 2002 to a variable flow regime; under the new operating regime less water was released in the fall and winter, and more water was released in the spring and summer, to benefit spawning sturgeon in the Kootenai River downstream of the dam. The change was permanently adopted in June 2008 by the USACE without input from BC Hydro, the Canadian CRT entity.

BC Hydro, while concerned about the downstream fisheries, objected to the unilateral US change in the Libby operating regime on the grounds that the CRT was signed, and Canadian land flooded, in return for a coordinated operation of Libby. Regardless, the operation of Libby Dam and Koocanusa Reservoir continues to provide Canada with important downstream power and flood risk management benefits. The USACE also continues to coordinate very closely with Canada on flood risk management issues.

1.2. CRT Review Process

As part of the CRT 2014 Review Process initiated by the BC government in 2011 there have been ongoing discussions with Columbia/Kootenay basin stakeholders regarding potential changes to the Libby Dam operating regime, as well as proposed capital works that could be constructed to mitigate the negative aspects of current operations. The Ministry of Energy, Mines, and Petroleum Resources (MEMPR) is the lead agency for this review. Residents and reservoir users have expressed concern regarding the impact of operation changes on late spring and summer water levels in Lake Koocanusa, which limits recreation access for boating use in some years. One idea that has been proposed by a group of reservoir users and stakeholders is the construction of a weir[3] across Lake Koocanusa in BC, directly upstream of the US border, to maintain the reservoir level at or above an elevation of 2440' (743.7 m), especially during the prime late spring and summer recreation season.

[3] Full pool in Lake Koocanusa is 2459' (749.5 m).

A dam[4] on the Canadian side of the border could not be built under the current provisions of the CRT, and would need the cooperation of the US MEMPR has therefore retained BGC Engineering Inc. (BGC) provide a high-level assessment of the potential impacts of the proposed dam and what potential issues/questions would need to be addressed to determine whether the proposed dam is a viable option.

As per a BGC proposal dated January 13, 2020, the scope of work for the assessment includes:

- A discussion of Variable Flood Control (VARQ FC) relative to Standard Flood Control (Standard FC) and how differences between the two operating procedures has impacted water levels on Koocanusa Reservoir.
- A high-level discussion of the potential impacts of the proposed dam on:
  - Recreation
  - Navigation
  - Hydroelectric power
  - Flood risk management
  - Ecosystems
- A high-level cost estimate for the proposed dam, including geotechnical considerations.
- A discussion of the potential issues and questions that would need to be addressed to determine whether the proposed dam is a viable option.
- Presentation of the study results at a roundtable meeting in Cranbrook.
- Addressing comments received by stakeholders and preparation of a final report.

The scope of work was completed under the General Service Agreement between BGC and the Province of British Columbia (Ministry Contract No. GS20MAN0077) dated January 2, 2020.

[4] Although stakeholders refer to the proposed structure as a weir, it is more appropriately referred to as a dam. The BC Dam Safety Regulation defines a dam as: a) greater than 1 m in height with an impoundment volume in excess of 1 million m^3; b) >2.5 m high with an impoundment volume in excess of 30,000 m^3; or c) >7.5 m high.

2.0 STUDY AREA

2.1. Overview

Lake Koocanusa is a 145 km long reservoir that formed through inundation of the Kootenay River in 1974 following completion of the Libby Dam. Although the dam is located in the US near the town of Libby, Montana, nearly half of the lake (70 km) extends north into British Columbia (Drawing 01). The lake name is an acronym derived from the Kootenay River, Canada and the USA (koo-can-usa).

Lake Koocanusa has a total watershed area of 23,270 km^2 at Libby Dam and a watershed area of 20,000 km^2 (85% of the total area) at the Canadian border. Thus, a large proportion of the inflows to Lake Koocanusa originate in Canada (Drawing 01). Three main tributaries – the Elk River, Kootenay River, and Bull River – supply 87% of the inflow to Lake Koocanusa within Canada (Chisolm et al., 1989). Peak flows in unregulated tributaries typically peak in May and June from snowmelt and rain-on-snow.

The Libby Dam powerhouse contains five turbines and is capable of generating 604 megawatts. Power generation and sale is managed by the Bonneville Power Administration. No direct compensation was given to Canada for the land flooded by Lake Koocanusa, but Canada gains power generation benefits on the lower Kootenay River in BC from the regulated discharges at the Libby power generating facilities. Libby Dam also provides flood control benefits for Canada at Kootenay Lake and on the lower Kootenay and Columbia Rivers.

Koocanusa Reservoir was authorized directly under the CRT and as a result, there is no provincial water license for the reservoir. BC Hydro, as the Canadian CRT entity, has informally taken on some of the ownership duties for the reservoir that are normally taken on by the water license holder. These duties include:

- a debris-clearing operation
- hosting annual spring Operations Update meetings at communities near the reservoir (Baynes Lake, Jaffray, Wardner).
- a weekly e-mail distribution of Lower Columbia Reservoir Update that includes a link to the USACE Koocanusa reservoir levels and forecasts (nws.usace.army.mil) and a phone number for information.

Unlike other BC reservoirs that have a provincial water license, Koocanusa Reservoir has not gone through a public Water Use Plan (WUP) process. While the BC government, BC Hydro, CBT, and other regional partners have provided many of the non-power benefits associated with a WUP process, some stakeholders believe that a Koocanusa WUP (or a Kootenay WUP for the whole system, as was done in the Columbia WUP) should be undertaken, since a WUP process would encourage public discussion around potential tradeoffs and may provide additional funding for mitigation and monitoring. However, without a BC water license, there is no legal basis for a WUP Order to be issued, and no Canadian agency has direct control of the USACE, owner/operator of Libby Dam.

2.2. First Nations

The Koocanusa area is within the Ktunaxa Nation traditional territory. For more than 10,000 years Ktunaxa people have lived in the area and used it for hunting and cultural purposes. The Tobacco Plains area served as one of the Ktunaxa's oldest wintering grounds for families and tribes that moved freely between northern Montana and the present sites of Invermere and Fernie (RDEK, April 5, 2013). Members of the Ktunaxa Nation, who cultivated varieties of wild tobacco in the area, traveled outside the area for events such as spring and fall buffalo hunts in the foothills in present day Alberta. The Ktunaxa Nation is composed of four communities: ʔakisq̓nuk First Nation, ʔakink̓umǂasnuqǂiʔit (Tobacco Plains Indian Band), ʔaq̓am (St. Mary's), and yaqan nuykiy (Lower Kootenay Band). The Ktunaxa Nation is progressing through the BC Treaty Commission process as well as participating in the CRT negotiation process, including as official observers.

In the late 1800s forestry, mining and ranching attracted European settlers to the area. This settlement in the late 1800s led to the establishment of the current Indian Reserves.

2.3. Physiography

Morphometric data for Lake Koocanusa are presented in Table 2-1. A volume-elevation curve is shown in Figure 2-1 based on USACE data (1977-2020) available for Libby Dam.

Table 2-1. Morphometric data for Lake Koocanusa (after Hensler, Dunnigan, and Benson, 2006).

Element	Units	
	metric	US Standard
Surface Elevation		
maximum pool	749.5 m	2459'
minimum operational pool	697.1 m	2287'
minimum pool (dead storage)	671.2 m	2222'
Area		
maximum pool	188.0 km^2	46,500 acres
minimum operational pool	58.6 km^2	14,487 acres
Volume		
maximum pool	7.24 km^3	5.87 million acre-ft
minimum operational pool	1.10 km^3	0.89 million acre-ft
Maximum length	145 km	90 mi
Maximum depth	107 m	350 ft
Mean depth	38 m	126 ft
Shoreline length	360 km	224 mi
Drainage area	23,270 km^2	8,985 sq.mi.

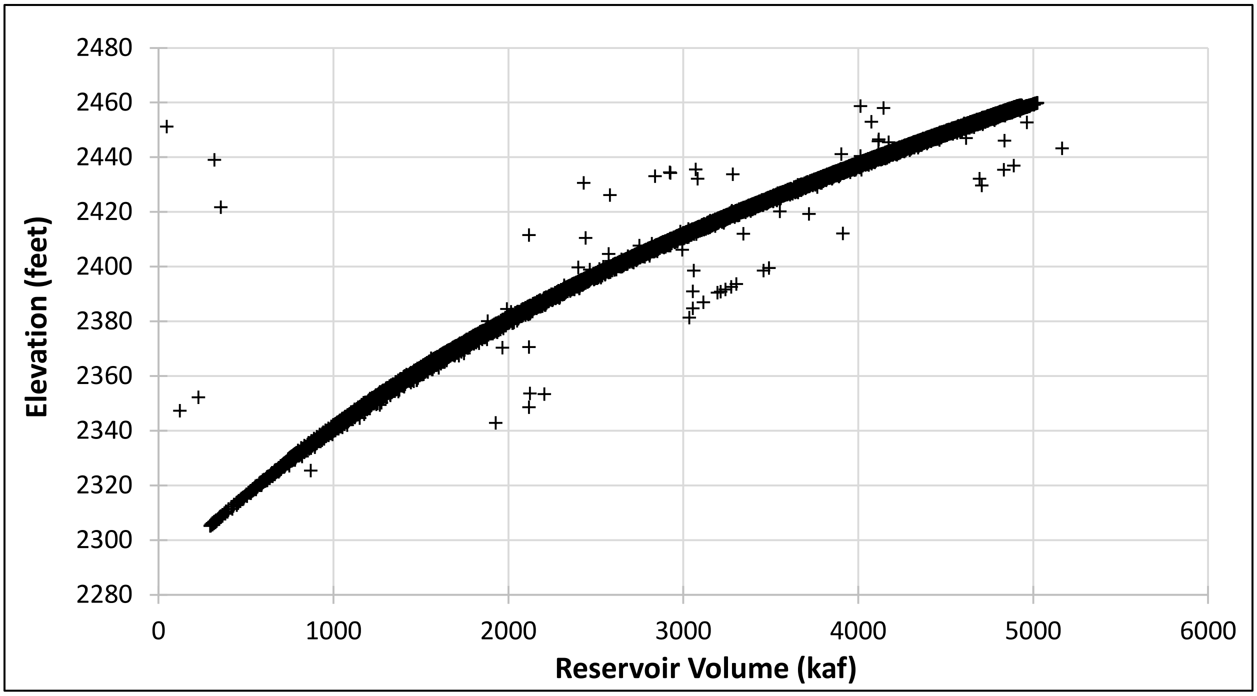

Figure 2-1. Volume-elevation curve for Lake Koocanusa. The reservoir volume is operational storage only.

Around the lake perimeter, the landcover is dominated by bedrock and mixed forest with minor grasslands (Drawing 02). The surface geology predominantly consists of bedrock, glaciofluvial and eolian (wind derived) sediments (Drawing 02).

2.4. Existing Development and Recreation

2.4.1. Overview

Within Canada, there are several small communities that are either adjacent to or in close proximity to the lake. From upstream to downstream (north to south) these are: Wardner, Jaffray, Elko, Baynes Lake, Kragmont, Grasmere, and Newgate (Appendix A). The lake is only crossed at one location, about 30 km north of the international border. Here, the lake is spanned by the 200 m long Kikomun Bridge; a 600 m long engineered spit on the west side of the lake, limits the bridge span at this location.

The lake is a popular destination for recreation, with a number of boat launches, beaches, and campgrounds located on its perimeter. These facilities are shown in Appendix A. Provincial parks include Wardner Provincial Park (established 1977) and Kikomun Provincial Park (established 1972); only the latter park provides a boat launch and campground. There are also several Provincial recreational sites on the lakeshore and private campgrounds (Appendix A).

While much of the recreational activity on Koocanusa Reservoir is dependent on, or related to, boating and watercraft, other popular activities include fishing and swimming. Mud bogging (offroad driving) is also popular in the spring (Easter and May long weekends) when the reservoir level is low. For the past few years, concerns have been growing about mud bogging in the area. This activity has resulted in associated land and environmental impacts on Crown land in and around Lake Koocanusa, particularly the Dorr Road and Umbrella Beach areas. In 2017, an estimated 3,000 people and 1,200 vehicles participated in unauthorized mud bogging events in the area. In response, the Province closed the Dorr Road Recreation Site around the Koocanusa reservoir from April 15 to May 1, 2019.

The primary access road on the west side of the lake is Kikomun Newgate Road. On the east side of the lake, the principal access roads are Jaffray-Baynes Lake Road and Highway 93. These two roads trend north-south with a number of roads providing direct access to the lake.

Development in the area is currently governed by the Lake Koocanusa Official Community Plan (OCP) (RDEK, April 5, 2013). The OCP was a collaborative effort between the RDEK, the Ministry of Forest, Lands, and Natural Resources Operation, and the Ktunaxa Nation Council (KNC).

2.4.2. Recreation Strategy

Due to the popularity of the area for recreation use and the lack of planning on Crown land, MLAs Bill Bennett and Steve Thomson (Minister of Forests, Lands and Natural Resource Operations) initiated the Koocanusa Recreation Steering Committee (KRSC) in 2014 to help address a range of issues related to tourism and recreation activities on Crown land in the Koocanusa area. The KRSC is a partnership between the Province of BC, KNC, Tobacco Plains Indian Band, RDEK, and the CBT. In 2017, the KRSC published the Koocanusa Recreation Strategy (http://www.koocanusarecreation.ca/koocanusa-recreation-strategy), which was developed to foster more sustainable and responsible recreation on Crown lands, while providing opportunities for local stakeholders and stewardship groups to play key roles in recreation management.

The strategy was created after extensive consultation and engagement, including a partnership with the local Koocanusa Recreation Public Advisory Group, four community open houses and a recreation management survey that received more than 1,100 responses. Key actions of the strategy include the following:

- Continue to educate recreation users about appropriate Crown land behaviour through signage and by distributing the Koocanusa Recreation Guidelines and Map.
- Support the Koocanusa Recreation Steward Program, which provides two additional natural resource enforcement officers for the Koocanusa area.
- Complete a recreation inventory of existing roads, trails, camping sites and staging areas.
- Continue to engage with local partners, advisors and stewardship groups.

The Strategy includes specific management actions for the Dorr-Grasmere area, defined as the Crown land south of the Elk River and west of Highway 93, extending south to the US border. Dorr-Grasmere was identified as an area where current recreation use patterns are significantly impacting Crown land values, and where more specific management approaches will be implemented over two phases starting in 2017. The focus of Phase 1 is identifying and directing recreation users toward appropriate trails, camping areas and parking and staging areas. Phase

2 will focus on formalizing a network of recreation trails and supporting facilities through regulation. This approach is expected to mitigate the growing number of recreation impacts while providing opportunities for continued recreation use in the area.

2.5. Fisheries

Eighteen species of fish are present in Lake Koocanusa, and the reservoir currently supports an important fishery for kokanee and rainbow trout in both Canada and the US (Table 2-2). Some limited shore fishing is possible in the spring and early summer, before the draw down, for small cutthroat trout and kokanee salmon. However, due to the size of the lake, a motorboat is needed to reach the best fishing spots (Hensler et al., 2006).

