Cottonwood Creek Water and Aquatic Resources Assessment

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Prepared for:
Living Lakes Canada
Nelson, B.C.

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Executive Summary

Cottonwood Creek watershed lies immediately to the south of Nelson B.C. with its headwaters in the Apex cross country ski area near Cottonwood Lake. The watershed drains north from mountain peaks and wetlands near the headwaters, through largely undisturbed privately held forested and semi-urban areas with build up creek banks and infilled floodplain just outside of Nelson, over Cottonwood Falls and through dense urban and light industrial zones, through the CPR lands in a concrete flume, to discharge into the West Arm of Kootenay Lake near the City of Nelson public works yard. Cottonwood Creek and three tributaries - Giveout, Selous and Gold Creeks – support forest harvesting on public and private lands, and have a history of metals exploration, extraction and smelting. The Giveout Creek watershed is crisscrossed with roads and trails, and both ground and surfaces waters are extracted throughout the entire watershed for a host of uses. All this use and development has affected the aquatic health in the watershed to an unknown degree.

To address these concerns of the aquatic health of the watershed, Living Lakes Canada commissioned this report to summarise and assess known water resources data and to determine water and aquatic related data and knowledge gaps with the end goal of developing a watershed management plan with a focus on water and aquatic resources.

Watershed management planning requires water resources data, and the analysis of existing water resources data found that water and water related resources in Cottonwood Creek are not well documented. Until very recently, there was no continuous hydrometric data for Cottonwood Creek; historic hydrometric data for Giveout and Selous Creeks exist but are limited in utility. Although surface water licenses state maximum water withdrawal rates for a variety of uses, the actual amount withdrawn is unknown, and the impact on aquatic resources especially during high demand periods has not been studied. Groundwater use from the 45 registered users is also unknown since available data only indicates well yield and not amount used.

Official water quality data - water samples that have been collected to a known standard - are sporadic and limited. The limited data indicates that metals concentrations are within provincial guidelines for the protection of aquatic life. Recent CABIN data collected indicates mixed results but overall good water quality. During the spring during rain events in the lower watershed, the creeks is very turbid largely due to city street abrasives being directed into the City of Nelson storm water system and discharging into Cottonwood Creek, resulting in sedimentation of lower reaches and negative impacts on aquatic life and fish habitat. Groundwater quality is a concern and potential threat to creek health particularly in the CPR owned land near the mouth.

Aquatic resources data – fish, fish habitat and invertebrates - have been studied and reported on several times. Rainbow Trout is the dominant fish species and inhabit all sections of the creek although whether the population abundance is at the creek carrying capacity is unknown. A complete habitat assessment from mouth to headwaters following the provincial Fish Habitat Assessment Procedures has not been completed, although it is clear that fish habitat is severely degraded in lower creek sections, particularly in all sections that pass through the City of Nelson. Fish habitat above Silver King Ski Hill Road area is considered good to excellent and fair to good between the Cottonwood Creek Falls and Silver King Ski Hill Road area.

A preliminary assessment of key threats to the aquatic health of the watershed includes sediment discharge from City of Nelson storm water sewers into the creek, water quality of effluent downstream of historic mining operations and resource extraction in the upper watershed, fish migration barriers posed by two culverts, groundwater contamination and floodplain encroachments. Data gaps include lack of continuous hydrometric and understanding of surface and groundwater use, comprehensive water quality data, a formal fish habitat assessment of the entire mainstem, and better understanding of ground water quality, possible contamination and interactions with surface waters.

Next steps to address the data gaps and preliminary threat to aquatic health of the watershed include considering development of a watershed management plan, securing use of the hydrometric data owned by the City of Nelson, continued collection of water quality data and re-evaluation of the collection plan given information in this report, conducting a fish habitat assessment following provincial standards, developing a list of possible instream and riparian enhancement project options, and engaging with the City of Nelson concerning how the creek corridor can be protected from encroachments of current and future land developments.

Limitation

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Yours sincerely,

2024-02-14

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1 Introduction

1.1 Background

Cottonwood Creek watershed despite its small size has seen a lot of development and changes over the last 150 years since settlers moved in and built industry, a townsite and community in the late 1800s. Although not overly evident to the casual eye, the watershed has seen more than its fair share of development and changes since that time. Development places pressures on the land and water and can cause a host of issues including losses of terrestrial and aquatic wildlife habitat, water quality degradation, groundwater pollution, soil erosion and loss and overuse of surface waters.

Cottonwood Creek is the main creek that drains through the town of Nelson. Its headwaters are high to the south and ringed by Evening Ridge to the east, Toad Mountain to the south, and the west shoulder of Giveout Creek to the west (Figure 1). The watershed is small in area at 64 km^2 but ranges in elevation from 532 m at the mouth to 2,200 m on Toad Mountain. The watershed also supports a wide variety of uses – from dense urban neighbourhoods, light industry and green space within the City of Nelson, to rural properties and logging on private lands outside the City along the creek corridor, to logging and recreational opportunities in the upper watershed elevations. All these activities use or influence water in one way or another. Although many local businesses and individual rely on the natural features and 'services' that the Cottonwood Creek watershed supply, there has never been an assessment and summary of the state of water resources in the watershed. In order to address this deficiency, Living Lakes Canada has commissioned this report that examines historic and current developments within the Cottonwood Creek watershed to determine what effect there is, if any, on the current state of water-related resources in the watershed.

The outcome of this report may lead to development of a watershed management plan that outlines processes and procedures for further understanding water and aquatic resources, how to protect them and ensure their quality and adequate quantify for users including wildlife.

1.2 Watershed Description

The Cottonwood Creek watershed encompasses an area of approximately 64 km^2 from the mouth near the City of Nelson's public works building to the headwaters immediately north of the Apex meadow where the Nelson Nordic Cross Country Ski club operates. The watershed contains three main tributaries to Cottonwood Creek: Gold Creek (4 km^2), Giveout Creek (15 km^2) and Selous Creek (15 km^2). The City of Nelson land base that drains to Cottonwood Creek is 3.4 km^2 and includes part of Uphill, Rosemont, and part of the downtown core (Figure 2).

The creek's profile is fairly consistent for most of its length. Gradient in the first reach where most fine sediment deposits is 0.5 %. Gradients through the CPR land and up to the waterfalls average 2.5%. In the remaining reaches until about 1000 m downstream of the lake, the gradient is consistently 4.9%. Fine sediment does not deposit in this section, and there are no active floodplains in the lower half of this section. The last 1000 m near the lake is on average 2.5% gradient.

Cottonwood Creek watershed has a long and detailed history of land use developments in the forestry, mining, transportation, energy, commercial, residential and industrial land use sectors. Current significant

(major) land uses in the watershed include forestry operations in the upper watershed, limited residential and commercial operations in the valley bottom mid watershed sections, and urban, commercial and light to heavy industrial development in the lower watershed. Highway 6 follows the creek closely in the valley bottom in the lower half of the watershed, and departs moderately from the creek alignment in the upper half of the watershed. A transmission line also follows the valley bottom and crosses the creek once in the vicinity of the Gold Creek confluence, otherwise the transmission line is well removed from the creek's active riparian area. All parts of the watershed contain active and abandoned roads and trails that service active logging cut blocks or abandoned mineral claims. The upper watershed area is dominated by logging both on private and public land. The lower half of the watershed is largely urban and semi-rural on the interface between the upper and lower sections.

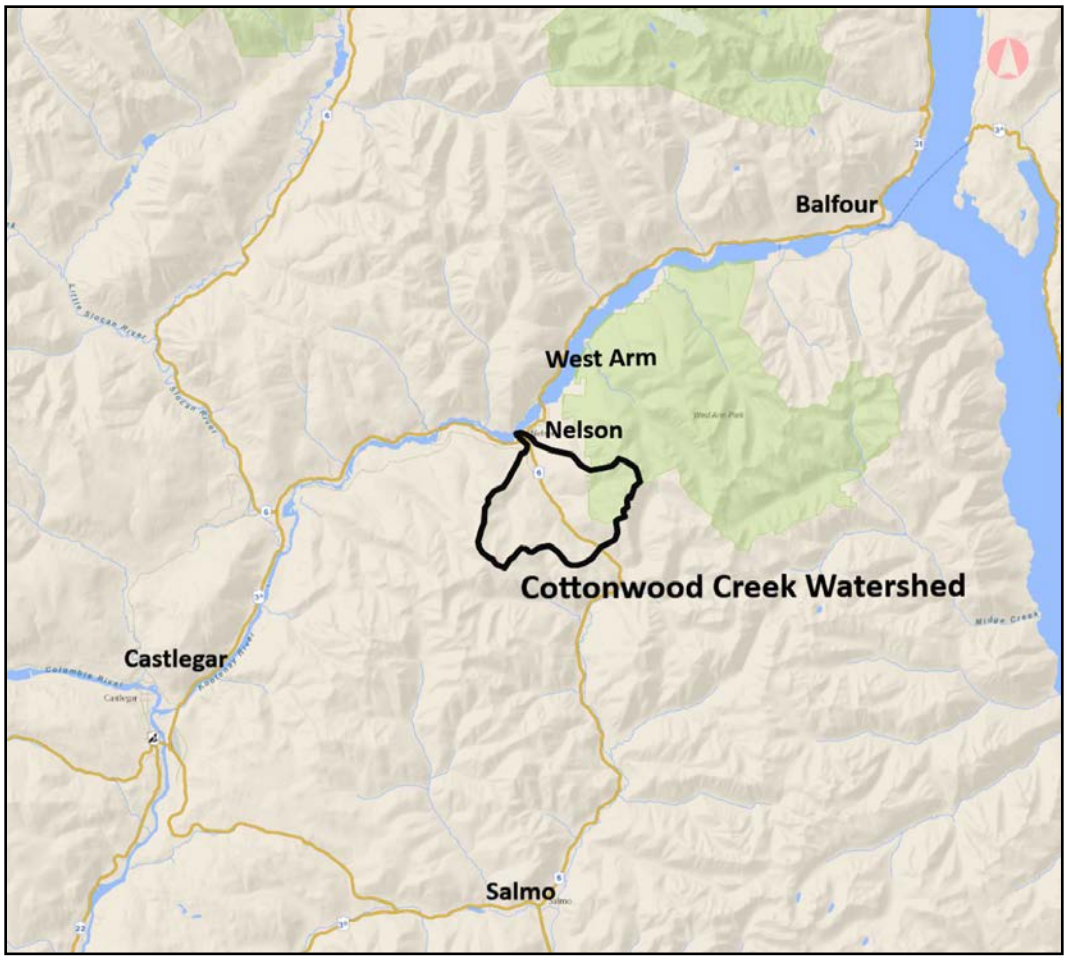

Figure 1: Location map of Cottonwood Creek south of Nelson B.C

1.3 Geology

Surficial materials found in Cottonwood Creek watershed were deposited during and after the Fraser Glaciation that ended approximately 11,500 years ago (Ryder et al. 1991). Most areas, particularly mid and lower elevations are covered with glacial and ablation tills that were deposited directly from glacier advancement and melting. Most tills in the drainage are basal tills with a common matrix of silt loams and fine sandy loams and are typically present at depths greater than 0.6 m (Deschenes et al. 2000). In the upper watershed, Cottonwood Creek has cut down through surficial soils and has exposed the underlying

till. There are also significant colluvium deposits, particularly in the valley bottom in the mid and lower watershed that are comprised of both coarse rock fragments and tills. In most of the lower reaches with higher stream gradient, erosive energy and discharge than upper reaches, the stream banks are comprised of large and stable colluvium material with some evidence of placed riprap. The creek planform is bounded by this large material and thus the creek's banks are stable and "armoured" in middle sections. In lower sections, particularly below the falls, creek banks have been riprapped over time with oversized angular rock to prevent bank erosion.