Table 2-2. Relative abundance and abundance trend from 1975 to 2002 of fish species present in Lake Koocanusa (after Hensler et al., 2006).

Common Name	Relative Abundance	Trend	Native
Game Fish Species			
Westslope cutthroat trout	R	D	Y
Rainbow trout	R	D	Y
Bull trout	C	I	Y
Brook trout	R	U	N
Lake trout	N	U	N
Kokanee salmon	A	U	N
Mountain whitefish	R	D	Y
Burbot	C	D	Y
Largemouth bass	R	U	N
White sturgeon	R	D	Y
Northern pike	R	U	N
Yellow perch	C	I	N
Non-Game Fish Species			
Pumpkinseed	R	U	N
Redside shiner	R	D	Y
Peamouth	A	I	Y
Northern pikeminnow	A	I	Y
Largescale sucker	A	S	Y
Longnose sucker	C	D	Y

Abundance codes: A = abundant, C = common, R = rare, N = not found

Trend codes: I = increasing, S = stable, D = decreasing, U = unknown

Within Canada, Kokanee account for 98% of the recreational harvest of Lake Koocanusa (BC Hydro, 2013). When the reservoir elevation is high there is more fishing effort, and at very low elevations there is little reservoir area remaining in Canada for fishing.

The Koocanusa area is within the footprint of the Fish & Wildlife Compensation Program (FWCP), a partnership funded by BC Hydro and others. Since the FWCP was established, the Koocanusa area has been, and continues to be, eligible for project funding for submissions that are aligned with one or more of the FWCP Action Plans. Additionally, during 2013-2018, work on fish and wildlife issues in and around Koocanusa Reservoir was enhanced through a special program coordinated by FWCP: over those five years, the Columbia Basin Trust (CBT) funded the Upper Kootenay Ecosystem Enhancement Program (UKEEP) which delivered, via the FWCP, $3 million specifically for Koocanusa projects.

Within Canada, shoreline management guidelines have been published for Lake Koocanusa (VAST, 2017). The guidelines provide a science-based assessment habitat value and required level of protection for individual segments of the lake's foreshore. The objective of the Guidelines is to help plan future developments and recreational activities on the lake, while conserving and restoring natural habitat that local fish and wildlife species rely on to complete their life cycle.

2.6. Hydroclimate

Climate is variable in the watershed. In the vicinity of Lake Koocanusa, mean annual precipitation (MAP) is about 450 mm with a mean annual temperature (MAT) of 6.3°C (Figure 2-2). Colder temperatures and higher precipitation are found at higher elevations. At Fernie, the MAP is approximately 1060 mm with a MAT of 5.3°C (Figure 2-3). Climate station locations are delineated on Drawing 01.

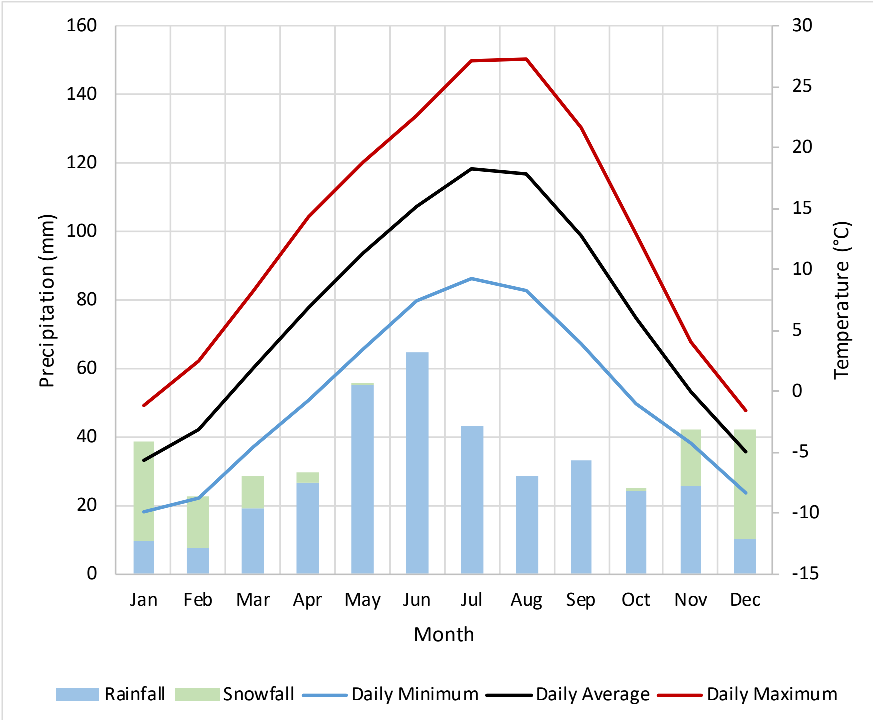

Figure 2-2. Average monthly temperature, snowfall (cm) and rainfall (mm) for the Baynes Lake Kootenay River climate station from 1980-2010.

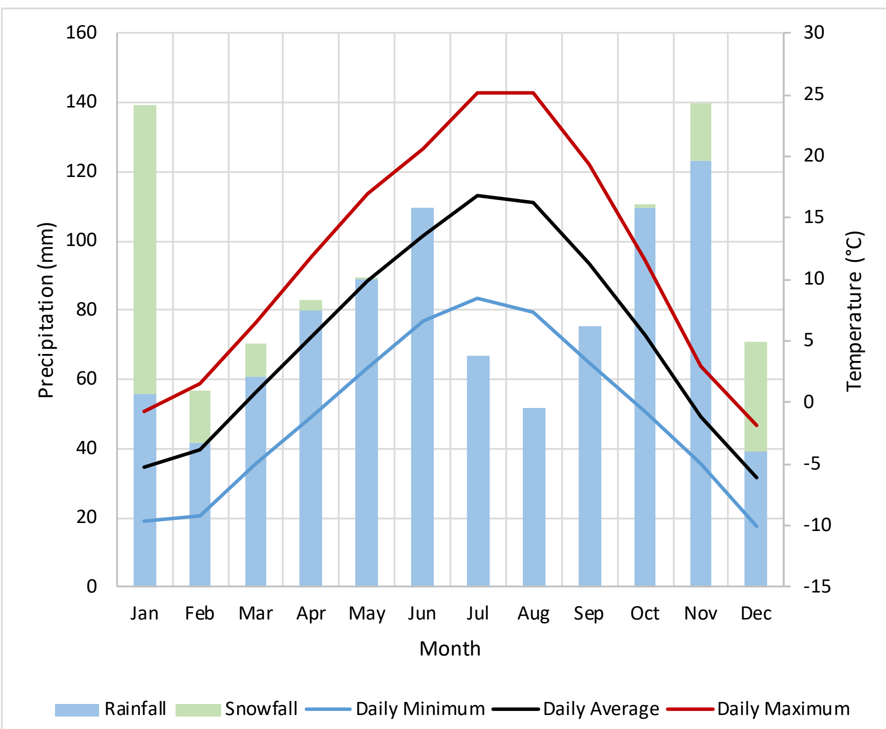

Figure 2-3. Average monthly temperature, snowfall (cm) and rainfall (mm) for the Fernie climate station from 1980-2010.

3.0 PROPOSED DAM

As noted in the introduction, a group of reservoir users and stakeholders have proposed the construction of a dam across Lake Koocanusa in BC, just upstream of the US border. The dam would be constructed to maintain the level of Lake Koocanusa within Canada at or above El. 2440’ (743.7 m), which is approximately 19 feet (6 m) below the normal full-pool level of El. 2459’ (749.5 m). The group considers this level to be the lowest reservoir level that can support significant recreational activities and the related businesses. If constructed, the dam could be operated to maintain the reservoir at or above El. 2440’ either: (a) throughout the year, or (b) only during the prime recreation season of late May through September.

The CBT (2004) found that a range of recreation stakeholders generally preferred a reservoir level of 2445’ (745.2 m) to 2455’ (748.3 m). This preferred range considers several negative factors that emerge at lower elevations, including the emergence of sand bars, the potential for dust mobilization during windstorms, and unpleasant aesthetics. Negative effects from high reservoir levels begin approximately 4 feet (1.2 m) below the full pool mark of 2459’ (749.5 m).

The proposed dam elevation can also be compared to key reservoir levels for various recreational activities, as summarized in Table 3-1. The quoted reservoir levels for the dock and boat launch (BC Hydro, 2013) are from the recently constructed Yaqakxaqlamki Regional Park (Koocanusa Boat Launch), which was opened on July 1, 2011. The launch and dock, located on the west side of the reservoir near Kikomun Bridge, was constructed with funding from BC Hydro, the CBT, and Teck.

Table 3-1. Key reservoir levels for Lake Koocanusa recreation activities.

Metric	Elevation	
	(feet)	(m)
Dock accessible[1]	2403	732.4
Dock floats[1]	2426	739.4
Min for boat launching[1]	2407	733.7
Min for swimming (preferred)	2449	746.6
Recreational fishing	2435	742.2

1. These values are for the Koocanusa Boat Launch. Other businesses around the lake without an engineered dock may require up to 10 feet more elevation to float.

There are several other boat launches and docks around the lake, including Koocanusa Campsite & Marina located across the road from the Koocanusa Boat Launch. The following boat ramp elevations are quoted in TetraTech (2005):

- Newgate Sandy Shores Resort – 2439’ (743.4 m)
- Gold Creek Bay Recreation Site – 2427’ (739.7 m)
- Kikomun Creek Provincial Park – 2396’ (730.3 m).

In most years, Lake Koocanusa is not fully fishable until about El. 2435' (742.2 m) because of high sediment concentrations from the slowly submerging mudflats (BC Hydro, 2013). This elevation is typically reached in mid-June. Kokanee move out of the reservoir in early September, resulting in a 2-month season that can support up to 25,000 angler-days/year.

With reference to Table 2-1, Lake Koocanusa currently has an operational storage capacity of 6140 Mm^3 between elevations 2459' and 2287' (749.5 m and 697.1 m). Construction of a dam at elevation 2440' would reduce the operational storage capacity of the reservoir. With reference to Figure 2-1, approximately 83% of the reservoir volume is below elevation 2440'. The reservoir also has a total length of approximately 150 km, of which 70 km is in Canada (45%). Therefore, the operational storage capacity of the reservoir could be reduced by about 40%. Accounting for less storage in Canada as the valley floor is at a higher elevation, the actual reduction in storage capacity is likely closer to 35%. To calculate a more accurate value, BGC contacted the USACE and BC Hydro to acquire bathymetric data for the reservoir. However, neither entity was able to locate such data within the timeframe of this report. The USACE did indicate that an updated bathymetric survey of the reservoir will be conducted in 2020.

4.0 HYDROLOGIC BACKGROUND

4.1. General

Lake Koocanusa formed through the inundation of the Kootenay River valley in 1974 as a result of closure of the Libby Dam. Changes to the Libby Dam operational regime have impacted both the timing and magnitude of downstream flows on the Kootenay River, as well as water levels on Lake Koocanusa. In the following sections we provide information on the operational regimes and use hydrometric data from several US Geological Survey (USGS), Water Survey of Canada (WSC), and USACE stations to assess their impacts on the water level in Lake Koocanusa. The gauge locations are shown in Drawing 01 and gauge characteristics are summarized in Table 4-1.

Lake Koocanusa has four major gauged tributaries: Elk River, Kootenay River, and Bull River (Canada), and Tobacco River (US). The three Canadian tributaries account for approximately 85% of the total watershed area of 23,270 km^2 at Libby Dam. Tobacco River is the primary tributary within the US and has a drainage area of 1,140 km^2, or approximately 5% of the total watershed area at the Libby Dam. Inflows within Canada from the Elk River, Kootenay River, and Bull River therefore govern the amount and timing of reservoir infilling in a typical year. The three tributaries are all nival, with streamflow typically peaking during the spring freshet, or snowmelt period, from May to July (Figure 4-1).

Table 4-1. Station information for WSC, USACE, and USGS gauges used in the hydrologic assessment.

Station Name	Kootenay River at Fort Steele	Elk River at Fernie	Bull River near Wardner	Libby Dam near Libby (LIB)	Kootenay River bl Libby Dam	Kootenai River at Libby MT
Station Number	08NG065	08NK002	08NG002	-	12301933	12303000
Agency	WSC	WSC	WSC	USACE	USGS	USGS
Watershed Area (km^2)	11,500	3,090	1,520	23,270	23,270	26,520
Latitude	49.6120	49.5035	49.4936	48.4105	48.4007	48.4002
Longitude	-115.635	-115.070	-115.366	-115.314	-115.319	-115.554
Realtime Gauge	Yes	Yes	Yes	No	Yes	Yes
Record Period	1963-2020	1919-2020	1914-2020	1975-2020	1971-2020	1910-1991
Record Length (complete years)	58	56	102	46	50	80
Regulation Type	Unregulated	Unregulated	Regulated	Regulated	Regulated	Regulated
Location	30 km northwest of Lake Koocanusa confluence	40 km northeast of Lake Koocanusa confluence	7 km east of Lake Koocanusa confluence	At Libby Dam	1 km downstream (southwest) of Libby Dam	25 km downstream (west) of Libby Dam
Comment	An additional gauge is located on the Kootenay River closer to the lake (08NG005) but has a shorter period of record.	Two additional gauges are located closer to the lake on Elk River (08NK005 and 08NK030) but have a shorter period of record.	-	Daily elevation data provided at reservoir forebay.	Gauge added downstream of Libby Dam during dam construction	Gauge decommissioned in 1991 as it had been replaced by 12301933.

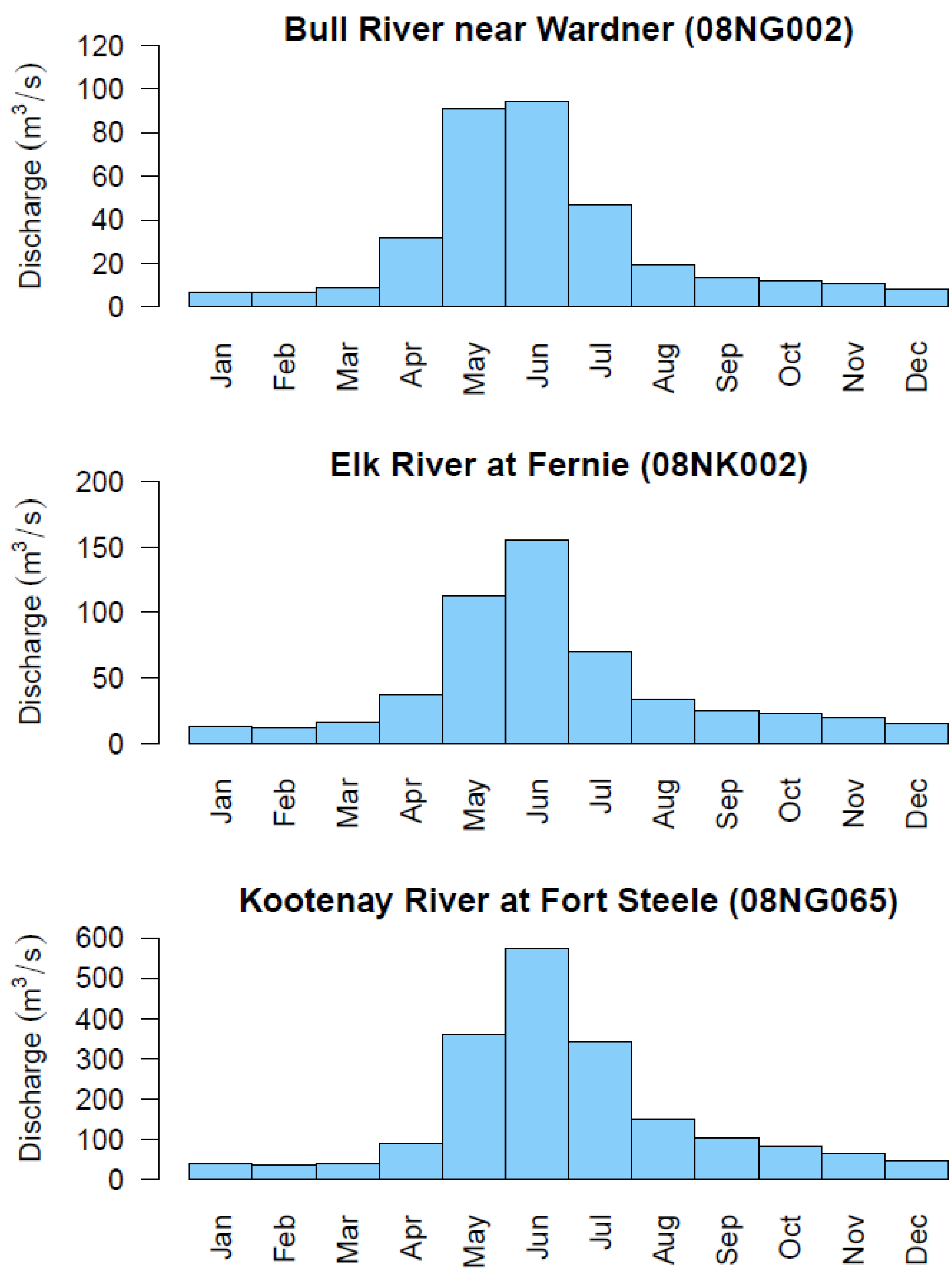

Figure 4-1. Average monthly discharge for the period from 1980-2020 at the three largest tributaries to Lake Koocanusa.

4.2. Operation of Libby Dam

Since dam closure in 1973, the operating regime of the Libby Dam has changed several times in response to changing flood storage requirements, an increased understanding of instream flow needs for various fish species and resulting legally required flow regimes to meet the needs of endangered fish species.

. The three primary operating regimes for Libby Dam are:

- **1973 to 1992 (Early FC)**: Standard Flood Control regime with operation of the dam driven almost exclusively by flood control and power generation.
- **1993 to 2002 (Standard FC):** – Standard Flood Control regime continues, and flood control remains a top priority. However, maintaining in-stream flow needs for downstream fisheries has a higher priority than power operations. During this period, discharge ramping rate[5] restrictions were also adopted in the late 1990's.
- **2003 to Present (VARQ FC)**: Variable Flood Control regime is adopted. With this regime there are higher flood control curves[6] for most inflow conditions, although flood control remains a top priority. Operations for downstream fisheries continues to have higher priority than operations for power due to court ordered legal requirements to meet the needs of endangered fish species.

Figure 4-2 shows the average daily flows for each phase. Each operational regime is also described in greater detail in the subsections below. Reservoir levels are discussed in Section 4.3.

4.2.1. Early Standard Flood Control (Early FC) – 1973 to 1992

Under Early FC, Libby Dam was regulated according to the CRT Flood Control Operating Plan (USACE, 1972), as amended by the review of Flood Control Columbia River Basin, Columbia River and Tributaries Study, CRT-63 (USACE, 1991). Each year a storage reservoir diagram (SRD[7]) specific to Libby Dam was used in combination with the seasonal inflow forecasts to determine how much storage space needed to be available in the upstream reservoir (Lake Koocanusa) by March 15 for flood control. Dam releases were then adjusted to meet the reservoir elevation associated with the determined storage space. This process of reducing reservoir levels is called drafting.

Under Early FC, Libby Dam would generally release high flows from January through April (Figure 4-2) in order to increase storage capacity to capture the spring runoff in May, June, and July when inflows from tributaries are typically highest (Figure 4-1). As the season progressed and forecasts

5 Discharge ramping is defined as the alteration of discharge in a stream channel resulting from the operation of a hydroelectric facility. Under Early FC, flow releases from Libby Dam were ramped up and down very rapidly, a practice that was detrimental to fish species and that had a negative impact on bank erosion.

6 Flood control curves enforce an upper bound on reservoir operations in order to manage future flooding risk.

7 An SRD determines the maximum allowable reservoir elevation based on a given water supply forecast.

changed, so did the storage requirements; in years with higher forecasted inflows a greater volume of storage was required, resulting in larger releases in the late winter and early spring to provide additional storage capacity. Because Lake Koocanusa drafted a large amount of water storage under Early FC, Libby Dam historically released little water from May to July (Figure 4-2) in order to refill, with a minimum outflow requirement of only 113 m^3/s (4,000 cfs).

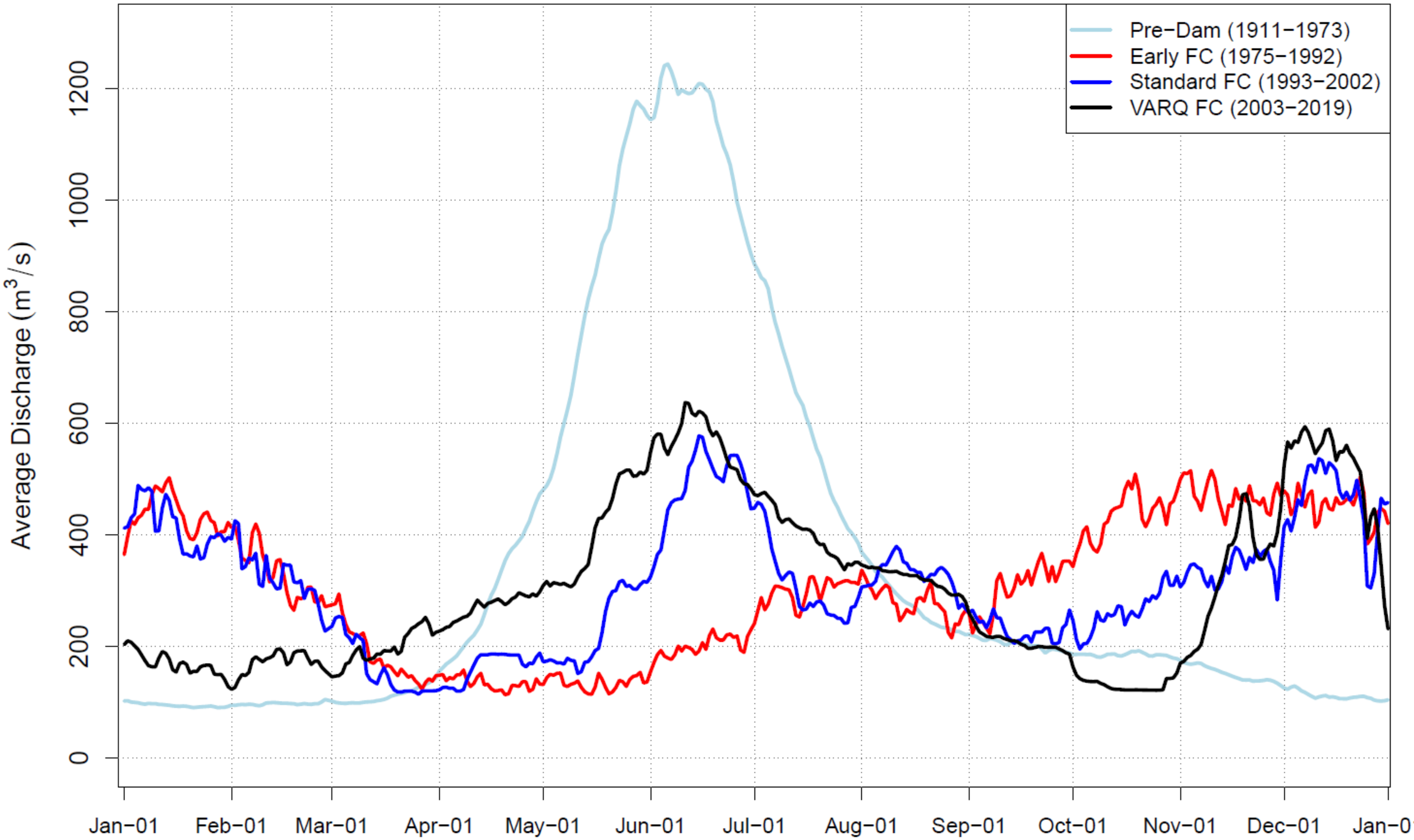

Figure 4-2. Average daily flows at the USGS gauge Kootenai River bl Libby Dam nr Libby MT (12301933) are shown for each operational regime. The average daily flow from the pre-dam period (1911 to 1973) at the USGS gauge Kootenai River at Libby MT (12303000).

4.2.2. Standard Flood Control (Standard FC) – 1993 to 2002

Eventually it was realized that the low summer releases associated with the Early FC operational regime were detrimental to several fish species including white sturgeon, bull trout, and salmon. From 1993 to 2002 the Standard FC procedures remained in place, but the operation of Libby Dam was altered to provide more water for fish, particularly during the freshet and low-flow summer months (mid-May to July), with power generation taking a lower priority. These changes were not legally required.

In the late 1990s limits were also instituted on the ramping rate for releases from Libby Dam. Before this period, aggressive Libby Dam discharge changes – normally caused by energy “load following” needs in the Pacific Northwest electrical system – caused rapid changes in Kootenay River flows downstream of the dam. This, in turn, resulted in significant changes in reservoir water levels over a period of several hours, with detrimental impact on fish and invertebrates. The rapid fluctuations also increased the rate of bank erosion in the Creston Valley (NHC, 1999).

4.2.3. Variable Flood Control (VARQ FC) – 2003 to Present

In December 2000, the US Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration’s (NOAA) National Marine Fisheries Service (NMFS)[8] each issued a Biological Opinion outlining measures to protect endangered species including sturgeon, bull trout, salmon and steelhead. Recommended measures included implementation of VARQ FC procedures at Libby Dam. The intent of the variable flow regime is to provide additional flows for downstream fish, while increasing the likelihood of reservoir refill and continuing to provide adequate downstream flood protection. VARQ FC allows for more assured provision of flows for endangered Kootenai River white sturgeon, threatened bull trout, and various listed stocks of salmon and steelhead in the Columbia River.

With VARQ FC, the release during the refill period varies according to the reservoir level, inflow water supply forecast, and the estimated duration of flood control. VARQ FC is intended to provide a similar level of flood protection as Standard FC, but with improved flow augmentation for fish. Standard and VARQ FC have the same storage space for flood control when the water supply forecast is greater than 120% of normal. In practice, there is only a difference between the two methods when the inflow forecast falls between 80% and 120% of normal (USACE, 2004). Within this range some of the water that would be stored during the refill period under Standard FC is instead passed through the dam under VARQ FC. Further details on the differences between Standard and VARQ FC are provided by the USACE (2004).

An Environmental Assessment (EA) for interim implementation of VARQ FC with fish flows (including sturgeon flows up to powerhouse capacity plus 1 kcfs spill) received a finding of No Significant Impact in December 2003 (USACE, 2002). Since then, the USACE has operated Libby Dam according to VARQ FC procedures and has continued to provide fish flows.

[8] Also known as NOAA Fisheries.

In 2006, the USACE in cooperation with the Bureau of Reclamation prepared a final Environmental Impact Assessment (EIS) on the Upper Columbia Alternative Flood Control and Fish Operations, Columbia River Basin. This final EIS addressed the long-term implementation of VARQ FC at Libby Dam and evaluated the potential effects of fish flow operations involving discharges greater than the existing powerhouse capacity[9] of 25,000 cfs (710 m^3/s), actions which were beyond the scope of the interim decision-making process. The EIS includes input from a revised Biological Opinion submitted by the USFWS on February 18, 2006. Four alternatives were assessed in the EIS: two Standard FC alternatives and two VARQ FC alternatives. Quantified recreation evaluation criteria for Lake Koocanusa included boat ramp days and swimming days in both Canada and the US. The EIS acknowledged that Canadian recreationists feel they are impacted at elevations below 2445' (745.2 m) for various purposes.

The Canadian Entity under the CRT (BC Hydro) objected to the USACE's unilateral adoption of VARQ FC on the grounds that Libby Dam, while still providing significant energy benefits and flood protection for Canada, does so at reduced levels for both power generation and flood control compared to the terms expected by Canada when it ratified the Treaty. This objection ultimately lead to the signing of the LCA between the Entities, as described in Section 1.1. However, local residents have raised concerns that reservoir levels during the peak recreation season (May to September) have lowered as a result of the VARQ FC operating regime.

4.3. Comparison of Standard FC and VARQ FC

4.3.1. Lake Level Analysis

Reservoir levels vary based on the amount of inflow from tributaries, especially during the spring freshet from May to July, as well as dam operations. In years with high snowpack, a larger amount of water is released from Lake Koocanusa in the spring to provide the storage needed for flood management during the freshet. In years with lower snowpack less water is released, as less storage capacity is needed, which can result in higher reservoir levels in the spring.

BGC used USACE reservoir level data from 1976 to 2019 to evaluate the impacts of changes in operational regime on reservoir level. Figure 4-3 shows reservoir levels in the spring and summer in each year since dam construction and Figure 4-4 shows the average daily reservoir level for each operational regime. Figure 4-4 also shows 2012 and 2019 water levels, which correspond to a wet and dry year. Reservoir levels are lowest in the winter and spring, with the minimum annual level occurring in early March to early May regardless of the operational regime. Similarly, reservoir levels typically peak in July or August and remain high through the month of September for all operational regimes.

[9] Powerhouse capacity actually ranges from 19,000 cfs (538 m^3/s) to 27,600 cfs (782 m^3/s), depending on the reservoir pool elevation (i.e., hydraulic head).