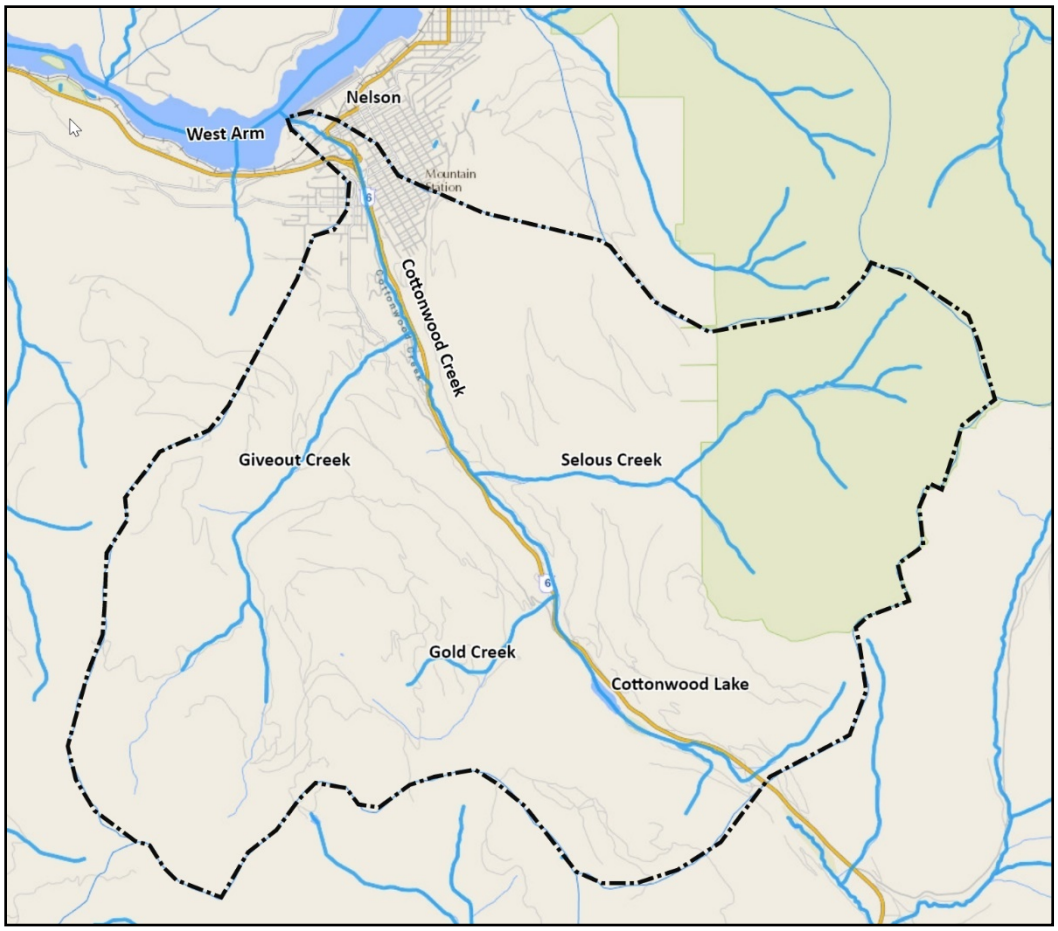

Figure 2: Outline of Cottonwood Creek watershed boundary and showing three main tributaries.

2 Past and Current Land Use of Cottonwood Creek Watershed

Cottonwood Creek is in the traditional territories of the Ktunaxa, Syilx and Sinixt Peoples. The Lakes (or Sinixt) People in particular settled in the Nelson area and used it as both a permanent and seasonal camp. It is possible that the Cottonwood Creek corridor was used by the Sinixt to travel south as there is a record of an old Sinixt footpath going south of Nelson towards Salmo; however, there is no ethnographic evidence to support a heavy use year-round traditional use along Cottonwood Creek (Pearkes, 2022). In the early days of settlers in the Nelson area, the creek got its current name from a trapper known as Cottonwood Smith who had a trapline along the creek. The creek name was initially known as Cottonwood Smith's Creek eventually became known as Cottonwood Creek (Norris, 1995).

2.1 Mining

Indigenous Peoples and their lifestyles were the sole human influence over the Cottonwood Creek watershed until the late 1800s. Settler resource extraction began following the discovery of silver, gold, zinc, lead and copper high in the watershed on the slopes of Toad Mountain in 1886. This led to the development of the Silver King mine between 1887 and 1900. The Silver King Mine extracted 202,000 metric tons of rock, 138,000 kg of silver and 6,800 kg of copper[1]. In 1958 16 tonnes of rock were milled and small quantities of silver, gold, lead and zinc were recovered. In 1883 the mine continued operation under the Hall Mines Company of London England Rock who built a 7.3 km long tramway and opened a 100 tonne per day smelter in 1896 in lower Rosemont, which increased to 300 tonnes per day in 1897. The smelter closed in 1907. Production under various companies continued until about 1949. Numerous small companies have owned or leased the property throughout the 1900s, the last exploratory work being recorded in 2009. Tailings from the smelter were dumped and left on the now CPR land to the south of the former RDCK transfer station at the very mouth of the Cottonwood Creek watershed. Black sand - the remaining slag from the smelter - remains along the lake foreshore to this day. Evidence of the mine - old wooden buildings, some unidentifiable machinery and large piles of crushed rock still exist below the Toad Mountain Peak in the Giveout Creek watershed.

Most of the registered mining claims are in the Giveout and Gold Creek watersheds. There are 22 mineral occurrences – locations where valuable minerals have been sampled. Over the years approximately 109 crown land grants were awarded to miners prospecting in the watershed. The vast majority of these were never worked and reverted to the crown. Nine mines in the western half and two mines in the eastern half of the watershed on or near the valley bottom were production mines (Figure 3).

One abandoned mine is located on the valley bottom just downstream of the confluence with Gold Creek. The Perrier Mine operated from 1913-1948 and mined 2027 tons of silver, gold, and lead bearing rock[2]. Remaining evidence of this mine or its effect on Cottonwood Creek water quality is unknown.

There are no recorded placer mining claims or operations in the watershed. Historical placer mines were typically located either within or near active creeks and rivers and can be extremely disruptive to the natural stream bed.

[1] Minfile Report No.: 082FSW176
[2] Minfile Report No.: 082FSW208

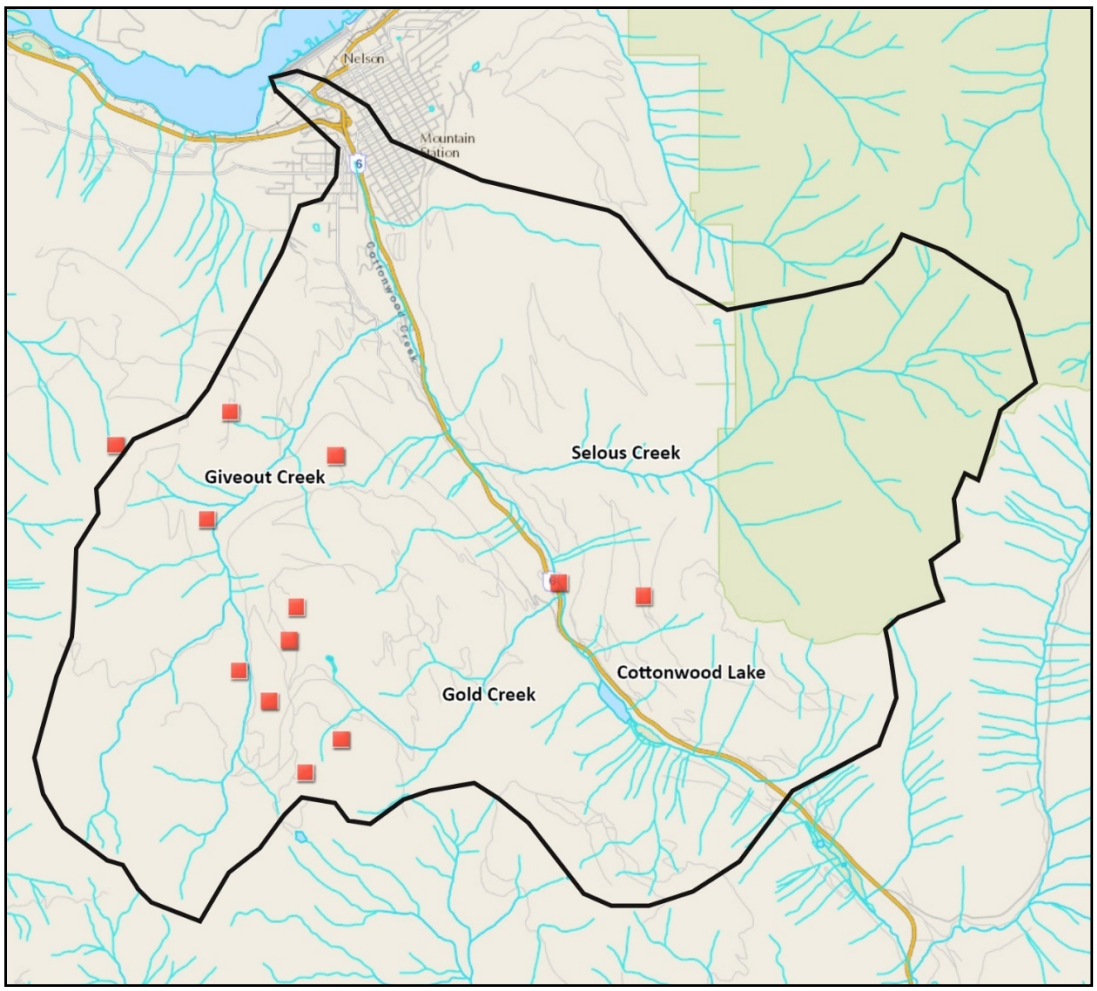

Figure 3: Dormant production mines in the watershed indicated with red marker.

2.2 Forestry

The Cottonwood Creek watershed outside of the city hosts forest harvesting operations in both the lower valley and upslope areas. Forestry in areas outside of the City of Nelson city limits fall into two categories: that which occurs on private land, and that which occurs on public land. Much of the land along the Highway 6 corridor is privately owned and managed by individuals or companies that are largely free to log and manage their land with few regulatory oversights[3]. They are however subject to requirements in the Water Sustainability Act and several other Acts that directly or indirectly involve water[4]. The upper elevation areas to the north and south of Cottonwood Creek are crown land with two West Kootenay companies holding tenures - Kalesnikoff Lumber Company, and ATCO Wood Products – to extract wood annually. Kalesnikoff operates in the eastern slopes that includes Selous Creek watershed, ATCO in the western area that includes Giveout and Gold Creek watersheds (Figure 4).

[3] https://kootenaymountainculture.com/logging-in-british-columbia/
[4] https://www.thefreepress.ca/news/b-c-ministry-clears-up-confusion-on-private-land-logging-regulations-5116233

Figure 4: Aerial view of forest harvesting in upper watershed; Nelson on right. Image date July 4, 2023

Historically the watershed was logged by locals. The earliest provincial records concerning harvesting in the watershed occur in 1961. Since that time, approximately 1826 hectares[5] have been logged (Figure 5). This is an approximate figure as some areas are included twice as they are on their second logging rotation, and logging occurred well before 1961 when publicly available records were published on government websites.

[5] Based on data derived from forestry layers at https://maps.gov.bc.ca/ess/hm/imap4m/

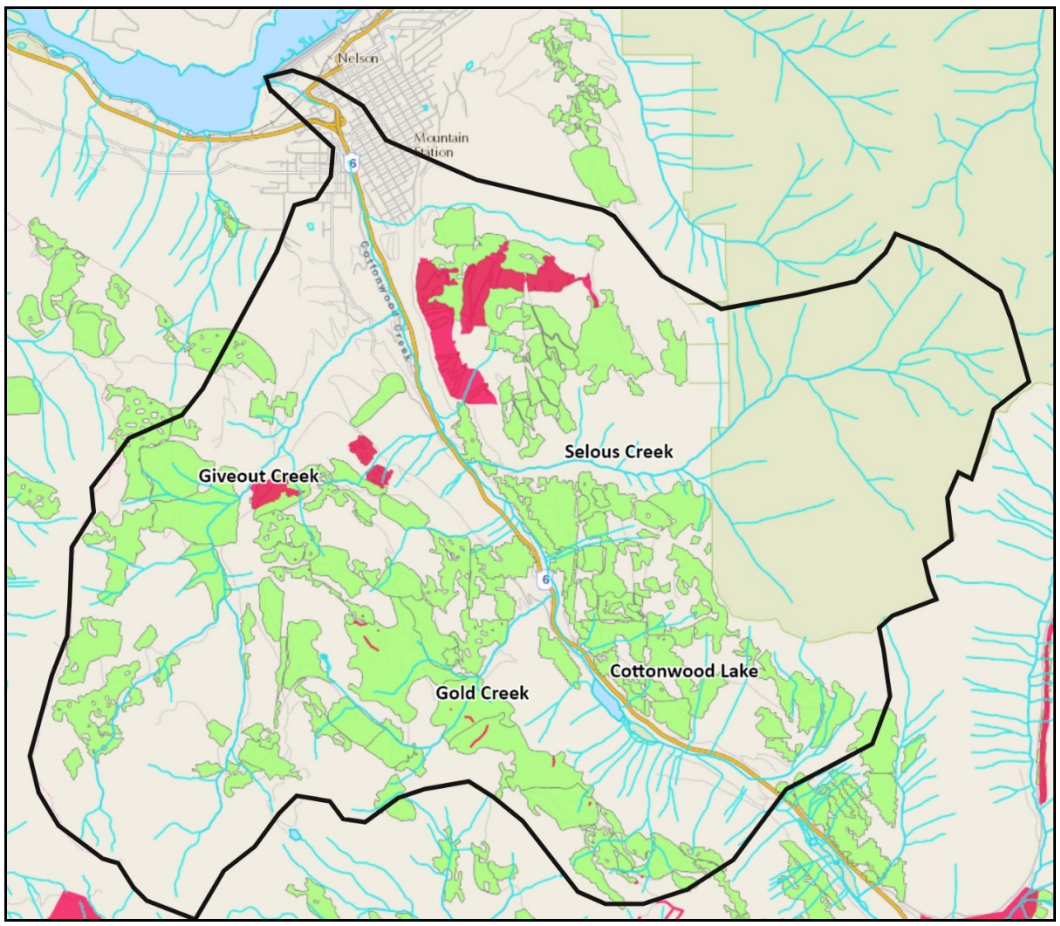

Figure 5: Forest harvested areas since 1961 in green; red indicates most recent areas harvested.