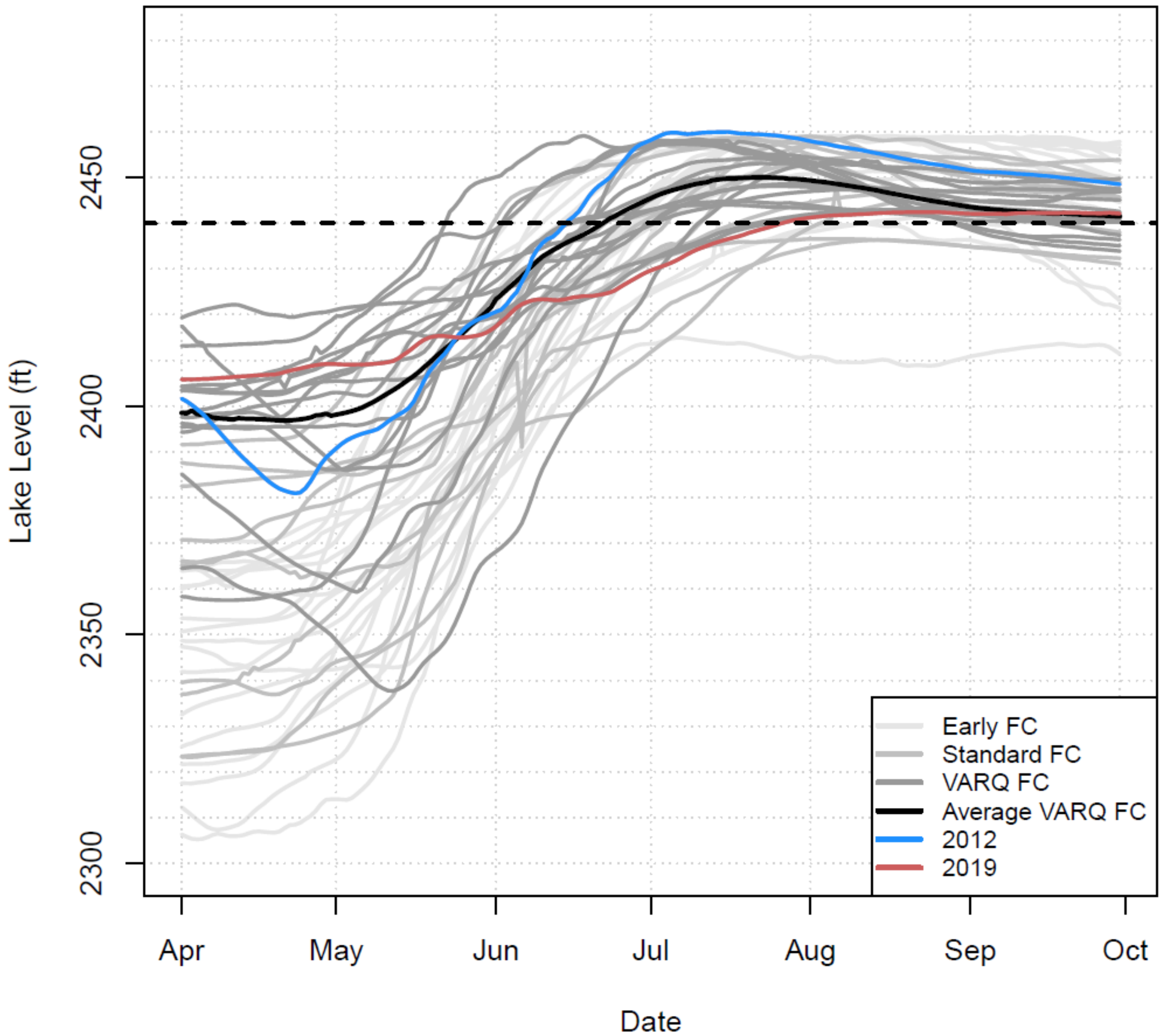

Figure 4-3. Daily reservoir level data recorded in the reservoir forebay from 1976 to 2019. A wet year (2012) is shown in blue and a dry year (2019) is shown in red. The dashed black line indicates the proposed dam elevation of 2440' (743.7 m).

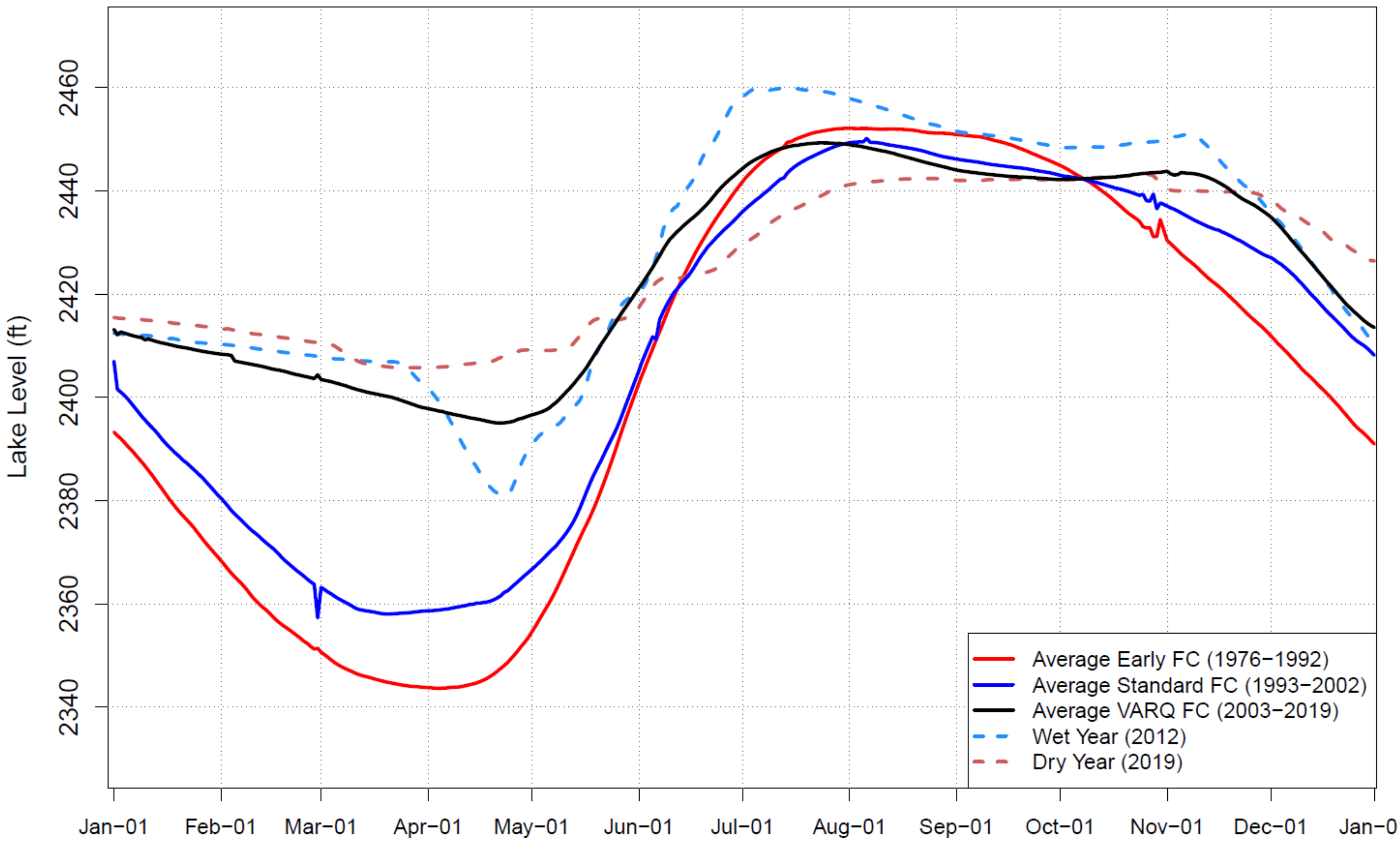

Figure 4-4. Average daily reservoir level for each operational period measured in the reservoir forebay.

While the patterns in reservoir level are similar for all operational phases, the magnitudes of the minimum and maximum reservoir levels differ. The minimum, mean, and peak reservoir levels are summarized in Table 4-2 for each of the main recreational months, and the distribution of reservoir levels are shown in Figure 4-5. The largest differences[10] between the operational regimes occurs when reservoir level is low in the spring, prior to the onset of the freshet; the mean reservoir level is 28 feet (8.5 m) higher in May under the current regime (VARQ FC) than under Standard FC, as less water is released in advance of the spring freshet to allow for higher releases for fisheries in the summer months. The mean reservoir level is 3.5 feet (1.1 m) higher in July under VARQ FC than under Standard FC, 2.8 feet (0.85 m) lower in August, and 4.7 feet (1.4 m) lower in September.

Table 4-2. Minimum, mean, and maximum reservoir for each operational regime.

		May	June	July	August	September
Minimum Reservoir Level (ft)	Early FC	2313.9	2376.9	2410.5	2408.8	2410.9
	Standard FC	2328.6	2387.7	2411.8	2434.7	2431.1
	VARQ FC	2337.7	2368.2	2426.8	2439.0	2433.9
Mean Reservoir Level (ft)	Early FC	2376.4	2424.9	2453.0	2458.4	2453.5
	Standard FC	2385.2	2423.6	2444.6	2449.5	2447.0
	VARQ FC	2411.6	2434.0	2448.1	2446.7	2442.3
Maximum Reservoir Level (ft)	Early FC	2435.5	2456.9	2459.0	2459.1	2459.0
	Standard FC	2439.3	2456.4	2458.9	2459.0	2455.6
	VARQ FC	2449.8	2459.1	2459.9	2457.9	2451.6

[10] The differences in reservoir level between operational regimes are statistically significant for all months ($p < 0.05$) with two exceptions: Early FC and Standard FC in the month of June and Early FC and VARQ FC in the month of July

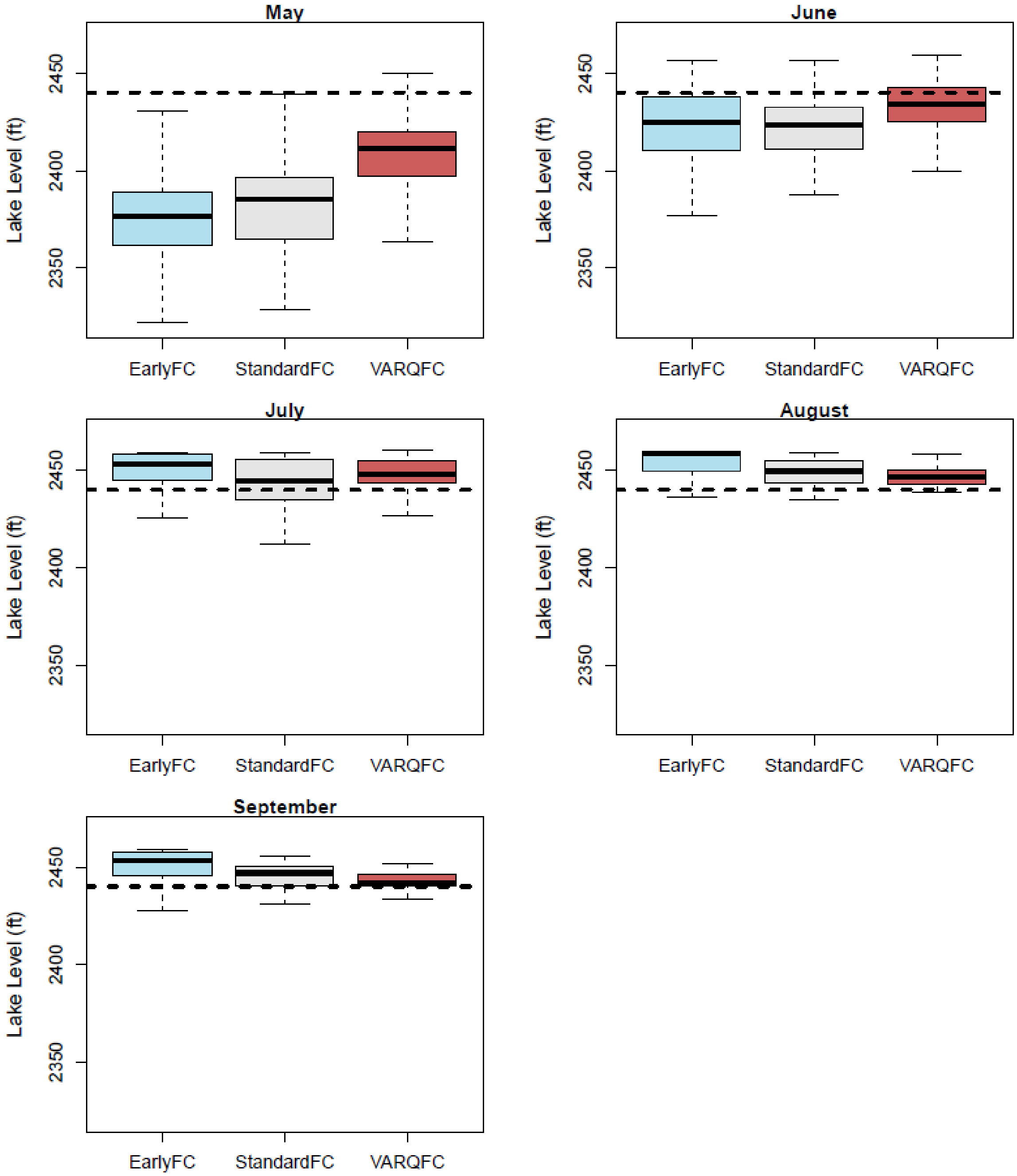

Figure 4-5. Distribution of reservoir levels from 1976 to 2019 for each operational regime. Dark black line represents the mean reservoir level, the hinges (upper and lower boundaries of the boxes) show the 25th to 75th percentile, and the whiskers show the maximum and minimum.[11] The dashed black line shows the proposed dam elevation (2440').

[11] Note that although all recorded reservoir levels are considered in the analysis, outliers are not shown in the figure.

The maximum reservoir level also varies with operational regime. The maximum monthly reservoir level increased in May through July under the VARQ FC regime but decreased by approximately 1 foot (0.3 m) in August and by 4 feet (1.2 m) in September when reservoir level is typically highest (Table 4-2). Figure 4-6 shows a time series of the peak reservoir level from 1976 to 2019. On average the annual maximum reservoir level has decreased by 5 feet (1.5 m) under the VARQ FC operational regime relative to Standard FC.

4.3.2. Snowpack Analysis

The USACE dam operations vary based on snowpack forecasts, resulting in different patterns in daily reservoir level throughout the spring and summer. Snow water equivalent (SWE) measurements from the nearest snow monitoring station, Morrissey Ridge (2C09Q), show that the lowest peak water levels coincide with low snowpack years. The four lowest peak reservoir levels recorded during the VARQ FC period (2009, 2010, 2015, 2019) occurred in years with SWE values that were 17% to 37% below the average value of 770 mm (Figure 4-6).