2.3 Hydropower

Nelson Hydro operated a run of river hydro electric plant on Cottonwood Creek starting in 1896 in the vicinity of the present day Cottonwood Falls. Water was diverted from the creek above the Cottonwood Creek falls in a 500 foot long wooden flume and pipe combination to a power plant located adjacent to the present site of the Nelson District Rod and Gun Club. The Cottonwood Creek power plant life was short lived as the City developed the current hydroelectric powerhouse at Bonnington Falls on the Kootenay River and commenced power production in 1907 and the Cottonwood Creek plant was abandoned[6].

2.4 Linear Developments

Linear developments are land development features that are narrow in width but extend for long distances and can act as fish and wildlife migration barriers (e.g. through culverts under roads, highways), cause increased soil erosion through runoff in ditches, increase in invasive species establishment, loss of wildlife habitat etc. Linear developments[7] in the Cottonwood Creek watershed include (Figure 6):

[6] http://www.nelson.ca/937/Heritage-Power
[7] Data derived from applicable provincial iMap layers.

- 8.9 km of the 48 km long Nelson Salmo Great Northern Rail Trail within the watershed;
- Water pipeline that is buried under the Rail Trail from Selous Creek water intake to the Nelson area;
- 11 km of Highways 3A and 6;
- Transmission line and cleared right-of-way that parallels Highway 6;
- 39 km of paved roads;
- 137 km of unpaved resource roads (e.g. Forest Service Roads, old mining roads/trails etc.); and
- 38 km of rough recreational trails.

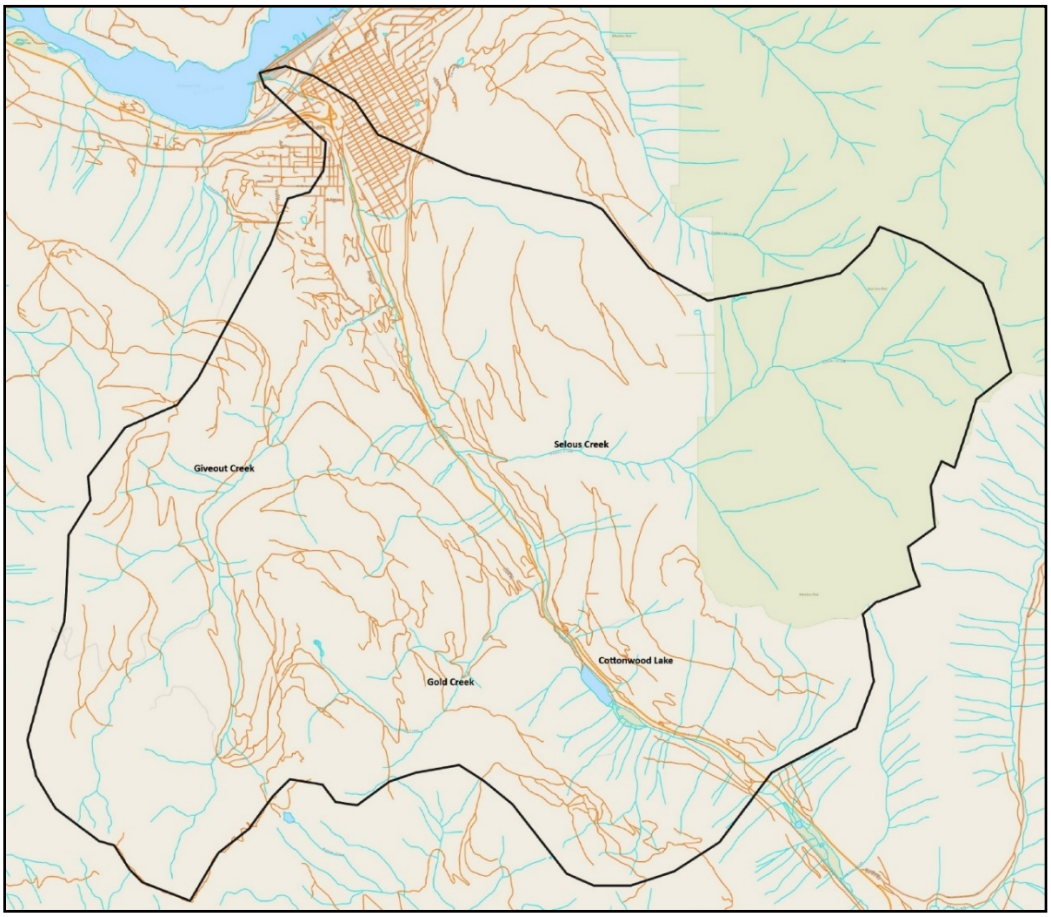

Figure 6: Linear developments- paved and gravel roads, trails - within the watershed.

2.5 City of Nelson

The most downstream part of the watershed drains through the City of Nelson. Cottonwood Creek enters the city just downstream of Cottonwood Rd and discharges into the West Arm of Kootenay Lake at the west end of the airport and encompasses 2.1 km^2 of the watershed. There is a long history of creek side development since the 1890s when the City built the run-of-river hydroelectric generating facility at the falls. Houses, businesses and industry have always been located beside the creek on the floodplain and have endured several flood events when the creek overtops its banks (BGC, 2023). The creek is heavily

impacted by the close proximity of developments as is evident by the concrete walls and large rock that form the creek banks and the limited riparian area. The creek downstream of the falls flows over a large alluvial fan where the creek once laterally moved back and forth over the millennia before it became confined in the present day channel. The mouth area would have appeared similar to the alluvial fan of 5 Mile Creek at Troupe Junction, populated with large cottonwood trees and small channels running over the floodplain area. Much of Cottonwood Creek is now inaccessible as it passes through private property (e.g. CPR lands, Nelson Ford), or else buildings are built immediately adjacent to the creek (Cottonwood Market area).

3 Water Resources

3.1 Surface Water

Historical hydrometric data for Cottonwood Creek are limited and sporadic in nature. There are no public records of the mainstem creek being gauged. There are likely numerous estimates of Cottonwood Creek discharge in grey literature concerning instream projects (i.e. – Baker Street bridge rebuild, several culvert placements, recent creek side developments that may have calculated flood levels, etc.) however these values would be based on historical hydrometric data derived from a regional hydrometric analysis or climate data to compute runoff and to derive extreme discharge values. Although derived values are useful as an estimate of watershed hydrology, real time data is much preferred.

Giveout Creek was gauged over 5 years from 1944 to 1948 (Water Survey of Canada hydrometric station No. 08NJ123[8]) and Selous Creek was gauged sporadically over 20 years from 1926 to 1975 (WSC hydrometric station No. 08NJ098[9]). The City of Nelson recently installed a hydrometric station on Selous Creek as part of their domestic water intake infrastructure (Rory Gallagher, per. comm.).

In early 2023 the City of Nelson established a hydrometric station on Cottonwood Creek in the Railtown area (Rory Gallagher, per. comm.) that over time will provide valuable flow data for flood forecasting and detailed hazard assessments.

Hydrometric estimates of current and future hydrological values for Cottonwood Creek are also available online with the Kootenay-Boundary Water tool[10]. The tool provides information on natural water supply, existing water rights, and environmental flow needs of rivers, lakes and streams in southeastern British Columbia. The reports are particularly useful for estimates of water- related flow threats or concerns particularly with low flow/drought conditions, however the data can be inaccurate for smaller watershed as may be the case with this report and as such the report summaries should be interpreted with caution. The report for Cottonwood Creek using the tool is found in Appendix 4.

The province operates a manually operated snow monitoring station (No. 2D04) in the Apex cross country ski area at 930 m in elevation that has been active from 1938. The station is visited monthly and the snow water equivalent is posted[11]. The province also operates the Southridge automated weather station at 1,990 m just 2.5 km to the east of the Cottonwood Creek watershed boundary[12]. Although technically outside the watershed, climate data from this station could be used to understand snowpack and water equivalent in Cottonwood Creek watershed at upper elevations. Lastly, the federal government operates climate station No. 1145M29 in Nelson at 535 m in elevation that is part of Environment Canada's country wide climate station network[13]. Climate data has been collected at this location since 1904, with the current station in operation since 1994.

Cottonwood Creek provides water for many users including for private domestic consumption, irrigation, public utility (City of Nelson), power generation, and irrigation. Water users who divert surface water for

[8] https://wateroffice.ec.gc.ca/report/historical_e.html?stn=08NJ123
[9] https://wateroffice.ec.gc.ca/report/historical_e.html?stn=08NJ098
[10] https://kwt.bcwatertool.ca/watershed
[11] https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=c15768bf73494f5da04b1aac6793bd2e
[12] https://avalanche.ca/map?panel=weather-stations%2F22
[13] https://weather.gc.ca/city/pages/bc-37_metric_e.html

any use must have an active water license that states the maximum allowable withdrawal rate (Figure 7). The total licensed amount of water in the Cottonwood Creek watershed is 7,851 cubic metres a day or 90 litres per second. Table 1 summarizes the number of active surface water licenses in the watershed. There are 147 active surface water withdrawal licenses, the majority of them for domestic use that only accounts for 3.4% of the total allocation. The largest license holder is the City of Nelson ('public utility') for withdrawals from Selous Creek during summer and fall periods when creek water discharge is the lowest. The second largest user is for commercial power production with a priority date in 1945 in the Giveout Cr watershed and used presumably to run a small hydroturbine such as a pelton wheel. It is unclear whether this facility still exists but if so, the water would necessarily return to Giveout Creek and have negligible impact on downstream water users or the watershed as a whole.

Table 1: Number and licensed amount of water licenses in several water license categories and distribution within sub drainages[14].

Use or Watershed	Number of Active Licenses	% of Numbers	Active License Amount (m^3/day)	% of Total Licensed Amount
Domestic	90	61.2%	266	3.4%
Irrigation – private	20	13.6%	271	3.5%
Commercial – Power production	1	0.7%	2,592	33.0%
Industrial	2	1.4%	1	0.01%
Public Utility[15]	1	0.7%	4,546	57.9%
Commercial	10	6.8%	139	1.8%
Other	23	15.6%	38	0.5%
Total	147	100.0%	7,851	100.0%
Giveout Cr	17	11.6%	2,860	36.4%
Selous Cr	3	2.0%	4,557	58.0%
Gold Cr	0	0.0%	0	0.0%
Cottonwood Cr	18	12.2%	170	2.2%
Small creeks and springs	109	74.1%	265	3.4%
Total	147	100.0%	7,851	100.0%

Cottonwood Creek has been considered as a domestic water supply option for City of Nelson (Urban Systems, 2017). The concept is considered 'marginal' as Cottonwood Creek would not supply sufficient licensed water especially during a drought year and the water is susceptible to contamination due to the close proximity to Highway 6. The intake would be between Selous Creek and Cottonwood Lake.

[14] Derived from data in iMapBC. See https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc

[15] City of Nelson withdrawal for domestic supply.

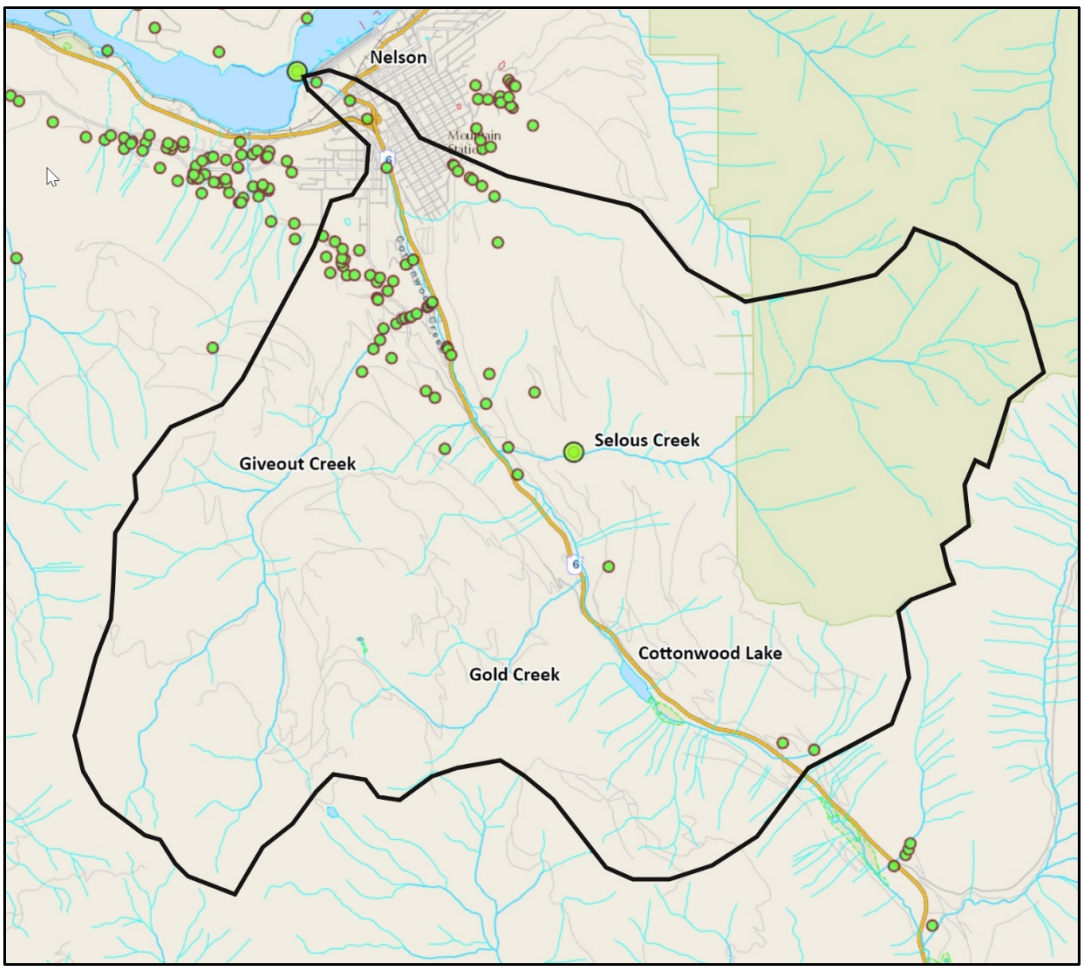

Figure 7: Surface water licenses the watershed as indicated by green dots.

3.2 Groundwater

Most of the domestic consumption using wells is concentrated in the valley bottom just outside of the city limits up to the Silver King Ski Hill Road area (Figure 8). Domestic-only use of well water does not require a license, however registered well drillers must submit well construction or decommission reports to the province. The province requires that all non-domestic well water users have a water license[16] that states a maximum allowable withdrawal rate.

Currently in the watershed there are 45 unlicensed wells that are primarily for domestic use (Table 2). The total yield of all wells combined is 4,001 litres per minute or 5,761 cubic metres per day. This is the maximum withdrawal rate based on well tests; the actual withdrawal amount is likely much less. Irrigation which typically is a large user of water only accounts for 10.4% of groundwater use. Over half of the total registered yield is registered for 'unknown' or 'other' uses.

Table 2: Registered Groundwater Well Users by Type

[16] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/groundwater-wells-aquifers/groundwater-wells/information-for-property-owners/well-records-registration/domestic-well-registration

Use	Number	% of Number	Well Average Yield (litres/min)	Total yield (litres/min)	% of Total Yield
Private Domestic	29	65%	51.2	1,381.6	34.5%
Irrigation	2	4%	208	415.8	10.4%
Commercial/ Industrial	1	2%	No data	No data	No data
Other/unknown	13	29%	169.7	2,203.7	55.1%
Total	45	100.0%	95.4	4,001.1	100.0%.

No publicly available data exists for groundwater resources within the watershed's upper elevations, and no known studies have examined groundwater resources except at the mouth area. CP Rail has many groundwater monitoring wells throughout their land near the waterfront; however, the raw data and/or summary reports concerning possible groundwater contamination and interaction of groundwater with the creek are not publicly available.

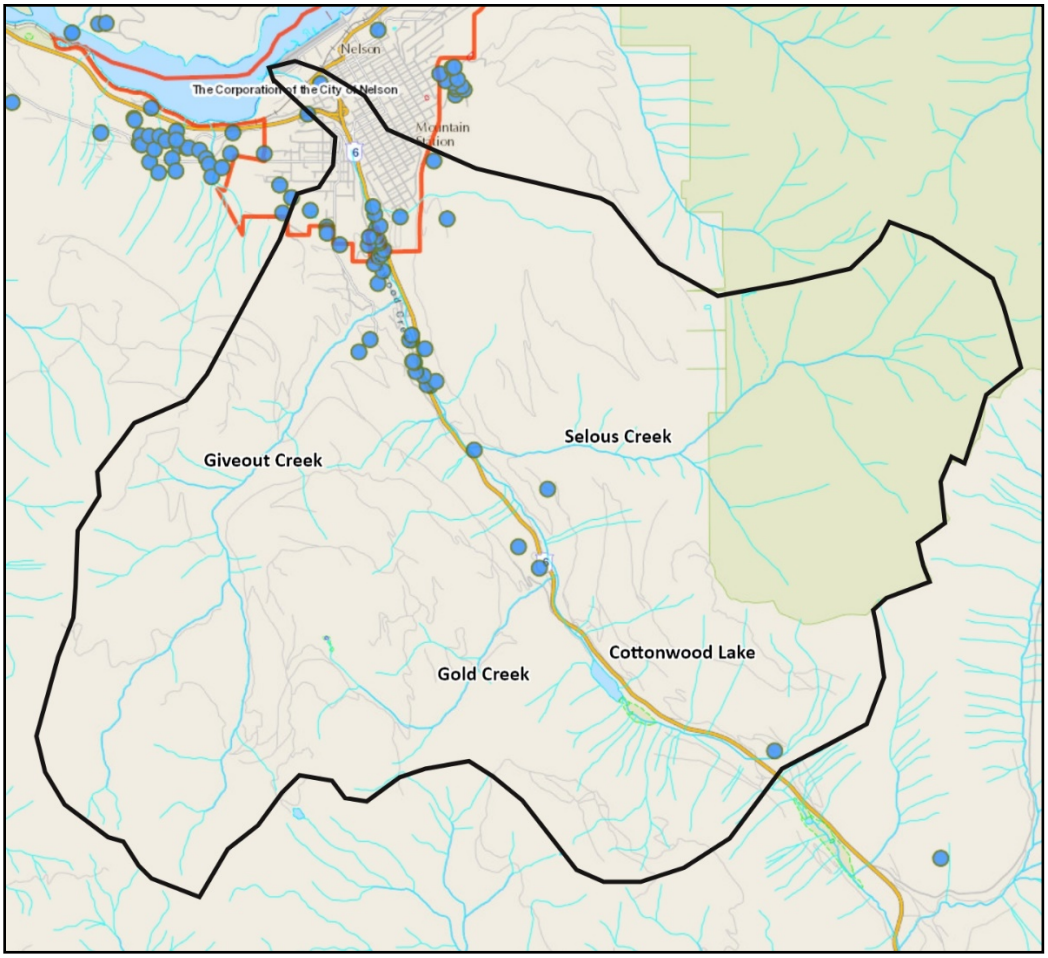

Figure 8: Registered groundwater wells in the watershed as indicated by blue dots.

3.3 Water Quality

Water quality sampling efforts and data in the Cottonwood Creek watershed has been sporadic and limited. There are two periods when water quality was sampled, in 2008, and from 2020 to the present.

The province conducted a water quality analysis using one sample on September 9, 2008 (See Appendix 1) for metals, conductance, pH, alkalinity and other elements. Under a separate initiative, between May and October 2008 Adam Kowalyshyn of the NDRGC took a series of water quality samples at Cottonwood Creek Lake, Selous Creek at the confluence with Cottonwood Creek, Cottonwood Creek at the falls and at the mouth with Kootenay Lake. The samples were analysed by UBC (See Appendix 2). None of the parameters tested exceeded guidelines for the protection of aquatic life[17] for either sampling program.

More recently water quality was assessed in 2020 and 2021 by the Friends of Kootenay Lake[18] following the CABIN[19] procedure. The CABIN procedure measures freshwater ecosystem health by focussing on small aquatic organisms (macroinvertebrates) whose presence or absence and abundance indicate the stream's ability to support aquatic life and point to possible agents responsible for the results. Three metrics were used to assess the health of aquatic life of 198 macroinvertebrate species in Cottonwood Creek relative to local reference streams[20]. Most indicators point to a good to excellent stream health with Cottonwood Creek being as healthy or healthier than local reference streams. The few exceptions may be due to legacy land disturbances in the upper watershed. Watershed monitoring following the CABIN procedure was carried out in 2023 (results pending) and will continue annually into the foreseeable future pending funding (per. comm. Paige Thurston).

Invertebrates were sampled following a modified CABIN procedures in October 2013 by Smit (2014) to determine the Shannon-Wiener Index (H'), the biotic index (BI) and the %EPT[21]. Results indicate that Cottonwood Creek has some impaired water quality compared to reference creeks, and that the invertebrate community is more tolerant of organic water pollutants than those aquatic invertebrate communities in the reference creeks (Smit 2014).

Water quality in Selous Creek is sampled annually by the City of Nelson as Selous Creek is one of four watersheds that City of Nelson extracts raw water from for distribution within the City. Results from the latest posted report are found in Appendix 3[22]. None of the parameters sampled exceed provincial guidelines for drinking water.

Living Lakes Canada[23] recently implemented a water quality monitoring program in six locations from Cottonwood Creek Lake down to the mouth (per. comm. Paige Thurston). Parameters measured include pH, dissolved oxygen, conductivity, temperature, bacteriological counts, metals and other contaminants. The program's goal is to determine if and where water quality changes as it flows from Cottonwood Creek Lake to the mouth that may point to the type and source of pollution.

[17] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines
[18] https://www.friendsofkootenaylake.ca/
[19] Canadian Aquatic Biomonitoring Network. See https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network.html
[20] See https://www.friendsofkootenaylake.ca/initiatives/watershed-monitoring/
[21] %EPT is the proportion of *Ephemeroptera* (E),. *Plecoptera* (P), and *Trichoptera* (T) in the total abundance sample.
[22] For the complete report including supporting information see: http://nelson.ca/374/Water
[23] https://livinglakescanada.ca/

The City of Nelson commissioned a report to study source water protection in the upper Selous Creek watershed (Dobson, 2021). The report is relevant as it describes threats to the quality and quantity of City drinking water supply. Most of the year water is not withdrawn from Selous Creek and discharges into Cottonwood Creek. Six hazards (e.g. forest development, fires etc.) to drinking water were identified that would result in either sediment production, or sediment production and peak flows. These hazards would likely occur during freshet period when all Selous Creek water flows freely into Cottonwood Creek and is not withdrawn for City domestic water purposes.

3.4 Fish

Fish species known to inhabit or historically inhabit Cottonwood Creek include Kokanee (*Oncorhyhchus nerka*), Rainbow Trout (*Oncorhynchus mykiss*), Redsided Shiner (*Richardsonium balteatus*) and Mountain Whitefish (*Prosopium williamsoni*) (Masse, 2002). Brook Trout (*Salvelinus fontinalis*)) and Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) were added as part of the stocking program and are not considered indigenous (FISS 2023).

Since stocking commenced in 1938, approximately 1.89 million fish - primarily Rainbow Trout and Kokanee - have been stocked throughout the Cottonwood Creek watershed (FISS, 2023). Since 1958, only Cottonwood Lake has been stocked and in the last ten years, the province has stocked the lake with 24,000 Rainbow Trout (FISS, 2023).

Masse Environmental Consultants Ltd. sampled sections of Cottonwood Creek below the falls for fish in July and August 2001. Rainbow trout, longnose dace and slimy sculpin were found (Masse 2002). In 2008 Masse and Miller sampled a 100 m section directly upstream of the Baker Street bridge and captured 18 juvenile and 20 adult Rainbow Trout. Consultants have also sampled for fish at discrete locations in the upper watershed primarily in the mainstem and found Rainbow Trout in several areas. It is reasonable to assume that Rainbow Trout are found throughout the upper mainstem reaches as spawning may occur here (Masse 2002) and some hatchery Rainbow Trout out-planted in the lake likely migrate downstream.