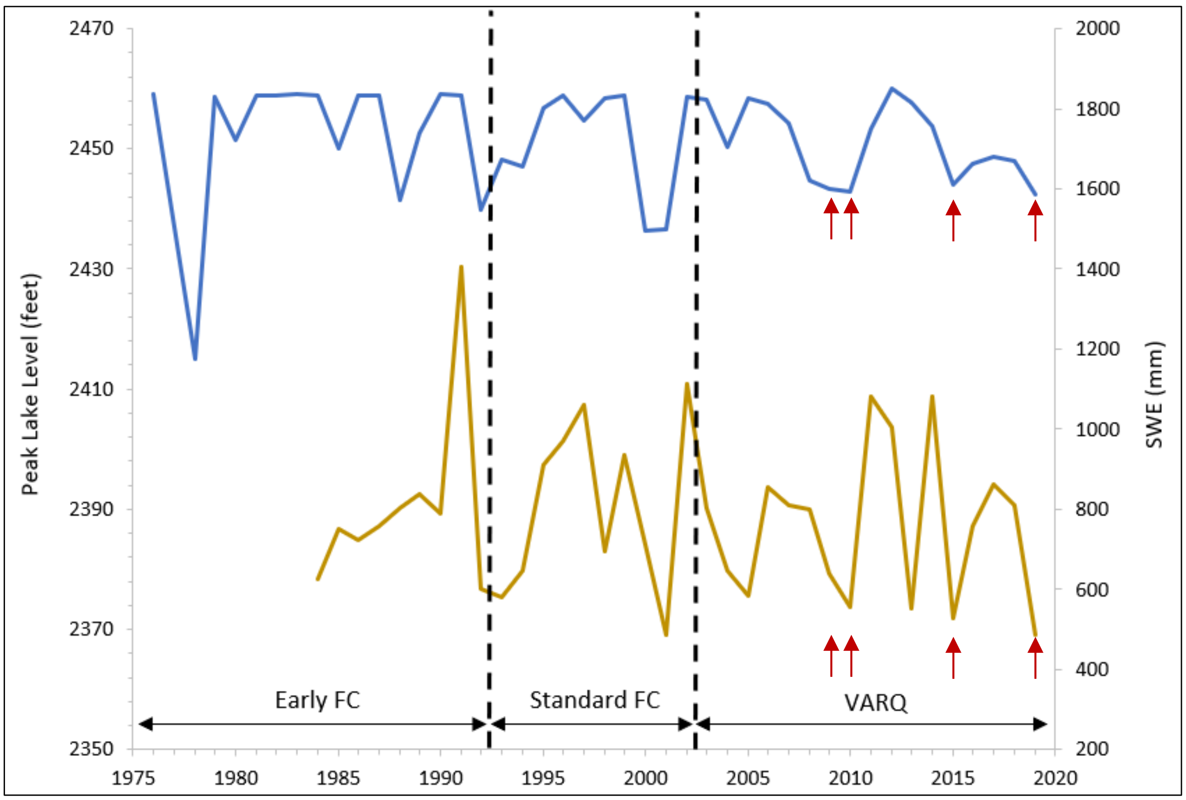

Figure 4-6. Time series showing peak reservoir level (blue line) and snow water equivalent (SWE) (gold line) from 1975 to 2019. Red arrows indicate the four years with the lowest peak water levels during the VARQ FC period.

Over the period of VARQ FC operations from 2003 to present, the lowest snow water equivalent was recorded in 2019, and the highest (1,080 mm, or 40% above average) was recorded in both 2011 and 2014. The snowpack was also high in 2012, with a maximum snow water equivalent of 1,050 mm (31% above average).

4.3.3. Comparison of “Wet” and “Dry” Year

BGC used the snowpack and streamflow data from the three main tributaries to evaluate the differences in lake levels between a “wet” year (2012) and a “dry” (2019) year. The wet year (2012) had the third largest snowpack recorded during the VARQ FC period and the fourth highest total inflow volume. The peak lake level recorded in July and August 2012 was the highest recorded for all operational regimes (Figure 4-3 and Figure 4-4). The dry year (2019) had the lowest snowpack recorded throughout the VARQ FC period and the second lowest inflow volume. The resulting peak lake level in July and August 2019 was the lowest recorded in the VARQ FC period.

The timing of lake level changes also varied between the wet year (2012) and the dry year (2019). Figure 4-3 shows that the 2012 reservoir level decreased in April and May due to drafting[12], as water was released to provide additional storage capacity in anticipation of the large spring freshet. The water level then increased in June, leading to a peak summer lake level of 2459.9’ (749.8 m), the highest on record. The lake level reached the proposed dam elevation of 2440’ (743.7 m) on June 15, 2012 and remained above the dam elevation until late November; the minimum July-August reservoir level of 2451.6’ (747.2 m) was 11.6’ (3.5 m) above the proposed dam elevation.

In the dry year (2019) the water level rose throughout April and May as water was retained in the reservoir in anticipation of low summer reservoir levels due to the low snowpack (Figure 4-3). The peak level at the end of May 2019 was higher than usual at 2416.6’ (736.6 m) (Figure 4-3). The average lake level over the months of May and June 2019 was also higher than typical at 2418’ (737.0 m) but remained 22 feet (6.7 m) below the proposed dam elevation of 2440’ (743.7 m). Although the reservoir level reached the proposed dam elevation on July 27, 2019, the peak July-August reservoir level in 2019 was the sixth lowest recorded since 1974 at 2442.5’ (744.5 m) and the lowest in the VARQ FC period. The minimum July-August reservoir level of 2429.6’ (740.5 m) was more than 10 feet (3 m) below the proposed dam elevation in 2019.

4.4. Climate Change

4.4.1. Historical Trends

Sylvester, Stephens, Tohtz, & Marotz (April 2009) noted that spring and early summer inflows (April 1 – July 31) to Lake Koocanusa, which originate primarily from the freshets on the Elk River, Bull River, and Kootenay River (Figure 4-1), increased steadily over the period from 1977 to 2007. BGC expanded the historical analysis of inflows to include the period from 2008-2019 using USACE data for Libby Dam. Figure 4-7 shows the average daily inflow from April 1 to July 31 for

[12] The reduction in spring lake level was even more significant in 2011 (i.e., the year with the highest recorded snowpack) resulting in the lowest recorded May lake levels throughout the VARQ FC period at 2337.7’ (712.5 m).

each year over the period from 1977 to 2019. Although there is a slight positive trend in the April-July inflows it is not statistically significant[13].

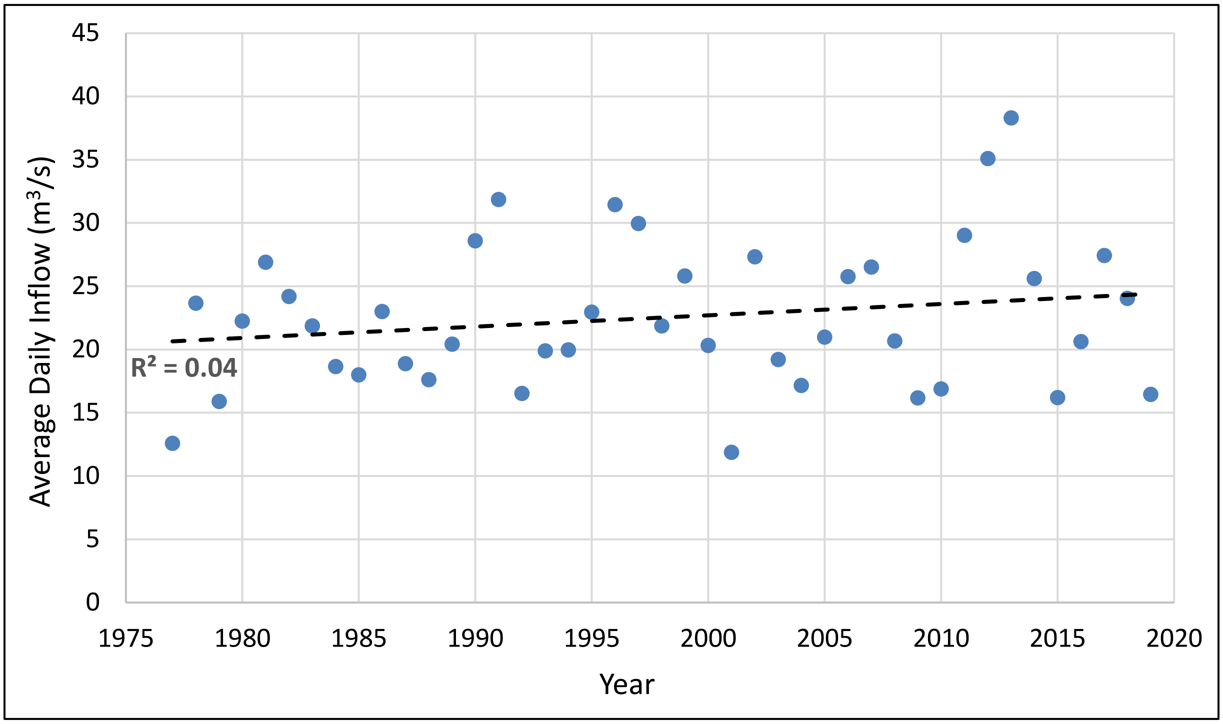

Figure 4-7. Average daily inflow to Lake Koocanusa from April 1 to July 31 for the years 1977 to 2019.

4.4.2. Future Projections

Streamflow depends in a complex manner on air temperature, the phase of precipitation (i.e., rain or snow), and the amount of precipitation. As a result, changes in streamflow can be difficult to predict based on changes in climate variables; projected changes in discharge vary spatially and seasonally based on snow and precipitation changes and topography-based temperature gradients. Researchers anticipate that high elevation regions throughout southeastern British Columbia will experience increases in snowpack, limiting the impact of climate change on spring streamflow in high elevation watersheds, while lower elevations are projected to experience a decrease in snowpack (Loukas & Quick, 1999; Schnorbus, Werner, & Bennett, 2014).

Within southeastern British Columbia winter snow water equivalent is projected to increase by 10-20 mm above an elevation of 1,600 m (Schnorbus et al., 2014). Based on this elevation threshold roughly 50% of the Upper Columbia River basin, including the headwaters of the main tributaries to Lake Koocanusa, will experience an increase in winter snowpack. Lake Koocanusa itself is located within the Kootenay River valley where elevations range from 750 m to 1000 m and is therefore anticipated to experience an increased proportion of winter precipitation falling as rain, as well as decreased snowpack (Schnorbus et al., 2014).

[13] Statistical significance was determined using the Mann-Kendall test, which produced a p-value of 0.41.

While the impact of climate change on snowpack is uncertain and highly variable, research shows that temperature changes will affect streamflow timing. Discharge is anticipated to increase in the winter and spring in the region due to earlier snowmelt and more frequent rain-on-snow events, while earlier peak flow timing is expected in many rivers (Schnorbus et al., 2014; Farjad, Gupta, & Marceau, 2016).

BGC used streamflow projections from the Pacific Climate Impacts Consortium (PCIC) to characterize potential changes in streamflow timing and magnitude in the three main tributaries to Lake Koocanusa. PCIC uses downscaled global climate models (GCMs), combined with a hydrologic model, to simulate streamflow at Water Survey of Canada gauges under a range of climate change scenarios for the period from 1955 to 2098. PCIC projections[14] for the three main tributaries to Lake Koocanusa – the Bull River, Elk River, and Kootenay River – show that the freshet is likely to shift earlier in the year, leading to earlier filling of Lake Koocanusa in the spring as the proportion of annual flow increases in the months of January through May in all three tributaries (Figure 4-8). The largest increases occur in April and May, with reductions from June to October.

[14] PCIC provides streamflows for three scenarios from the Special Report on Emissions Scenarios: A1B, A2, and B1. BGC used the GCM projections for the A1B scenario which is characterized by low population growth, development of new technologies, balanced energy sources, and rapid economic growth.

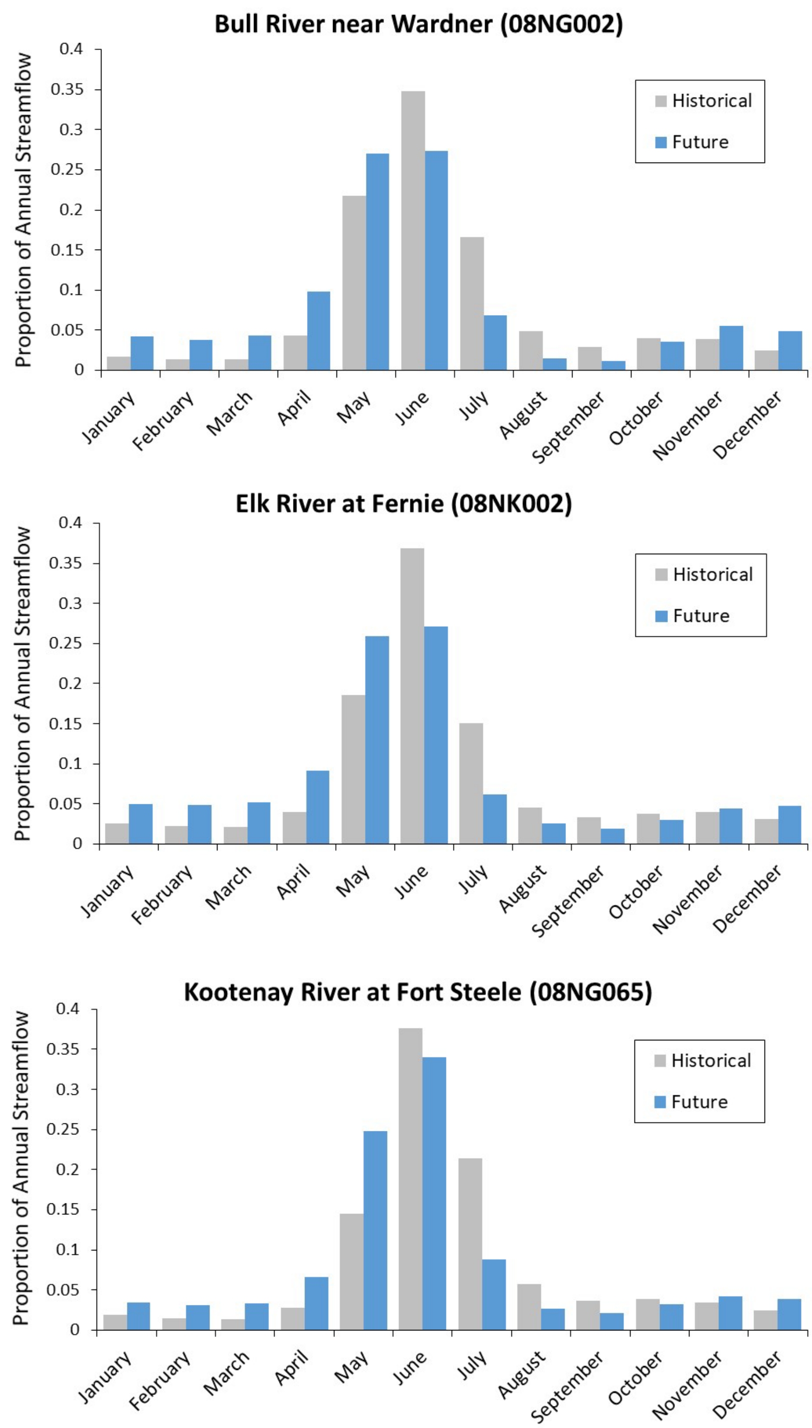

Figure 4-8. Monthly proportion of annual streamflow for the historical (1955-2000) and future (2050-2095) periods from PCIC projections.