The most recent fish sampling that has occurred in Cottonwood Creek found Rainbow Trout, Longnose Dace (*Rhinichthys cataractae*), Sculpins (*Cottus spp*.) and a spawning Bull Trout (*Salvelinus confluentus*) (Smit, 2014). The survey was conducted in the fall of 2013 in the two bottom reaches (immediately downstream of the CPR lands to the mouth with Kootenay Lake). Bull trout have not been recorded before in Cottonwood Creek and suggests that if spawning habitat in the lower Cottonwood Creek were rehabilitated it might be utilised for spawning Bull Trout and Kokanee (Smit, 2014). Rainbow Trout fry also found near the old spawning platforms (immediately upstream of Lakeside Drive bridge) suggesting that a spawn occurred here in the spring of 2013 (Smit 2013).

3.5 Fish Habitat Assessments and Fish Habitat Restoration Projects

Several fish habitat assessments have been conducted on the Cottonwood Creek mainstem following variety of standards (Thomson, 2009, 2013; Smit, 2013; Silvatech 2014; Selkirk College, 2004; Masse 2002, 2013) although no formal fish habitat assessment following the provincial Fish Habitat Assessment Procedure (Johnson 1996) has been conducted. Thomson (2009) described all four reaches of the creek, from the mouth to Cottonwood Lake in detail. Thomson (2013) and Smit (2013) describe the fish habitat in detail downstream of Cottonwood Creek falls. Silvatech (2014) focusses primarily on culvert

assessments and fish migration barriers throughout the mainstem. Masse (2002) described habitat and riparian areas in several areas along the mainstem up to the lake.

3.5.1 Between Cottonwood Lake and Silver King Ski Hill Road (4.2 km)

Fish habitat in the Cottonwood Creek mainstem from the Silver King Ski Hill Road to Cottonwood Lake is largely unimpacted. The creek bed comprises of stable alluvial sediments of varying size, some suitable for spawning, the riparian area consists of mature conifer trees and brush that shade the creek, there is an abundance of wood and organic matter in the wetted perimeter, and the floodplain is accessible and active during freshet. Sediment deposition in the creek bed from the highway and upslope activities has occurred in the past (Thomson, 2009). Rainbow Trout have been sampled sporadically throughout this section. There are no known barriers to fish migration from the Silver King Ski Road area towards Cottonwood Creek Lake.

3.5.2 Between Silver King Ski Hill Road and Cottonwood Creek falls (2.9 km)

Fish habitat in the section downstream of the Silver King Ski Hill Road is markedly different than upper sections. The creek channel is confined in most sections with large angular rock (riprap) along both banks. There is no active floodplain as it has been either infilled or made inaccessible with the riprap. Annual floodwaters remain bound by the rock banks resulting in torrent flow conditions that fish would find difficulty holding in and spawning sized gravels are largely absent in narrower sections. Deep pools area found throughout the section, and Masse (2013) considers the habitat value as high. The riparian zone, although narrow in many places, is largely intact and shades and overhangs the creek. Notable exceptions include where Highway 6 is near the top of the bank and where the creek is adjacent to Nelson Toyota. Two culverts are fish migration barriers under most flow conditions, and certainly for juveniles under all flow conditions at where the creek passes under Highway 6 near Strom Rd and at Kline Rd.

Historically Kokanee were observed and spawned in Cottonwood Creek sections below the falls. Habitat degradation due to encasing the creek in a concrete flume, channelisation, sedimentation, and water pollution are thought to be responsible for the absence of Kokanee spawning in the creek (Thomson, 2009). To address the notable Kokanee absence, a collaboration and largely volunteer effort in 1990 between the BC Fish and Wildlife and the NDRGC resulted in spawning platforms being installed in the mainstem channel between the CPR flume and the Lakeside Drive Bridge. Large sill logs that are still present were placed across the channel and backfilled with spawning gravels. Fifty thousand Kokanee eggs were then planted in the newly established gravel platforms. Unfortunately, Kokanee did not return to spawn in the platforms in the following years.

In the 1940s, the Nelson District Rod and Gun Club (NDRGC) built over a series of years 10 juvenile Rainbow Trout rearing pools at the bottom of Cottonwood Creek falls where the Japanese gardens and the Cottonwood Creek market are located. Some time later at the same site a hatchery was built and operated by the provincial fish and game branch. Millions of Kokanee Salmon, Rainbow Trout, and Eastern Brook Trout eggs were raised at the hatchery and fingerlings were distributed as far as Ontario, Oregon, Washington, and California[24]. Rainbow Trout raised in this hatchery were used to stock Cottonwood Creek. Water for the hatchery came directly from the creek. However, pollution – heavy silting and raw

[24] Nelson Daily News. March 17, 1965.

sewage - in the creek caused several die-offs and even after the hatchery started using well water, water pollution remained a problem[25]. The hatchery closed in 1965 and operations were transferred to a new hatchery facility built near Wardner in the East Kootenays (Province of B.C., 1965).

3.5.3 Between Cottonwood Creek Falls and the downstream side of CPR lands (0.6 km)

In this section the creek is confined in its entirety by either large angular rock or concrete. The channel width is extremely narrow as adjacent properties have developed to the top of the bank and eliminated or filled in the floodplain. Water velocity during freshet approaches 4 m/s. The channel bed comprises of large stable rock or concrete – there are no spawning sized gravels, off channel habitat, instream wood and organic debris, all features that fish require to inhabit the area. Riparian vegetation is sporadic throughout. The creek is encased in a concrete flume through CPR lands which was built in the early 1950s after the 1948 flood severely impacted CPR yard operations. The flume itself is a fish migration barrier and has no fish habitat value. The downstream end of the flume is a 1 m drop that also constitutes a fish migration barrier.

3.5.4 Between End of CPR lands to mouth (0.33 km)

This section contains natural features such as native gravels, mature riparian vegetation and limited in-stream woody debris. Creek banks are mostly vegetated with limited riprap and there is no evidence of recent bank erosion. This is the only section in the lower reach where the creek functions naturally as is evident from partial lateral, side bar and riffle formation, sediment deposition patterns and weak meander formations. The installed sill logs across the entire wetted width however partially confound natural channel function (including lateral movement) and sediment deposition, although pools have formed below each sill log which are likely utilised by resident fish.

The section closest to the West Arm of Kootenay Lake downstream of Lakeside Drive bridge is low gradient and relatively wide where fine sediments deposit and mid channel bars form. Kootenay Lake backwaters here during high water events, typically during spring freshet and late fall. Banks are well vegetated with native tree and shrubs (both naturally stocked and planted by the NDRGC) and stable. No large wood is found in the wetted channel. Fish residence in this section is likely low except during high water as pools, spawning habitats and in-stream overhead cover are lacking.

3.6 Preliminary Assessment of Key Threats to Watershed Health.

There are several key threats - in no particular order - that impact the health of the watershed, primarily pertaining to water quality, quantity and aquatic health:

1. Heavy loading of sediment (road abrasives) from City of Nelson stormwater discharge into the creek.

The City of Nelson discharges stormwater into the creek at approximately 26 locations as detailed in Thomson (2009). The sediment is primarily road sand and gravel. The coarser fraction (and small gravels) will settle in the lower reaches of the creek where Rainbow Trout and Kokanee spawning could normally occur. The finer fraction (silts) will remain in suspension resulting in high turbidity (murky to the eye) levels

[25] Nelson Daily News. March 17, 1965.

that are damaging to aquatic life. Thomson (2009) found high turbidity levels and total suspended solids concentrations that far exceeded guidelines for the protection of aquatic life. There is little to suggest that these reported levels have changed significantly. In 2008 the City installed three sediment containment traps in the City stormwater system (Thomson, 2009) that are designed to reduce sediment volumes being discharged to the creek.

2. Unknown sediment loading into creek from Highway 6

As detailed in Thomson (2009) snow throw from the clearing of snow from Highway 6 contains road sand and salt/salt brine that can affect water quality in Cottonwood Creek. Approximately 1,950 m of highway is immediately adjacent to Cottonwood Creek, and road salts or abrasives applied to the road may end up in the creek, either from direct snow throw or through drainage via many of the roadside ditches and culverts.

3. Water quality from mining tailings.

Giveout Creek watershed had numerous mining claims that were developed to varying degrees including the well-known Silver King mine. Mining tailings, the rock left on the site are exposed in several areas of the watershed. Exposed mining tailings particularly from metal mines that contain sulfide minerals when oxidized create sulfuric acid which is detrimental to aquatic life. This phenomenon is known as Acid Rock Drainage. It can occur long after a mine ceases production. There are no known water quality sampling data on ARD for the Giveout Creek watershed. Tailings effluent from the Perrier Mine on the mainstem just downstream from the confluence with Gold Creek should also be investigated.

4. Fish Migration Barriers

The downstream end of the concrete flume in the CPR lands (a 1 m high falls) as well as the 170 m long concrete lined flume that bisects the CPR land are fish migration barriers under all flow conditions for all fish species and age classes. There are two culverts – one under Kline Road, the other under Highway 6 - that are classified as a fish migration “barrier” and “obstacle” respectively (Silvatech, 2014). Both sites are considered moderate priority for restoration of fish migration characteristics (Silvatech, 2014).

5. Floodplain encroachments

The floodplain has been encroached upon in lower creek sections, generally starting in the Silver King Road area all the way to the mouth. Buildings and infrastructure have been built up to the top of the creek bank, and the floodplain infilled in some sections. Downstream areas are more prone to flooding when upstream floodplain areas are nonfunctional with little storage capacity.

6. Groundwater water quality concerns in the CPR lands.

The CPR lands have long been known to be contaminated with hydrocarbons because of historic operations. The extent of contamination is not publicly available, nor is information concerning site remediation or future plans for the site. Given that the entire CPR property is located on an alluvial fan with groundwater originating from the Cottonwood Creek watershed, it is possible that any contaminants in the groundwater are slowly migrating towards the lower sections of Cottonwood Creek and ultimately to Kootenay Lake.

7. Sediment inputs to Cottonwood Creek from landslides

Thomson (2009) reported sediment inputs to Cottonwood Creek from several upslope sources including from a 1997 landslide in Schesnuk Creek (between Ward and Selous Creek), and from a cutblock south of

Selous Creek. However, those events occurred many years ago, and the valley bottom deposition zone has not been assessed since.

8. Climate change affecting water resources.

Climate change projections for the West Kootenays as they affect local watersheds such as Cottonwood Creek fall into four broad categories (British Columbia, 2019):

- Warmer and drier summer conditions;
- Increased fire risk;
- Increasing variability; and
- Increasing risk of spring flooding.

All four climate change predictions will have a measurable impact on local watersheds over the next several decades. One of the most measurable impacts involves both the quantity and timing of stream flows in the mainstem Cottonwood Creek and three subdrainages. Spring runoff – or freshet – will occur earlier and be a larger event than historically has occurred resulting in widespread flooding (BGC Engineering, 2023). Cottonwood Creek has been prone to major floods in the past, with at least five occurring since the 1950's (BGC Engineering, 2023), some with destructive consequences. Climate change will only exacerbate flooding and the magnitude of damage given that many structures – private residences, businesses and important infrastructure are near the creek and/or on the floodplain (as described earlier). Typical adaptation strategies being considered or employed by communities include hardening river banks with large rock or sheet piles. dredging and widening channels so that they can convey more water, removing debris in channels including wood that can impede runoff, etc.

Climate change models also predict that low flow periods - typically July to September – will get longer with less water than current conditions which will have a direct impact on aquatic organisms including fish. Water temperatures will also increase given that groundwater discharge into creeks will also be lower in late summer due to early water runoff and a smaller snowpack, and summer air temperatures will increase by 2.4°C[26].

The Kootenay Water Tool predicts water flows and variability for the Cottonwood Creek watershed will decrease over the next several decades for mid- summer to late summer but increase during late fall to early spring periods. These changes are due to less precipitation and hotter air temperatures during the summer period, and precipitation in the winter months falling as rain instead of snow that runs off earlier (see Appendix 3).

[26] https://www.pacificclimate.org/sites/default/files/publications/Climate_Summary-Kootenay-Boundary.pdf

4 Watershed Health Indicators

Watershed health indicators are tools that can help assess the health of a watershed. Watershed health can be measured in any number of ways, and there is no consensus on the superiority of one particular methodology or set of watershed health indicators over another. Issues such as human disturbances, the amount and type of resource extraction, historical use of the watershed, water use, population density, wildlife use, ecological diversity and many other indicators that can be used to measure watershed health widely between watersheds. Indicators tend to be data intensive and can require significant effort and resources to obtain, analyse and present in ways that are understandable, actionable and meaningful. As such, practitioners tend to tailor indicators to a subset of overall health indicators that are directly applicable to the watershed of interest (Fraser Basin Council, 2014).

There are number of considerations in choosing which indicators to use including:

- Relevancy to the state, pressure or management response in the watershed and to reference watersheds;
- Existence of data bases, longevity and/or continuity of data and data quality in the watershed and reference watersheds; and,
- Data should be collected for a sufficient period into the future to allow for data trends to become statistically apparent.

The Fraser Basin Council (2014) prepared a discussion paper on watershed health indicators that proposed the following indicators for watershed health in BC watersheds that are a third order or greater. They are similar to indicators suggested by Alberta (2014). The indicators are grouped into five broad categories: Freshwater Quality and Quantity, Fish and Wildlife, Ecosystems, Resource Use and Impacts, and Resource Conservation.

Freshwater Quality and Quantity

- Stream surface water quality (relevant parameters), quantity; flow allocations, flow commitments;
- Lake levels;
- Groundwater levels and allocations; well density; and
- Benthic invertebrates.

Fish and Wildlife

- Health of resident fish;
- Status of key wildlife populations; and
- Habitat vulnerabilities and pressures.

Ecosystems

- Variation and extensiveness/intactness of ecosystems – area by type and biogeoclimatic zone;
- Wetlands - area, classification;
- Riparian disturbance;
- Invasive species;
- Habitat status/condition; water temperature, flow, physical habitat, habitat area; and
- Change in land use / land cover, ecosystem conversion over time.

Resource Use and Impacts

- Land use and land cover - percent of each; urban density;
- Forest cover;
- Water use by resource sector; stream allocation by sector, zone;
- Riparian forest practices - number of streams by stream condition, classification;
- Road density and stream crossings;
- Forestry; equivalent clearcut area, volume harvested; restocking;
- Impervious surfaces - percent area;
- Linear Developments – density;
- Mines – total number of mines, footprint, water license by volume; and
- Urban Impact; urban runoff, industrial and municipal effluent, spills, releases.

Resource Conservation

- Watershed stewardship and restoration activities (instream, upslope);
- Sustainable Forest Management operations – percent area of sustainable certified forest operations;
- Water and watershed planning activities; and
- Area conservation or park land.

The above suggested general indicators were assessed for their applicability or relevance to the Cottonwood Creek watershed, their ease of measurement, existing sources of data, existing data quality and ease of comparison with other BC watersheds. Once assessed, a subset of Indicators was recommended to be included, excluded or included but implementation postponed to a later date in a watershed health assessment program (See Table 3).

Programs for each high priority indicator will have to be carefully developed to ensure the resulting data is robust, meaningful and comparable year to year and with other local watersheds or reference watersheds. Once the high priority indicators programs are established, consideration can be given to the indicators whose implementation were postponed.

Table 3: Indicators of watershed health recommended for Cottonwood Creek watershed.

Indicator		Relevant	Priority	Existing Data; Data Quality	Comment	Recommendation
Freshwater Quality and Quantity						
	a. Stream surface water quantity; flow allocations, commitments.	Yes	High	Very limited; Varies	City of Nelson recently established a hydrometric station on lower Cottonwood Creek.	Include
	b. Stream surface water quality (relevant parameters)	Yes	High	Limited; Varies	Water quality sampling efforts have been sporadic and are dated. Living Lakes recently commenced a water monitoring program that samples throughout the mainstem.	Include
	c. Benthic invertebrates	Yes	High	Limited; Limited	Important Indicator	Include
Fish and Wildlife						
	a. Status of key wildlife populations; fish	Yes	High	Limited and sporadic; Good	Sporadic fish data, primarily Rainbow Trout.	Include
	b. Aquatic habitat status/condition; water temperature, flow, physical habitat, habitat area	Yes	High	Limited/ Anecdotal	Any fish habitat assessment should follow provincial FHAP procedures.	Include
Ecosystems						
	a. Wetlands -area, classification	Yes	Medium	None;	Small wetlands in headwaters area predominant wetlands; Requires GIS interpretation	Postpone
Resource Use and Impacts						
	a. Land use and land cover - % of each; urban density	Yes	Low	Good; Good	Requires GIS interpretation	Postpone
	b. Forest cover	Yes	Medium	Yes; High	Requires GIS interpretation	Include
	c. Water use by sector; stream allocation by sector, zone	Yes	Medium	Yes; High	Completed for this report	Completed
	d. Riparian forest practices - # of streams by stream condition, classification	Yes	Medium	Mixed; Unknown quality	Data for public land tenure holders available (requires GIS interpretation)	Postpone
	e. Road density and stream crossings	Yes	Medium	Yes; Good	Can be used to compare with other watersheds; Requires GIS interpretation; LiDAR data reveals higher density of roads than iMap.	Postpone
	f. Urban Impact; urban runoff, industrial and municipal effluent, spills, releases,	Yes	High	Mixed; Unknown	Contaminants contained in stormwater (e.g. Hydrocarbons, road abrasives, salt, etc.). Water quality monitoring program should be designed to sample expected contaminants.	Include
Resource Conservation						
	a. Area conservation or park land	Yes	Low		Easily measured; prevents resource degradation	Include

5 Information Summary and Data/Knowledge Gaps

There are numerous gaps in a wide range of data sets. Most of the pertinent water related data reviewed is limited, non- existent, dated or sporadic. There are very few data sets that are long term.

5.1 Surface Water Discharge

Hydrometric data for the watershed is sparse, incomplete or dated. There is no historical data available for the mainstem creek. This is a significant shortcoming for the development of an indicator or a watershed management plan. Although the City of Nelson recently installed hydrometric stations near Nelson Ford on the mainstem, and on Selous Creek at the point of drinking water diversion, it will take several years of data collection from these stations before any meaningful analysis of surface discharge can occur. The five years of hydrometric data for Giveout Creek from 1944-1948 is dated, incomplete and largely unusable. The only continuous hydrometric data in the watershed is for Selous Creek from 1965 to 1974. However, Selous Creek watershed is only 23% of the Cottonwood Creek watershed area and thus this data is of limited value in inferring Cottonwood Creek flows. There are likely numerous estimates of Cottonwood Creek discharge in grey literature concerning creek side on instream projects (i.e. – Baker Street bridge rebuild, several culvert placements, recent creek side developments that may have calculated flood levels etc.) however these values would be based on computer models using data derived from a regional hydrometric analysis or using climate data to derive extreme discharge values that are required for design purposes.

5.2 Groundwater Quantity and Quality

There are 45 wells in the valley bottom area that have well records including static water levels and refill rates. An analysis and mapping of groundwater resources has not occurred and there is no groundwater observation well[27] in the Cottonwood Creek watershed. Similar to other areas in B.C., there is little information on groundwater quality. The majority of well users are for domestic supply so the water is assumed to meet provincial drinking water quality standards. However, given the presence of numerous legacy mines and mining exploration in the Giveout Creek watershed and older land developments along the creek corridor outside of the City limits this assumption should be verified.

5.3 Water Quality – Surface water

There are only sporadic grab samples of water quality in the mainstem that indicated water quality at a point in time, and most grab samples are from the lower watershed. Water quality testing of 52 parameters including metals was completed in 2008 in the lower watershed by the province, and none of the parameters exceeded maximum approved provincial guidelines (Appendix 1). The NDRGC sampled four sites throughout the watershed over 6 months in 2008 and found that none of the parameters exceeded provincial guidelines (Appendix 2). Whether these water samples were collected following provincial standards is not clear. Thomson (2009) took grab samples of mainstem water in the lower watershed during spring melt downstream of City of Nelson stormwater outfalls to determine turbidity levels and found that all samples well exceeded provincial guidelines. Water quality data would also be

[27] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/groundwater-wells-aquifers/groundwater-observation-well-network

measured during environmental monitoring during instream construction works but these again would be grab samples that measure turbidity only.

As such there is little water quality data available and none of it continuous where the data's quality is assured. Living Lakes recently commenced a water quality monitoring program at several locations along the mainstem; this program will continue pending funding.

5.4 Fisheries, Aquatic Habitat and Riparian Areas

Cottonwood Creek supports several species with Rainbow Trout being the dominant species. Fish have been sampled throughout the watershed numerous times for various projects, as such it is highly likely that Rainbow Trout inhabit all sections of the mainstem. The last known sampling occurred in the first reach adjacent to the public works yard in 2013 (Smit, 2014) The upper watershed has not been sampled (according to publicly available records) since 2008. Although Rainbow Trout presence is well documented, sampling is dated and sporadic. Understanding whether other species are present and their distribution is much more limited.

Spawning Kokanee used to inhabit the reaches below Cottonwood Falls in the fall period but have not been seen for many years (Thomson, 2009); however, sampling during the fall period has not confirmed this assertion. A spawning Bull Trout sampled in the fall of 2013 (Smit 2014) was unexpected and should be considered an anomaly as Bull Trout do not appear in any historic Cottonwood Creek fish inventory records.

Like fish sampling, fish habitat assessments have been done over the last 20 years in isolated area and following a variety of assessment procedures. A formal fish habitat assessment of the entire mainstem has not been completed. Fish habitat from Cottonwood Lake down to where the creek passes under Highway 6 near the former OM Foods location the habitat is considered good with a dense mature riparian canopy. From this point downstream to the highway interchange the habitat degrades and is considered good to fair. Creek banks are often comprised of large rock, and the channel overly narrowed due to close proximity of adjacent developments and the infilling of the floodplain. Long sections are immediately adjacent to Highway 6 where all mature riparian vegetation has been removed. Spawning gravel patches, and instream organic debris are rare although deep pools are frequent, and off channel habitat non-existent. Below the Cottonwood Falls it is clear even from casual observations that the fish habitat is in extremely poor condition. From the falls to Baker Street bridge the creek is either laterally confined and overly narrowed by large angular rock or concrete walls. Mature riparian vegetation exists but is inconsistent with some sections exposed. Further downstream the creek is encased in a concrete flume – concrete on three sides - through the CPR lands with no riparian vegetation. Adjacent to the public works yard the fish habitat is in fair condition but is compromised by the placed channel spanning log sills, and gravel compaction with sediment from upstream sources including City of Nelson stormwater outfalls.

5.5 Data Gaps

From the above description of various water and aquatic related aspects of the watershed, there are several data gaps that should be addressed:

1. The hydrometric monitoring program recently established on the mainstem needs to collect and analyse several years of data before it can be used to describe watershed hydrology, analyse trends and compare Cottonwood Creek hydrology to reference watersheds.
2. Water quality monitoring data is sporadic and dated. The water quality monitoring program recently established by Living Lakes at several locations on the mainstem requires a few years of

collection, analysis, and adjustments before it can be used to determine overall watershed health, trends and to contrast with reference watersheds.

3. Water quality data for Giveout Creek and other targeted areas in the watershed to sample metals and acid rock drainage.
4. Formal fish habitat assessment of the mainstem from the mouth to Cottonwood Lake.
5. Groundwater quality and migration data and possible contamination in the alluvial fan (mouth) of the creek.
6. Groundwater use and extent of aquifer, although there may be insufficient demand to warrant a groundwater/aquifer study given that most wells are on the valley floor adjacent to the creek.

6 Summary of social and political dynamics of Cottonwood Creek

Cottonwood Creek watershed lies within the governance purview of three levels of colonial government, First Nations, and the City of Nelson. Each influence Cottonwood Creek watershed health in fulfilling their respective responsibilities, and as expected there is overlapping jurisdiction. The following summary is a very brief description of the role of each as it pertains to Cottonwood Creek watershed health with a focus on water governance.

6.1 Federal Government

The federal government plays a minor role in watershed governance and freshwater decision making. Relevant federal legislation includes the *Fisheries Act, Species at Risk Act* and *Environmental Assessment Act.* Within Cottonwood Creek the *Fisheries Act* is likely the most pertinent as it influences both water quality and fish habitat quality and quantity as they are affected by human related disturbances. Violations of the Fisheries Act can result in serious penalties; however, the Act is rarely enforced for small scale violations and federal fisheries staff are rarely involved in Nelson area projects.

6.2 Provincial Government

The Province has a significant role in watershed governance through several legislative laws and regulations, notably the *Water Sustainability Act.* Other Acts govern drinking water, forestry, mining, transportation, and agriculture to name a few that all affect watershed health. The province is responsible for regulating timber harvesting and enforcing best land management practices on crown lands (tenure holders Kalesnikoff Lumber and ATCO Forest Products) and mining outside of the City of Nelson, maintenance of Highway 6, addressing threats to surface and ground water quality and quantity including contaminated sites throughout the entire watershed.