BGC also used the PCIC projections to analyze the change in total inflows for the period from April to July, when most inflow occurs. Based on an ensemble of PCIC simulations for eight GCMs, the average daily streamflow in April-July is projected to increase in all three tributaries in the future (2050-2095) relative to the historical period (1955-2000), though the change is minimal in the Bull River (Table 4-3). The Kootenay River, which is the largest tributary, has the largest projected change. Considering the three gauges together, PCIC projects an average increase of 5.5% in April 1 to July 31 inflows to Lake Koocanusa in the future (2050-2095) (Table 4-3). Flows are projected to decrease by an average of 45% in the future (2050-2095) in the remainder of the prime recreation season from August 1 to September 30 (Table 4-3).

Table 4-3. Summary of projected changes in streamflow in the future (2050-2095) relative to historical period (1955-2000). The numbers in parentheses indicate the minimum and maximum percent change from the eight GCMs.

Gauge	Name	Change from Base to Future Period	
		April 1 – July 31 (freshet)	August 1 – September 30
08NG002	Bull River near Wardner	+0.5% (-19%; +13%)	-63% (-75%; -54%)
08NK002	Elk River at Fernie	+3.8% (-17%; +18%)	-36% (-49%; -30%)
08NG065	Kootenay River at Fort Steele	+6.7% (-10%; +19%)	-46% (-59%; -40%)
Combined	**-**	**+5.5% (-13%; +18%)**	**-45% (-59%; -40%)**

5.0 IMPACTS OF PROPOSED DAM

The impacts of the proposed dam were evaluated for two scenarios. The dam could be operated to maintain the reservoir at or above El. 2440' either: (A) throughout the year or (B) only during the prime recreation season of late May through September. With Scenario B, it is assumed that drawdown practices would be similar from November through end of April. Water levels typically start to increase at the start of May as snowmelt commences. As 85% of the watershed is in Canada, the proposed dam on the Canadian side would fill first to El. 2440', before spilling over to the US side.

For the following analysis, it has been assumed that there is sufficient runoff to fill the proposed dam to El. 2440' by the middle of May and that water levels would be maintained at or near that level until end of September[15]. For either Scenario A or B, the dam would require a gated spillway structure to safely convey inflows to the US side of the reservoir. Such design details are beyond the scope of this assignment but would need to be considered for future work, if required.

5.1. Reservoir Level

The following description applies to both scenarios.

BGC used reservoir level data to evaluate the impact of the proposed dam on the reservoir water level throughout the year, as well as in the summer recreational season specifically. Figure 5-1 shows the daily reservoir levels from 2003 to 2019. Throughout the period of VARQ FC operations (2003-2019) the reservoir level has been below the proposed dam elevation of 2440' (743.7 m) for an average of 65% of the year. As shown in Figure 5-1, the reservoir is primarily below the proposed dam elevation in the months of December through May, which is required to provide sufficient draft for the freshet runoff.

[15] Although it should be recognized there are likely instances where it may not be possible attain a reservoir level of El. 2440' by mid-May (e.g., a lower than expected spring runoff in combination with a significant available draft volume).

Table 5-1 summarizes the proportion of time that the reservoir level has been above and below the proposed dam elevation in the recreational season (mid-May to late-September) throughout the period of VARQ FC operations. This table also shows the anticipated increase in reservoir level[16] as a result of the dam during each time period.

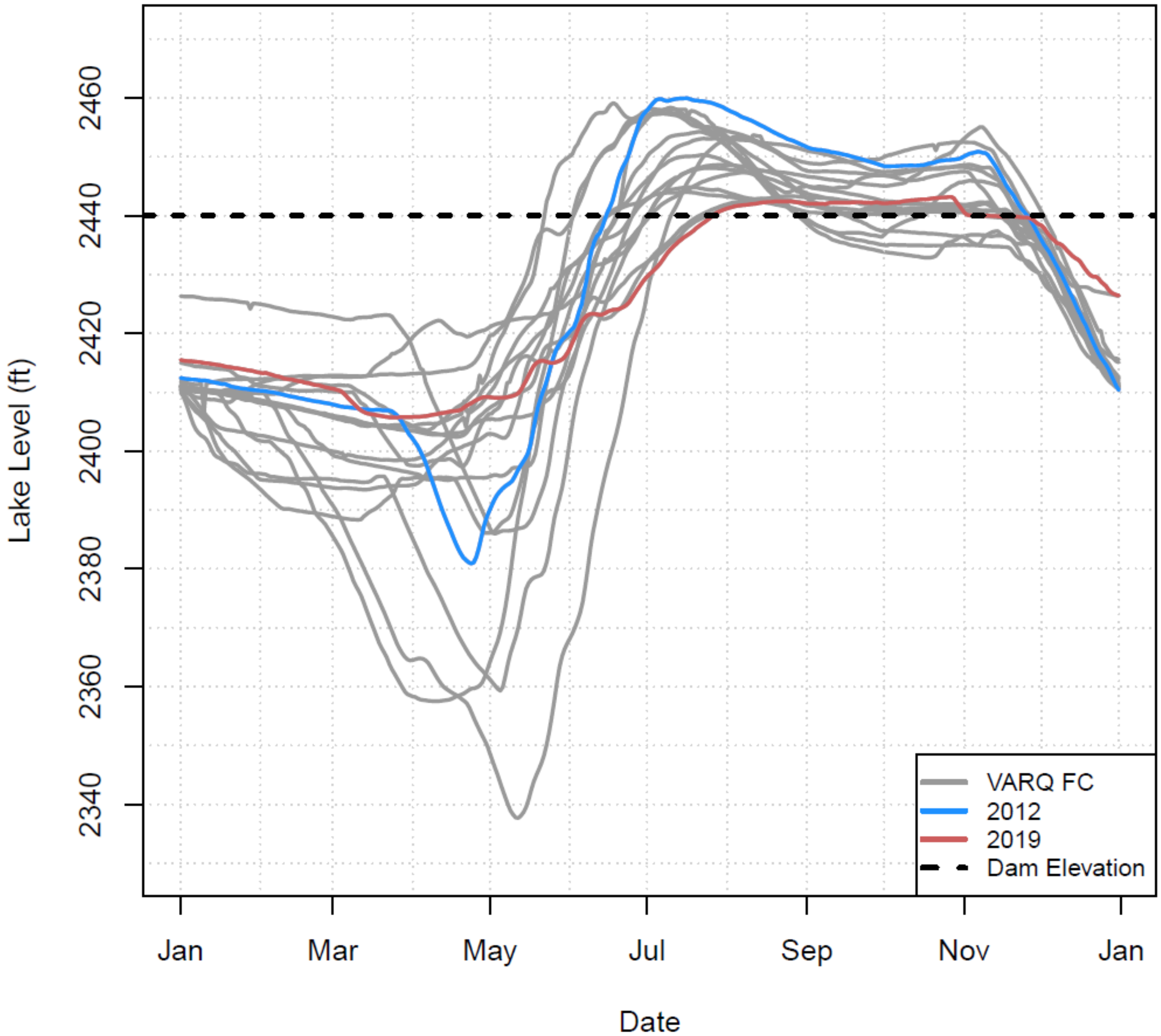

Figure 5-1. Daily reservoir level throughout the year for the VARQ FC operational period (2003-2019). The dashed line indicates the elevation of the proposed dam of 2440' (743.7 m).

[16] The increase in reservoir level was determined by calculating the mean reservoir level for days below the proposed dam elevation of 2440' (743.7 m). The lake rise therefore only indicates the anticipated rise on days within a period when the reservoir is below 2440' (743.7 m), and not the mean increase over the entire period, which will be lower than shown.

Table 5-1. Summary of the percentage of time that the proposed dam would have impacted reservoir level and the mean rise in reservoir level for the recreational season during past VARQ operations (2002-2019).

Time Period	Time Above Dam Elevation		Time Below Dam Elevation		Mean Reservoir Level Increase with Dam (feet)
	(%)	(days)	(%)	(days)	
May 15-31	3	0.5	97	16.5	24
June 1-14	16	2.2	84	11.8	14
June 15-30	47	7.5	53	8.5	8
July 1-14	77	10.8	23	3.2	5.8
July 15-31	90	15.3	10	1.7	0.8
August 1-14	100	14.0	0	0.0	0
August 15-31	97	16.5	3	0.5	0.1
Sept 1-14	82	11.5	18	2.5	2.2
Sept 15-30	77	12.3	23	3.7	3.8

The proposed dam would raise the reservoir level for an average of 45% of the days during the main recreational season from mid-May to the end of September based on the VARQ FC operations during 2003-2019. The potential impacts would be greatest from mid-May to end of June, where water levels have historically been above elevation 2440’ (743.7 m) approximately 20% of the time. Considering July and August alone, the percentage of days that water levels would be impacted by the proposed dam decreases to 9%.

Table 5-1 shows that historically the lake was below the proposed dam elevation less than 25% of the days in July, and less than 3% of the days in August. In September, water levels have historically been above elevation 2440’ (743.7 m) about 80% of the time.

While the recreation season is defined as mid-May to end of September, the intensity of use is greatest during July and August. The impact of the dam during this period would be small, as the dam would only increase the water level by an average of 5.8 feet (1.8 m) in early July when the reservoir level is typically below the proposed dam elevation (Table 5-1). In the remainder of July and August the dam would have a negligible impact on water level. From mid-May to end of June, the increase in reservoir level would be much more significant with an average increase of 15 feet (4.7 m). During the month of September, the increase in water level would be less than 4 feet (1.2 m).

The impact of the proposed dam would also vary by year. In seven of the 17 years that VARQ FC has been in place, the dam would have had no impact on water level during the prime recreation season as it remained above 2440’ (743.7 m) throughout the months of July and August (Figure 5-1). However, the proposed dam would have a more significant effect on July-August water levels in low snowpack years (5 of the 17 years that VARQ has been in place). The analysis provided in Table 5-1 is repeated below for a wet year (2012, Table 5-2) and a dry year (2019, Table 5-3).

Table 5-2. Summary of time that the proposed dam would have impacted reservoir level and the rise in reservoir level for the recreation season during a wet year (2012).

Time Period	Time Above Dam Elevation		Time Below Dam Elevation		Reservoir Level Increase with Dam (feet)
	(%)	(days)	(%)	(days)	
May 15-31	0	0	100	17	28
June 1-14	0	0	100	14	9.9
June 15-30	100	16	0	0	0
July 1-14	100	14	0	0	0
July 15-31	100	17	0	0	0
August 1-14	100	14	0	0	0
August 15-31	100	17	0	0	0
Sept 1-14	100	14	0	0	0
Sept 15-30	100	16	0	0	0

Table 5-3. Summary of time that the proposed dam would have impacted reservoir level and the rise in reservoir level for the recreation season during a dry year (2019).

Time Period	Time Above Dam Elevation		Time Below Dam Elevation		Reservoir Level Increase with Dam (feet)
	(%)	(days)	(%)	(days)	
May 15-31	0	0	100	17	25
June 1-14	0	0	100	14	18
June 15-30	0	0	100	16	15
July 1-14	0	0	100	14	7.2
July 15-31	29	5	71	12	1.2
August 1-14	100	14	0	0	0
August 15-31	100	17	0	0	0
Sept 1-14	100	14	0	0	0
Sept 15-30	100	16	0	0	0

5.2. Recreation

The analysis of boat launch and dock accessibility was limited to the Koocanusa Boat Launch (Section 3.0). Table 5-4 summarizes the accessibility of this boat launch since the onset of VARQ FC operations in 2003[17] for an average, wet, and dry year. During the recreation season, the dock and boat launch have been accessible the majority of the time, with the exception of the last two weeks in May. The proposed dam would have no impact on boat launch access in the prime recreational months of July and August but would improve conditions from mid-May to mid-June. Detailed data are not available for the other docks on the reservoir, but it is generally expected that the proposed dam would improve access to recreational facilities.

Swimming beaches around the reservoir are more usable at higher reservoir levels, with a preferred level of 5 to 10 feet (1.5 to 3 m) below full pool (El. 2459’, 749.5 m). The proposed dam at elevation 2440’ would be below this preferred level. In addition, there would only be minor impacts to water levels in July and August (Table 5-1), when swimming would be most popular.

Within Canada, Kokanee account for 98% of the recreational harvest of Lake Koocanusa (BC Hydro, 2013). In most years, the reservoir is not fully fishable until about El. 2435' (742.2 m) because of high sediment concentrations from the slowly submerging mudflats. This elevation is typically reached in mid-June, though the exact date has varied from as early as May 19 (in 2005) to as late as July 12 (in 2019). Kokanee move out of the reservoir in early September, resulting in a 2-month season that can support up to 25,000 angler-days/year. Fishing opportunities in Canada would be improved by 1-month with the proposed dam.

The CBT (2004) also found that a range of recreation stakeholders generally preferred a reservoir level range of 2445’ (745.2 m) to 2455’ (748.3 m). The proposed dam would not have a positive or negative impact on these users.

Overall, the data indicates that maintaining a reservoir level of 2440’ year-round or during the prime recreation season only would improve the viability of recreation on the Canadian portion of the reservoir, resulting in improved recreation for local residents, as well as increased tourism and other economic benefits for the area. Reservoir shoreline aesthetics are also generally more pleasing at higher, and more stable reservoir levels for watercraft within Canada may also be improved due to the higher reservoir levels. However, the opposite would be true on the US side of the reservoir.

[17] Note that the dock was built in 2011 so accessibility in the period from 2003-2011 is provided for reference only.

Table 5-4. Average proportion of days that the Koocanusa Boat Launch recreational facilities have been accessible since the onset of VARQ FC in 2003.

Month	Average Year Percent of Days (%)			Wet Year (2012) Percent of Days (%)			Dry Year (2019) Percent of Days (%)		
	Dock Accessible (2403')	Boat Launch Accessible (2407')	Dock Floats (2426')	Dock Accessible (2403')	Boat Launch Accessible (2407')	Dock Floats (2426')	Dock Accessible (2403')	Boat Launch Accessible (2407')	Dock Floats (2426')
May 15-31	80	75	18	88	76	0	100	100	0
June 1-14	94	93	56	100	100	64	100	100	0
June 15-30	98	97	86	100	100	100	100	100	31
July 1-14	100	100	100	100	100	100	100	100	100
July 15-31	100	100	100	100	100	100	100	100	100
August 1-31	100	100	100	100	100	100	100	100	100
Sept 1-15	100	100	100	100	100	100	100	100	100
Sept 16-30	100	100	100	100	100	100	100	100	100
Jan 1 – Dec 31	86	46	53	87	83	52	100	89	51

5.3. Navigation

The presence of a dam at the Canadian border, without an accompanying navigation lock, would clearly hinder, or halt, navigation on Koocanusa Lake between the two countries. Construction of a navigation lock as part of the dam project would substantially increase cost (see Section 6.0). However, it is not clear to BGC how much cross-border navigation currently occurs. Crossing the border by boat is illegal for the general public and the population density is low on both sides of the border. Hence, it is likely that the amount of cross-border navigation is low, and the cost of a navigation lock is unlikely to be justified.

5.4. Hydroelectric Power

Scenario A

As noted in Section 3.0, the proposed dam on the Canadian side of the border would reduce the amount of usable storage available for the USACE's operation of Libby Dam by about 30%. It is expected that the USACE would need to modify its Libby operating regime in response to Canada's operation of a dam. The reduction in usable Libby storage would result in reduced US power values generated at Libby due to reduced storage flexibility and head losses[18]. It is likely that Libby discharges during the fall/winter, the most valuable time for power production, would need to be reduced, relative to the current operating regime, in order to manage the risk of drafting the US portion of the reservoir too low. Conversely, spring/summer Libby discharges would likely be higher than under the current operating regime, as more water would need to be released due to the reduced storage availability.

Due to these changes in the Libby seasonal discharge pattern, there would also be negative impacts on downstream powerplant production in Canada (and further downstream at US powerplants on the Columbia River). Lower Libby discharges during fall/winter implies lower inflows into Kootenay Lake and the lower Kootenay River, resulting in reduced Canadian generation during this valuable period for power generation. Higher Libby discharges during spring/summer would lead to higher downstream inflows, higher spring/summer generation and additional spill at Canadian Kootenay River powerplants. Overall, the impact on power generation values within Canada would be negative.

Scenario B

Seasonal operation of the dam at El. 2440' during the prime recreation season of late May through September is not expected to significantly impact hydroelectric power in most years, as it would not impose conditions too dissimilar to existing operations. However, it could impact downstream operations in low inflow years.

[18] The height difference between the water reservoir and the tail race in a hydroelectric facility is termed the gross head and it determines the maximum amount of power that can be produced.

5.5. Flood Risk Management

Scenario A

Higher spring/summer Libby discharges would result in increased flood risk for downstream US communities such as Bonners Ferry, and for Canadian communities on Kootenay Lake and downstream on the Kootenay and Columbia rivers. The current operating regimes for Libby Dam and Duncan Dam[19] result in peak Kootenay Lake levels during high water years that are reduced by 6 feet (1.8 m) compared to natural conditions (i.e., no upstream dams) (Figure 5-2). While this flood peak reduction is due to both dams, the current storage operation of Libby Dam is likely responsible for more than half of the downstream level reduction (K. Ketchum, pers. comm.). If the Libby operating regime was modified in response to reduced usable storage in Lake Koocanusa, then peak levels for Kootenay Lake and downstream during flood years would likely be higher.

However, it is recognized that this evaluation is limited in scope. If the operation of Libby Dam was hindered by the proposed dam, the impact would not necessarily have to be felt in Kootenay Lake alone. The entire Columbia system operation could be adjusted to optimize the new regime.

Scenario B

Seasonal operation of the dam at El. 2440' during the prime recreation season of late May through September is not expected to significantly impact flood risk.

[19] Duncan Dam was the first of the three CRT dams to be built in Canada. Construction of the dam began in 1965 and it was operational by 1967. The dam is an earthfill structure with no power generation facilities. Its purpose is to control the flow of water from the Duncan River into Kootenay Lake in conjunction with the Libby Dam to assure operational water levels for the Kootenay Canal and the Corra Linn projects downstream,

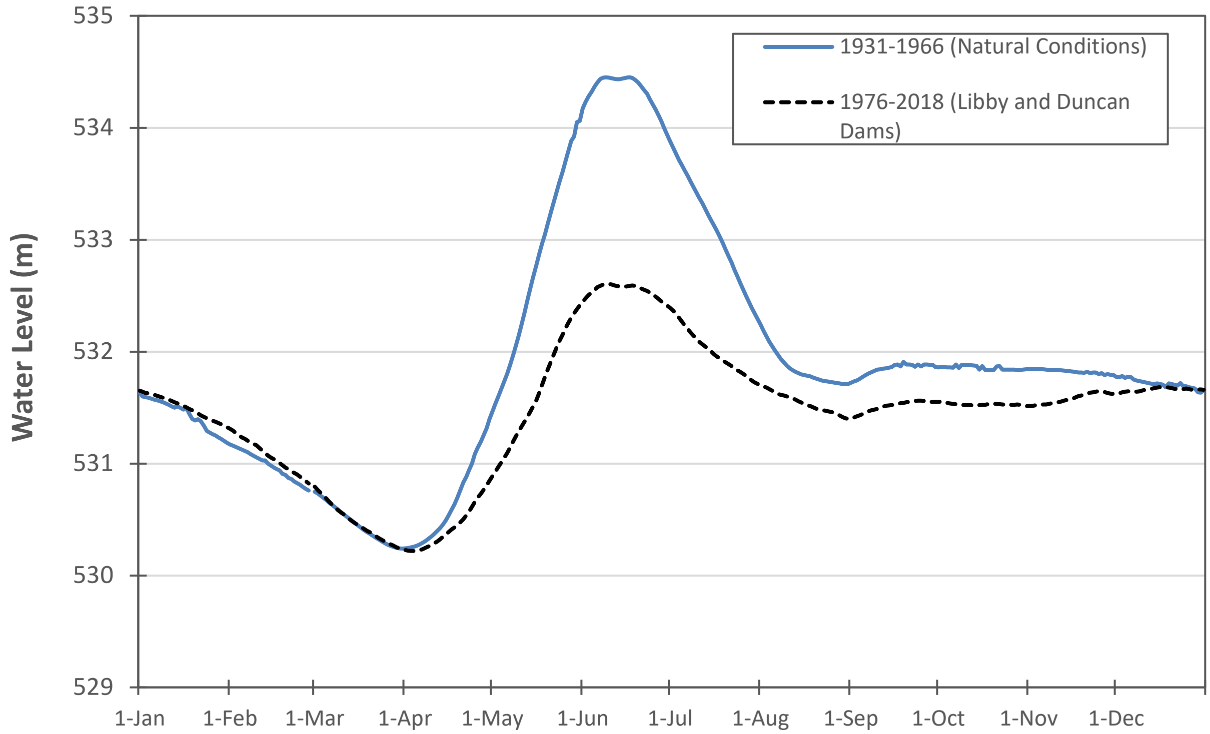

Figure 5-2. Average daily lake level at WSC station *Kootenay Lake at Queens Bay* (08NH064) for pre-dam (1931-1966) and post-dam (1976-2018) periods.

5.6. Ecosystems

The potential impacts of the proposed dam on the ecosystem of Lake Koocanusa and the Kootenay River have only been qualitatively assessed at a high level.

1. While a more stable reservoir level on the Canadian side of the dam would likely improve some ecosystem conditions there, the opposite would be true on the American side, where reservoir levels would need to fluctuate more to compensate for the loss of storage flexibility.
2. With a dam in place, the ability of fish and other aquatic life to move throughout the Koocanusa Reservoir between Canada and the US would also be hindered. This may have negative impacts on fish spawning in Lake Koocanusa and in the upstream Kootenay River. Therefore, fish passage would need to be included in the dam design, although residual impacts to fish habitat would likely remain.
3. The loss of Lake Koocanusa storage flexibility may also result in the US needing to modify its Libby discharge regime. Such a modification would likely impact downstream fish (e.g., Kootenai white sturgeon, salmon, bull trout).

6.0 COST ESTIMATE FOR PROPOSED DAM

A high-level cost estimate for the proposed dam was evaluated using a recent paper published by Petheram and McMahon (2019). Those authors looked at the costs of 98 dams constructed across Australia since 1888. The dam costs were then related to a number of variables including dam volume, dam height, reservoir capacity, reservoir surface area, and catchment area. An example relationship for reservoir capacity is provided in Figure 6-1.

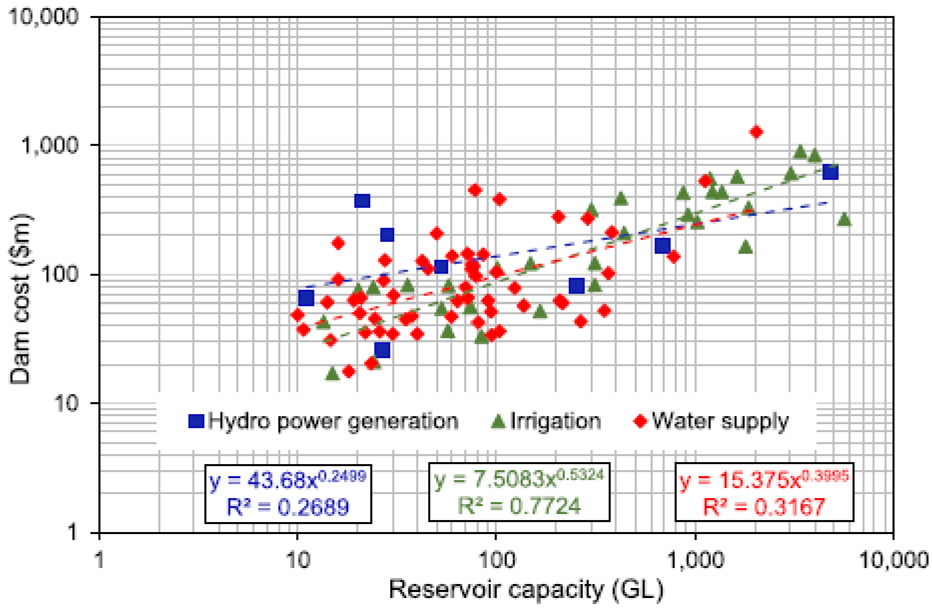

Figure 6-1. Relationship between final dam cost (2016AUD) and reservoir capacity (from Petheram & McMahon, 2019).

The mean final cost of the dams evaluated by Petheram and McMahon (2019) was approximately $100 million (CAD). Table 6-1 summarizes the costs of the proposed Lake Koocanusa dam based on the Petheram and McMahon cost relations with catchment area (20,000 km^2), storage capacity (2500 GL), surface area (65 km^2), and an assumed dam height of 45 m. Only irrigation and water supply dam relations were used by BGC.

Table 6-1. Estimated cost of the proposed Lake Koocanusa dam based on selected metrics from Petheram and McMahon (2019).

Variable	Estimated Cost (CAD) (million $)
Catchment Area	$1,150,000,000
Storage Capacity	$450,000,000
Surface Area	$850,000,000
Dam Height	$80,000,000

Using these metrics, the estimated costs have a wide range with a minimum estimate of \$80 million to a maximum of \$1.1 billion. While the range in estimated cost is high, this analysis demonstrates that the dam construction would be very costly. Petheram and McMahon (2019) also note that annual operation and maintenance (O&M) costs of the investigated dams varied from 0.14% to 0.35% of the final dam cost.

The empirical cost estimate formula of Petheram and McMahon is limited in its scope, and the lower end of the range is likely conservatively low in this particular case. Project specific aspects that will likely increase cost that may not be included in the empirical formula include:

- Navigation lock
- Fish passage (which is much harder to provide with such widely fluctuating water levels, especially if the upstream level is going to fluctuate)
- Site geology constraints
- Construction accessibility
- CRT, BC Utilities Commission (BCUC), public, and First Nations consultation.

In consideration of the above, the cost of the proposed dam is likely to be in excess of \$400 million. Such an estimate is consistent with the cost of the Duncan Dam, which is an earthfill structure with no power generation facilities (but no fish passage). The 1964 costs of the Duncan Dam were \$25 million, which is \$214 million in 2020 dollars (BC Hydro, pers. comm.). The length of the proposed dam would be about twice the length of the Duncan Dam, resulting in a rough cost estimate of \$428 million.

It is further noted that not only would fish passage be difficult to accommodate due to widely fluctuating reservoir levels, but also the conveyance of flow. A dam at El. 2440' would be regularly submerged during the summer months, as the reservoir has a full pool elevation of 2459' (749.5 m) (Figure 4-3). This full pool elevation is 19' (5.8 m) higher than the proposed dam elevation. A standard earthfill dam could not be built to withstand near annual submergence without significant reinforcement (e.g., armouring of the downstream face of the dam), which would incur additional costs. The alternative is that the dam would need to be built to the same crest elevation as Libby Dam. A unique engineering solution would also be required for the dam spillway due to the backwater effects from Libby Dam (i.e., flows would need to be able to be conveyed both from upstream to downstream of the dam and from downstream to upstream).

7.0 VIABILITY OF PROPOSED DAM

This report has explored and summarized the major issues associated with a proposal to build and operate a dam across Lake Koocanusa for the purpose of raising water levels on the Canadian side. The presence of such a dam would result in positive impacts for Canadian recreation and potentially other values. On the other hand, the dam’s estimated construction costs are likely in excess of $400 million. There would also be negative ongoing impacts to power production and flood risk management, if the dam was operated to maintain the reservoir at or above El. 2440’ throughout the year. These negative impacts largely disappear if the high reservoir level is only maintained during the prime recreation season of late May through September.

If a decision is made to continue investigating the possibility of a dam, then preliminary design work on the dam would be needed to obtain a more accurate construction cost estimate. Studies on costs and benefits (both direct & indirect) for all issues should be initiated. As part of this process, a number of key questions will need to be answered, as these could affect the business case for the project. For example:

- What are the Canadian legal and regulatory hurdles for this project?
- Which Canadian agency would be the “owner” of the dam? And who would pay for it?
- Would the US agree to such a Canadian dam proposal?
- How would the US Libby operating regime be adjusted in reaction to Canada’s operation of a dam at the Canada-US border?

8.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

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APPENDIX A
Koocanusa Recreation Brochure

Welcome to Koocanusa / Kiʔsuʔk kyukyit

Each year, more than 100,000 people visit this area. On a typical summer weekend, tens of thousands of people are recreating in the Koocanusa area.