6.3 First Nations

First Nations have a key role in applying their traditional land management practices and holistic vision to the watershed, and influencing future land use and development activities that affect water and their traditional territory. The Okanagan Nation Alliance Castlegar office has expressed interest and offered to support lower creek restoration initiatives spearheaded by the Nelson District Rod and Gun Club. The Sinixt Confederacy have recently established a Nelson based office with two permanent staff who would likely be interested in future Cottonwood Creek initiatives. The Ktunaxa Nation Council may also have an interest in projects in this area.

6.4 Regional District of Central Kootenay

The RDCK is generally responsible for providing services to landowners, residents, and businesses outside the City of Nelson. Most private property outside the City is located on the valley bottom, typically within 200 m of Cottonwood Creek. The RDCK notably regulates building on lands considered geotechnical hazards that could include areas in the valley bottom particularly downstream of the confluence with Giveout Creek (BCG, 2023). RDCK is also responsible for maintaining the headwater Cottonwood Lake Regional Park and the linear rail trail, water conservation, and owns and operates several community water services (although none in Cottonwood Creek watershed).

RDCK has not been involved in Cottonwood Creek restoration activities as all of those activities have taken place in the lower reaches inside the City of Nelson jurisdiction. RDCK would necessarily be a partner in restoration efforts in areas within its jurisdiction.

6.5 City of Nelson

The City of Nelson regulates most of the land use activity within City limits from Nelson Toyota to the Cottonwood Creek mouth at Kootenay Lake. The city is responsible for storm sewer outfalls that discharge road runoff into the creek, permitting infrastructure that could encroach on the creek or creek riparian area, water withdrawals from Selous Creek during low flow periods typically in August and September. Most importantly, the city develops and leads long term neighbourhood and area planning processes that can affect land use around the creek perimeter and the viability of future creek restoration efforts for decades to come. For example, the Railtown Sustainable Neighbourhood Action Plan (2016) contains conceptual ideas and sketches on how Cottonwood Creek corridor can be modified to blend into a new neighbourhood. Modifications proposed include minor instream restoration (e.g. removal of some concrete walls), a pathway along the creek and in some areas paths cantilevered over the creek (Nelson, 2016). The City has been helpful with and encouraging of the Nelson District Rod and Gun Club with various instream and riparian restoration initiatives. Councils over the years have been receptive about the Club's ideas and efforts but have cited budgetary and capacity restraints as reasons for not getting directly involved in projects. The City has provided restoration materials, equipment and in-kind services whenever possible, all which are greatly appreciated.

The city also recently initiated a hydrometric monitoring program on Cottonwood Creek that is discussed in Section 4.1 above.

6.6 Local Groups and Organisations

Traditionally the Nelson District Rod and Gun Club has stewarded the creek, dating back to the 1940s when the Rainbow Trout rearing pools and later the hatchery were built near where the Cottonwood Falls market now stands. The NDRGC has completed instream and riparian restoration projects in the lower watershed, monitored water quality, removed garbage, commissioned studies concerning the health of Cottonwood Creek, run the annual family fishing day on Cottonwood Creek to promote proper fishing etiquette and to introduce the public to the sport, and has advocated for restoration and protection of the creek for many years.

Living Lakes Canada and Friends of Kootenay Lake are both involved in Cottonwood Creek water quality monitoring and in developing further resources to monitoring the watershed in its entirety and are coordinating the investigation and reporting to understand further and improve Cottonwood Creek watershed health.

6.7 Selkirk College

Selkirk College students have participated in a variety of Cottonwood Creek related research and restoration projects over the last 20 years. Students researched and wrote plans for fish habitat, ecological restoration, mineral extraction and management, and water quality and proposed the *Cottonwood Creek Land Use Plan* (2004). Other students were involved in planting the riparian area at the creek mouth in the mid 2000s and have written reports on urban impacts on fish and fish habitat in the creek (Smit, 2014).

Local public schools have not been recently involved in creek related monitoring or restoration projects. However, their involvement represents a tremendous opportunity to inspire youth to be stewards of the creek and their involvement should be encouraged.

7 Recommendations concerning a Watershed Management Plan

7.1 Watershed Management Plan Process

Watershed Management Planning is a well-established process whose overarching goals and objectives are defined by the specific issues and planning needs for the watershed in question. For example, the following types of plans have been developed for watersheds in the Okanagan basin[28]: Drought Management Plans, Water Use Plans, Watershed Protection Plans, Watershed Assessment Plans, and Water Allocation Plans. Integrated Watershed Management Plans that involve environmental, social and economic issues are broader in nature and are utilised in Ontario. Generally a Watershed Management Plan is a land and resource use plan that focuses on those activities that affect water resources (surface and subsurface) within a watershed. A watershed is a discrete area where all water within the specified area drains towards a common point, usually a larger river or lake. It is a convenient area demarcation as what happens to water in the higher elevation area in the watershed can affect water resources in lower elevation areas in the watershed.

The most recent Watershed Management Plan developed in the West Kootenays was for the Kettle River[29] in the RDKB over a five-year period culminating in the 2014 plan (RDKB, 2014). The Kettle River watershed has significant water related issues that required a lengthy planning process involving many concerned citizens and stakeholders, public outreach and workshops, planning committees and advisory groups, production of discussion and technical papers and significant funding. The involved planning process was appropriate for the complex issues facing the Kettle River watershed, the large and diverse area, the diversity of stakeholders, and the many land uses within the watershed that draw on or affect water resources. Cottonwood Creek does not contain near the complexity of water related challenges the Kettle River watershed but contains some of the same water issues on a much smaller scale.

When considering how to approach developing a watershed management plan there are a number of considerations including:

1. What is the vision for the watershed?
2. What are the watershed management goals? How wide or narrow should the focus be?
3. What are the water related issues facing the watershed? What is known, what is not known about water and water-related issues in the watershed?
4. How will the planning process be structured?
5. Who should be involved in developing the plan; when do they get involved? Who will coordinate the planning process?
6. What is the timeframe for the process?
7. How will the planning process be funded?

In order to scope out the idea of developing a watershed management plan, the next step in this process involves addressing the above questions. In doing so it may become apparent that developing an inclusive

[28] See http://obwb.ca/ for excellent information concerning the variety of water related plans.
[29] See https://kettleriver.ca/

watershed management plan is not the best process to achieve the overall goals and objectives, and an alternative scaled back process may be more appropriate. It is possible that there is insufficient water related data to develop a watershed management plan, with the focus shifting to setting up data collection, monitoring and analysis programs for parameters identified in the data gap analysis.

7.2 Recommendations

The following recommendations fall into two areas: determining the planning framework that is most appropriate to achieve the goal of improving overall watershed health; and actions that can be taken in the near term to collect and analyse data in order to support decision making concerning future watershed management programs and structure.

Determination of the most appropriate planning framework should start with considering the discussion and questions presented in Section 8.1. The more near-term recommendations are as follows:

1. Hydrometric Data

   Approach the City of Nelson's concerning their hydrometric monitoring station on Cottonwood Creek to determine their interest in sharing data and data analysis. Consider creating a water balance model and study of the watershed.

2. Water Quality Monitoring

   Continue the recently established Living Lakes Canada water quality monitoring program and adjust the monitoring program (station locations, sampling frequency, parameters evaluated, etc.) if required to address the water quality issues identified in this report, including metals concentrations in Giveout Creek and Cottonwood Creek immediately downstream of tailings, turbidity caused by road and highway runoff and stormwater discharge, possible contamination as the creek passes through semi-rural and urban areas, etc.

3. Groundwater contamination in lower watershed

   Engage with Canadian Pacific Railway (CPR) and/or the City of Nelson to determine current extent of groundwater contamination in CPR-owned land that may affect water quality in the lower creek, and what remediation plans are in effect.

4. Fish Habitat

   Conduct an instream bioinventory and aquatic habitat assessment of the mainstem creek by following the provincial Fish Habitat Assessment Procedure (Johnson, 1996).

5. CABIN monitoring

   Continue with the CABIN program that assesses stream health through presence and abundance of aquatic organisms. Re-evaluate the program parameters, sampling locations and sampling frequency considering the information in this report.

6. Initiate a stream health indicators assessment program that ties in water quality and quantity data with consideration of using a local reference watershed to compare results.

7. Look for opportunities to involve local public schools and Selkirk College in the collection and analysis of water related data and the development of monitoring and/or watershed restoration plans.

8. Develop and prioritize a list of possible instream and riparian restoration options in consultation with stakeholders, determine data required to advance each option, and develop appropriate programs to advance priority projects.
9. Engage with the City of Nelson to determine how and ensure that long term plans that include the Railtown Development Plan, the Sustainable Waterfront and Downtown Master Plan, and the City Official Community Plan encourage appropriate current and future development setbacks from the creek and preserve the creek corridor from future encroachments.

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Appendix 1: Water quality data from sample in lower watershed Sept 22, 2008[30]

Parameter Name		Results	Parameter Code/Units
Ag-T	<	0.000005	Ag-T (mg/L)
Al-T		0.0244	Al-T (mg/L)
Alkalinity Total 4.5		74	Alkalinity Total 4.5 (mg/L)
Ammonia Dissolved	<	0.005	Ammonia Dissolved (mg/L)
As-T		0.00028	As-T (mg/L)
B--T	<	0.05	B--T (mg/L)
Ba-T		0.031	Ba-T (mg/L)
Be-T	<	0.00001	Be-T (mg/L)
Bi-T	<	0.000005	Bi-T (mg/L)
Ca-T		27.3	Ca-T (mg/L)
Carbon Total Organic		2.1	Carbon Total Organic (mg/L)
Cd-T		0.000037	Cd-T (mg/L)
Chlrid:D		4.1	Chlrid:D (mg/L)
Co-T		0.000034	Co-T (mg/L)
Cr-T		0.0002	Cr-T (mg/L)
Cu-T		0.00126	Cu-T (mg/L)
Fe-T		0.037	Fe-T (mg/L)
Hardness Total (T)		77.6	Hardness Total (T) (mg/L)
K--T		2	K--T (mg/L)
Li-T		0.0011	Li-T (mg/L)
Mg-T		2.32	Mg-T (mg/L)
Mn-T		0.0036	Mn-T (mg/L)
Mo-T		0.00092	Mo-T (mg/L)
N.Kjel:T	<	0.02	N.Kjel:T (mg/L)
Na-T		3.29	Na-T (mg/L)
Ni-T		0.00167	Ni-T (mg/L)
Nitrate (NO3) Dissolved		0.113	Nitrate (NO3) Dissolved (mg/L)
Nitrate + Nitrite Diss.		0.115	Nitrate + Nitrite Diss. (mg/L)
Nitrogen - Nitrite Diss.		0.002	Nitrogen - Nitrite Diss. (mg/L)
Nitrogen Organic-Total	<	0.02	Nitrogen Organic-Total (mg/L)
Nitrogen Total		0.12	Nitrogen Total (mg/L)
Ortho-Phosphate Dissolved		0.003	Ortho-Phosphate Dissolved (mg/L)
P--T		0.006	P--T (mg/L)
Pb-T		0.000215	Pb-T (mg/L)
Phosphorus Tot. Dissolved		0.006	Phosphorus Tot. Dissolved (mg/L)
Res:Tot	<	144	Res:Tot (mg/L)
Residue Filterable 1.0u		140	Residue Filterable 1.0u (mg/L)
Residue Non-filterable	<	4	Residue Non-filterable (mg/L)
Sb-T		0.00044	Sb-T (mg/L)

[30] Data available from https://a100.gov.bc.ca/pub/ems/listDataFiles.do; File No. EMSWR_Rus_042759

Parameter Name		Results	Parameter Code/Units
Se-T		0.00028	Se-T (mg/L)
Si-T		4.62	Si-T (mg/L)
Sn-T	<	0.00001	Sn-T (mg/L)
Specific Conductance		190	Specific Conductance (uS/cm)
Sr-T		0.148	Sr-T (mg/L)
Sulfat:D		12	Sulfat:D (mg/L)
Sulfur Total		5	Sulfur Total (mg/L)
Ti-T		0.0014	Ti-T (mg/L)
Tl-T		0.000003	Tl-T (mg/L)
Total NO2+NO3	<	0.1	Total NO2+NO3 (mg/L)
U--T		0.000386	U--T (mg/L)
V--T		0.0005	V--T (mg/L)
Zn-T		0.0021	Zn-T (mg/L)
pH		8.2	pH (pH units)

Appendix 2: Metals water quality data collected by NDRGC at four locations in 2008.