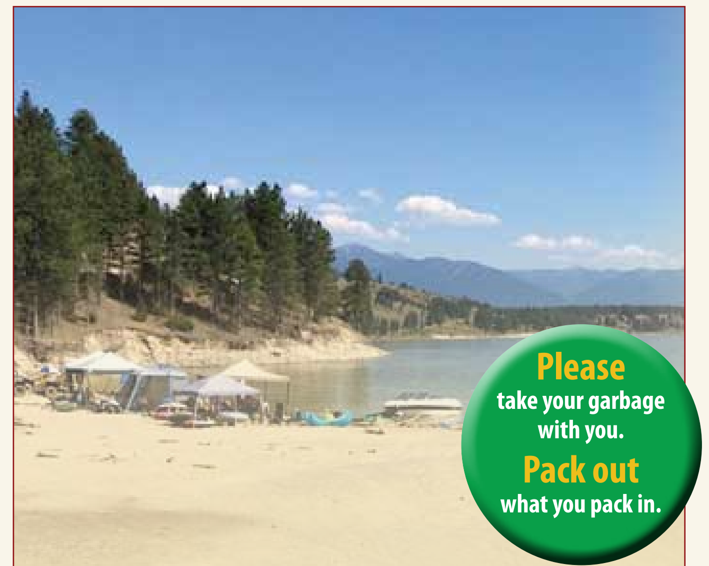
This map will help you find:

- designated boat launches;
- designated public camping and recreation sites;
- restricted access areas;
- garbage and sani-dump services; and
- parks and protected areas.

Crown Land
Private Land
Restricted Access Areas*
Recreation Sites
Parks and Protected Areas
Tobacco Plains Indian Reserve
Dorr- Grassmere Recreation Management Area
Camping Sites
Main Boat Launch
Boat Launches
Sani-Dump
Garbage Facilities
Paved Roads
Secondary Roads
Trans Canada Trail

* Access Management Areas are areas where the province has restricted motorized access. For more information visit www.env.gov.bc.ca/kootenay/eco/accessmaps.htm

KOOCANUSA Recreation
koocanusarecreation.ca



Please take your garbage with you. Pack out what you pack in.

Koocanusa Recreation Strategy

In 2017, a Recreation Strategy was completed for the Koocanusa area. The Koocanusa Recreation Steering Committee is in the process of implementing this Strategy with an initial focus on actions in the Dorr-Grasmere area. Visit koocanusarecreation.ca for more details.

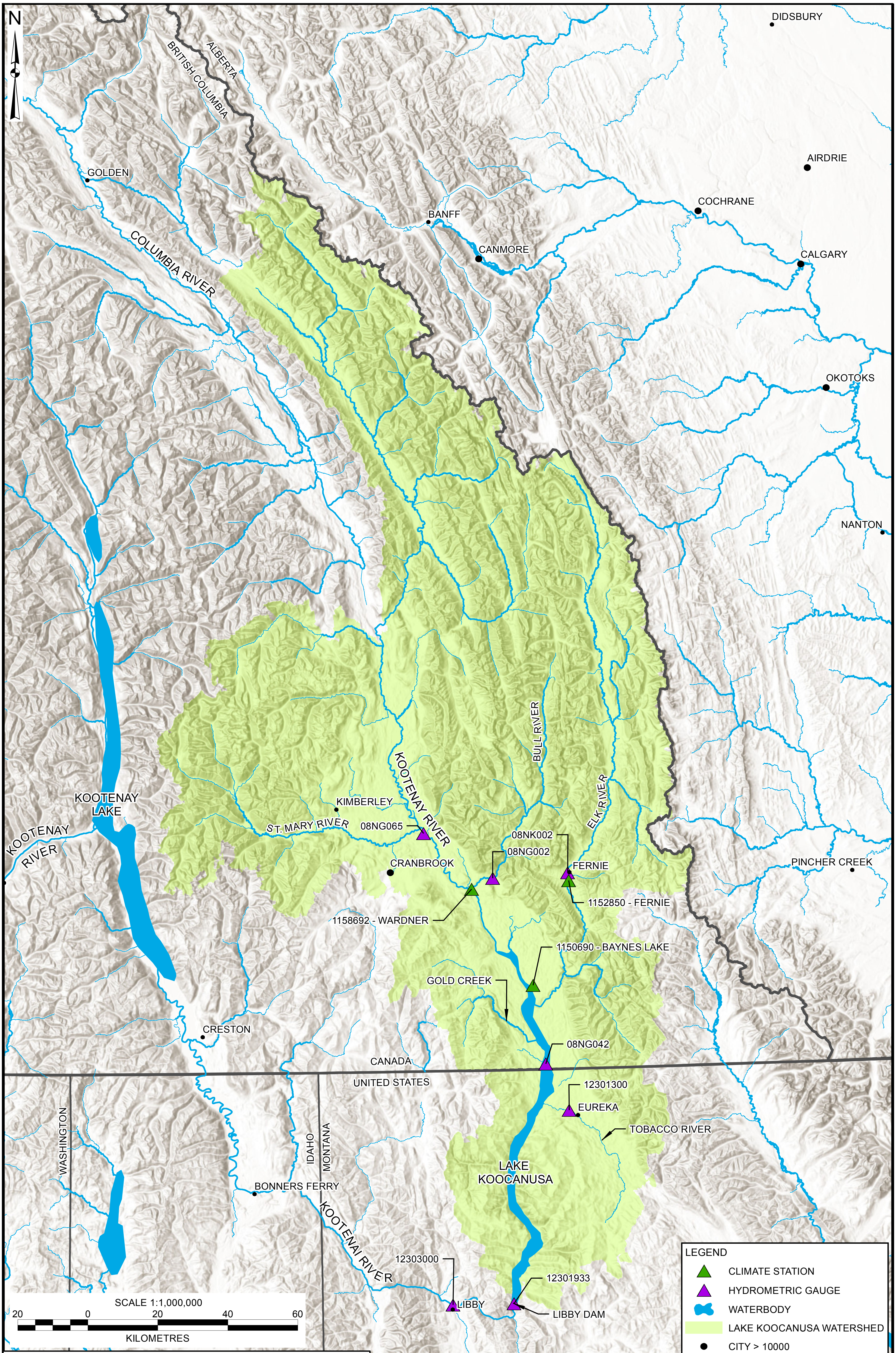
Dorr-Grasmere Recreation Management Area

Beginning in 2017, a new recreation management approach will be implemented in the Dorr-Grasmere area. The vision, to be implemented over several years, is a well-maintained network of recreation trails for motorized and non-motorized users, which is supported by appropriate camping and parking areas.

Implementation of the new recreation management approach will occur over two phases. The first phase will begin in the summer of 2017 and focus on identifying, and directing recreation users to appropriate trails and Crown land camping areas. Basic trail markers and signs will be installed, unsustainable trails will be deactivated, and enforcement officials will increase their presence in this area. The second phase of the management approach will formalize and legally designate trails and camping areas, allowing for more effective enforcement of recreation activities.

I CLEAN, DRAIN, DRY MY BOAT TO STOP INVASIVE SPECIES

DRAWINGS



NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "LAKE KOOCANUSA - HIGH LEVEL ASSESSMENT OF A PROPOSED DAM", AND DATED MAY 2020.
3. BASE TOPOGRAPHIC DATA BASED ON SRTM DEM PROVIDED BY ESRI, DATED 2015.
4. COORDINATE SYSTEM IS NAD 1983 CSRS UTM ZONE 11N.
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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

PROJECT:
LAKE KOOCANUSA - HIGH LEVEL ASSESSMENT OF A PROPOSED DAM

TITLE:
WATERSHED OVERVIEW

PROJECT No.:	DWG No:
0466-001	01

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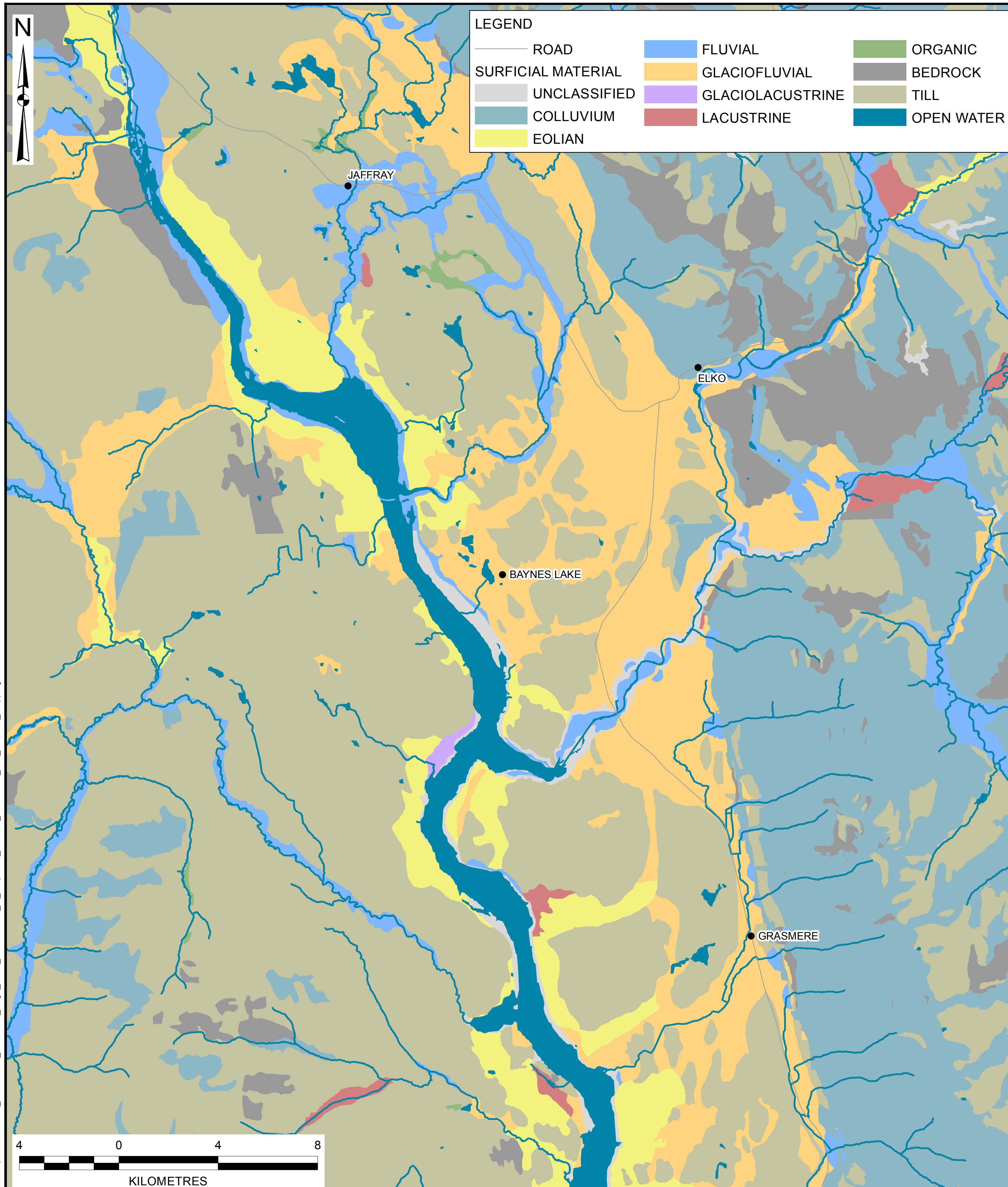

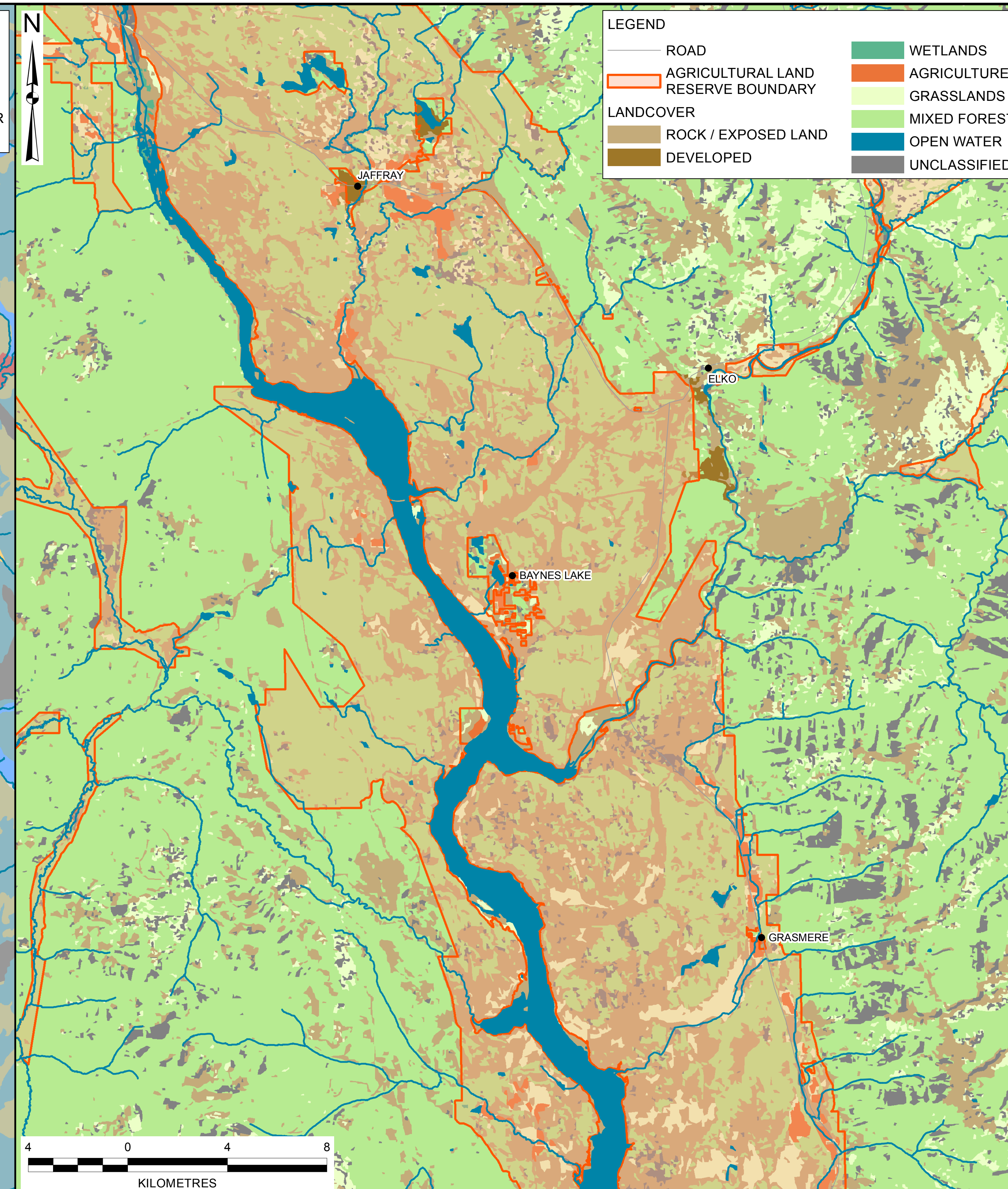

NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "LAKE KOOCANSUA - HIGH LEVEL ASSESSMENT OF A PROPOSED DAM", AND DATED MAY 2020.
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PROJECT:
LAKE KOOCANSUA - HIGH LEVEL ASSESSMENT OF A PROPOSED DAM

TITLE:
LANDCOVER AND SURFICIAL MATERIAL

PROJECT No.:	DWG No:
0466-001	02

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