Date	Site	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Se	Si	Sr	Zn
1-May-08	Below Cottonwood lake	0.0150		0.0016	0.0216	29.3349				0.0293	0.0705	1.9631	1.7645	0.0062	0.0003	3.3210				0.0001		0.1157	
8-May-08	Below Cottonwood lake	0.0104	0.0016	0.0024	0.0201	25.5906		0.0005		0.0033	0.0260	1.7481	1.5414	0.0084	0.0012	2.9021			0.0006	0.0027	0.1913	0.1054	
15-May-08	Below Cottonwood lake	0.0112			0.0112	17.8025					0.0377	0.6332	0.6523	0.0045		0.6625				0.0003	0.1759	0.0644	
22-May-08	Below Cottonwood lake	0.0558		0.0004	0.0145	18.2203				0.0132	0.1201	1.3575	1.1155	0.0059		1.5654	0.0043	0.0054	0.0008		0.0378	0.0760	0.0094
23-May-08	Below Cottonwood lake	0.1083	0.0106	0.0031	0.0183	17.0373	0.0044	0.0031	0.0026	0.0136	0.1981	1.2710	1.0261	0.0080	0.0042	2.5625	0.0028	0.0260				0.0723	0.0073
29-May-08	Below Cottonwood lake	0.0239			0.0152	17.0819				0.0155	0.0403	1.2413	0.9282	0.0051		1.6661				0.0011	0.2181	0.0745	
19-Jun-08	Below Cottonwood lake	0.0113	0.0021	0.0019	0.0158	21.4141		0.0002		0.0026	0.0338	1.3991	1.1721	0.0051	0.0002	2.1918					0.0918	0.0895	
16-Jul-08	Below Cottonwood lake	0.0175		0.0008	0.0186	25.1503				0.0003	0.0438	1.6886	1.5596	0.0053		1.7658				0.0012		0.1104	
16-Aug-08	Below Cottonwood lake	0.0078		0.0009	0.0215	30.2320			0.0008	0.0022	0.0282	2.0752	1.9218	0.0036		2.3066			0.0018	0.0046	0.0310	0.1243	
18-Sep-08	Below Cottonwood lake	0.0051		0.0003	0.0205	29.8009				0.0058	0.0305	2.0539	2.0280	0.0039		2.6046			0.0029	0.0003		0.1171	
17-Oct-08	Below Cottonwood lake	0.0090		0.0008	0.0189	29.4921				0.0004	0.0201	2.1182	1.9140	0.0022		2.5119					0.0200	0.1162	
29-May-08	Selous Creek, at Cottonwood Creek																						
19-Jun-08	Selous Creek, at Cottonwood Creek	0.0747			0.0142	8.2983			0.0004	0.0058	0.0802	0.7733	0.6350	0.0013		0.7368					0.0415	0.0326	0.0003
16-Jul-08	Selous Creek, at Cottonwood Creek	0.0146			0.0289	18.3718				0.0254	0.0503	1.4820	1.2371	0.0011	0.0003	0.8833				0.0011		0.0660	
16-Aug-08	Selous Creek, at Cottonwood Creek	0.0170		0.0017	0.0376	23.9057				0.0006	0.0223	1.7263	1.3558	0.0007		0.9109					0.1047	0.0894	
16-Aug-08	Selous Creek, at Cottonwood Creek	0.0221		0.0010	0.0348	21.7992				0.0030	0.0207	1.6152	1.2950	0.0009		0.7552			0.0035		0.0853	0.0857	
18-Sep-08	Selous Creek, at Cottonwood Creek	0.0081		0.0022	0.0385	23.9052		0.0001		0.0130	0.0289	1.9559	1.7246	0.0009	0.0008	1.0456					0.0377	0.0923	
17-Oct-08	Selous Creek, at Cottonwood Creek	0.0064		0.0002	0.0282	18.8878		0.0000		0.0165	0.0447	1.5836	1.2567	0.0012		0.9359		0.0029			0.0001	0.0721	0.0033
1-May-08	Cottonwood Creek, below falls	0.0146		0.0012	0.0210	22.1595				0.0046	0.0464	1.6732	1.7249	0.0046		2.8516		0.0014			0.0547	0.1098	
8-May-08	Cottonwood Creek, below falls	0.0980	0.0036	0.0003	0.0189	17.7333	0.0009			0.0076	0.1683	1.2456	1.4332	0.0083	0.0003	1.7494	0.0004	0.0055	0.0037	0.0006	0.0657	0.0845	0.0044
15-May-08	Cottonwood Creek, below falls	0.0696		0.0010	0.0173	17.3319				0.0206	0.1820	1.1839	1.3963	0.0167		1.6810		0.0027	0.0037		0.0884	0.0842	0.0056
15-May-08	Cottonwood Creek, below falls																						
22-May-08	Cottonwood Creek, below falls	0.1597	0.0015	0.0000	0.0155	11.9668	0.0009	0.0003	0.0009	0.0057	0.2103	0.9624	1.1658	0.0152	0.0001	1.1853	0.0026	0.0114	0.0006		0.0157	0.0611	0.0032
23-May-08	Cottonwood Creek, below falls																						
29-May-08	Cottonwood Creek, below falls	0.0487		0.0017	0.0112	11.3829		0.0004	0.0006	0.0002	0.0475	0.9280	0.9946	0.0045	0.0001	0.7308					0.1105	0.0608	
29-May-08	Cottonwood Creek, below falls	0.0519		0.0015	0.0107	11.2594				0.0002	0.0478	0.9149	0.9823	0.0044		0.7277					0.1621	0.0600	
19-Jun-08	Cottonwood Creek, below falls	0.0334	0.0020	0.0012	0.0170	14.3323				0.0066	0.0301	1.0834	1.2492	0.0030		1.4667					0.1067	0.0763	
16-Jul-08	Cottonwood Creek, below falls	0.0201		0.0021	0.0266	23.2725		0.0004	0.0002	0.0065	0.0506	1.8715	2.1110	0.0025	0.0001	1.8779		0.0002		0.0010	0.0983	0.1272	
16-Aug-08	Cottonwood Creek, below falls	0.0165		0.0017	0.0290	28.0349		0.0001		0.0011	0.0330	1.8586	2.1152	0.0036		2.0082					0.0793	0.1471	
18-Sep-08	Cottonwood Creek, below falls	0.0339		0.0003	0.0321	28.2355			0.0002	0.0078	0.1086	1.9492	2.2849	0.0105		2.2154		0.0168	0.0022			0.1504	0.0006
17-Oct-08	Cottonwood Creek, below falls																						
22-May-08	Cottonwood Creek, mouth	0.0978		0.0015	0.0112	11.2560				0.0124	0.1172	0.9768	0.9901	0.0105		0.7150		0.0062	0.0009		0.2702	0.0584	
29-May-08	Cottonwood Creek, mouth	0.0305			0.0100	10.9031				0.0144	0.0343	0.8611	0.9551	0.0020		0.6700		0.0018		0.0007	0.2082	0.0563	
19-Jun-08	Cottonwood Creek, mouth	0.0450		0.0007	0.0141	13.1890				0.0130	0.0677	0.9404	1.2368	0.0027		1.2384					0.0767	0.0687	
16-Jul-08	Cottonwood Creek, mouth	0.0256			0.0231	21.0724			0.0005	0.0103	0.0688	0.6169	3.0315	0.0070		1.1006		0.0065	0.0091	0.0010		0.0985	
16-Aug-08	Cottonwood Creek, mouth	0.0185	0.0006	0.0028	0.0307	30.0842				0.0069	0.0429	2.1296	2.5109	0.0080	0.0005	2.9574				0.0010	0.1179	0.1512	

Appendix 3: Water quality results from City of Nelson Selous Creek Water Intake

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Urban Systems - Nelson Office	**WORK ORDER**	21B1924
PROJECT	City of Nelson Water Sampling	**REPORTED**	2021-02-24 17:05

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Selous Creek (21B1924-01) | Matrix: Water | Sampled: 2021-02-16 10:00						
Anions						
Chloride	**0.14**	AO ≤ 250	0.10	mg/L	2021-02-18	
Fluoride	< 0.10	MAC = 1.5	0.10	mg/L	2021-02-18	
Nitrate (as N)	**0.056**	MAC = 10	0.010	mg/L	2021-02-18	
Nitrite (as N)	< 0.010	MAC = 1	0.010	mg/L	2021-02-18	
Sulfate	**12.7**	AO ≤ 500	1.0	mg/L	2021-02-18	
Calculated Parameters						
Hydrogen Sulfide	< 0.01	N/A	0.01	mg/L	2021-02-24	
Hardness, Total (as CaCO3)	**62.9**	None Required	0.500	mg/L	N/A	
Langelier Index	**-0.6**	N/A	-5.0		2021-02-24	
Solids, Total Dissolved	**74.2**	AO ≤ 500	1.00	mg/L	N/A	
General Parameters						
Alkalinity, Total (as CaCO3)	**55.3**	N/A	1.0	mg/L	2021-02-22	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	N/A	1.0	mg/L	2021-02-22	
Alkalinity, Bicarbonate (as CaCO3)	**55.3**	N/A	1.0	mg/L	2021-02-22	
Alkalinity, Carbonate (as CaCO3)	< 1.0	N/A	1.0	mg/L	2021-02-22	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	N/A	1.0	mg/L	2021-02-22	
Carbon, Total Organic	**0.94**	N/A	0.50	mg/L	2021-02-19	
Colour, True	**5.6**	AO ≤ 15	5.0	CU	2021-02-19	
Conductivity (EC)	**124**	N/A	2.0	µS/cm	2021-02-22	
Cyanide, Total	< 0.0020	MAC = 0.2	0.0020	mg/L	2021-02-19	
pH	**7.75**	7.0-10.5	0.10	pH units	2021-02-22	HT2
Solids, Total Suspended	< 2.0	N/A	2.0	mg/L	2021-02-20	
Sulfide, Total	< 0.020	AO ≤ 0.05	0.020	mg/L	2021-02-23	
Temperature, at pH	**21.6**	N/A		°C	2021-02-22	HT2
Turbidity	**0.12**	OG < 1	0.10	NTU	2021-02-19	
UV Transmittance @ 254 nm - Unfiltered	**91.4**	N/A	0.10	% T	2021-02-19	
UV Transmittance @ 254nm	**91.4**	N/A	0.10	% T	2021-02-19	
Total Metals						
Aluminum, total	**0.0116**	OG < 0.1	0.0050	mg/L	2021-02-22	
Antimony, total	< 0.00020	MAC = 0.006	0.00020	mg/L	2021-02-22	
Arsenic, total	< 0.00050	MAC = 0.01	0.00050	mg/L	2021-02-22	
Barium, total	**0.0296**	MAC = 2	0.0050	mg/L	2021-02-22	
Boron, total	< 0.0500	MAC = 5	0.0500	mg/L	2021-02-22	
Cadmium, total	**0.000016**	MAC = 0.005	0.000010	mg/L	2021-02-22	
Calcium, total	**22.1**	None Required	0.20	mg/L	2021-02-22	
Chromium, total	< 0.00050	MAC = 0.05	0.00050	mg/L	2021-02-22	
Cobalt, total	< 0.00010	N/A	0.00010	mg/L	2021-02-22	
Copper, total	**0.00076**	MAC = 2	0.00040	mg/L	2021-02-22	
Iron, total	< 0.010	AO ≤ 0.3	0.010	mg/L	2021-02-22	
Lead, total	< 0.00020	MAC = 0.005	0.00020	mg/L	2021-02-22	
Magnesium, total	**1.84**	None Required	0.010	mg/L	2021-02-22	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Urban Systems - Nelson Office	**WORK ORDER**	21B1924
PROJECT	City of Nelson Water Sampling	**REPORTED**	2021-02-24 17:05

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Selous Creek (21B1924-01) | Matrix: Water | Sampled: 2021-02-16 10:00, Continued						
Total Metals, Continued						
Manganese, total	**0.00146**	MAC = 0.12	0.00020	mg/L	2021-02-22	
Mercury, total	< 0.000040	MAC = 0.001	0.000040	mg/L	2021-02-22	
Molybdenum, total	**0.00078**	N/A	0.00010	mg/L	2021-02-22	
Nickel, total	< 0.00040	N/A	0.00040	mg/L	2021-02-22	
Potassium, total	**1.85**	N/A	0.10	mg/L	2021-02-22	
Selenium, total	**0.00052**	MAC = 0.05	0.00050	mg/L	2021-02-22	
Sodium, total	**1.51**	AO ≤ 200	0.10	mg/L	2021-02-22	
Strontium, total	**0.0834**	7	0.0010	mg/L	2021-02-22	
Uranium, total	**0.000220**	MAC = 0.02	0.000020	mg/L	2021-02-22	
Zinc, total	< 0.0040	AO ≤ 5	0.0040	mg/L	2021-02-22	

Glossary of Terms:

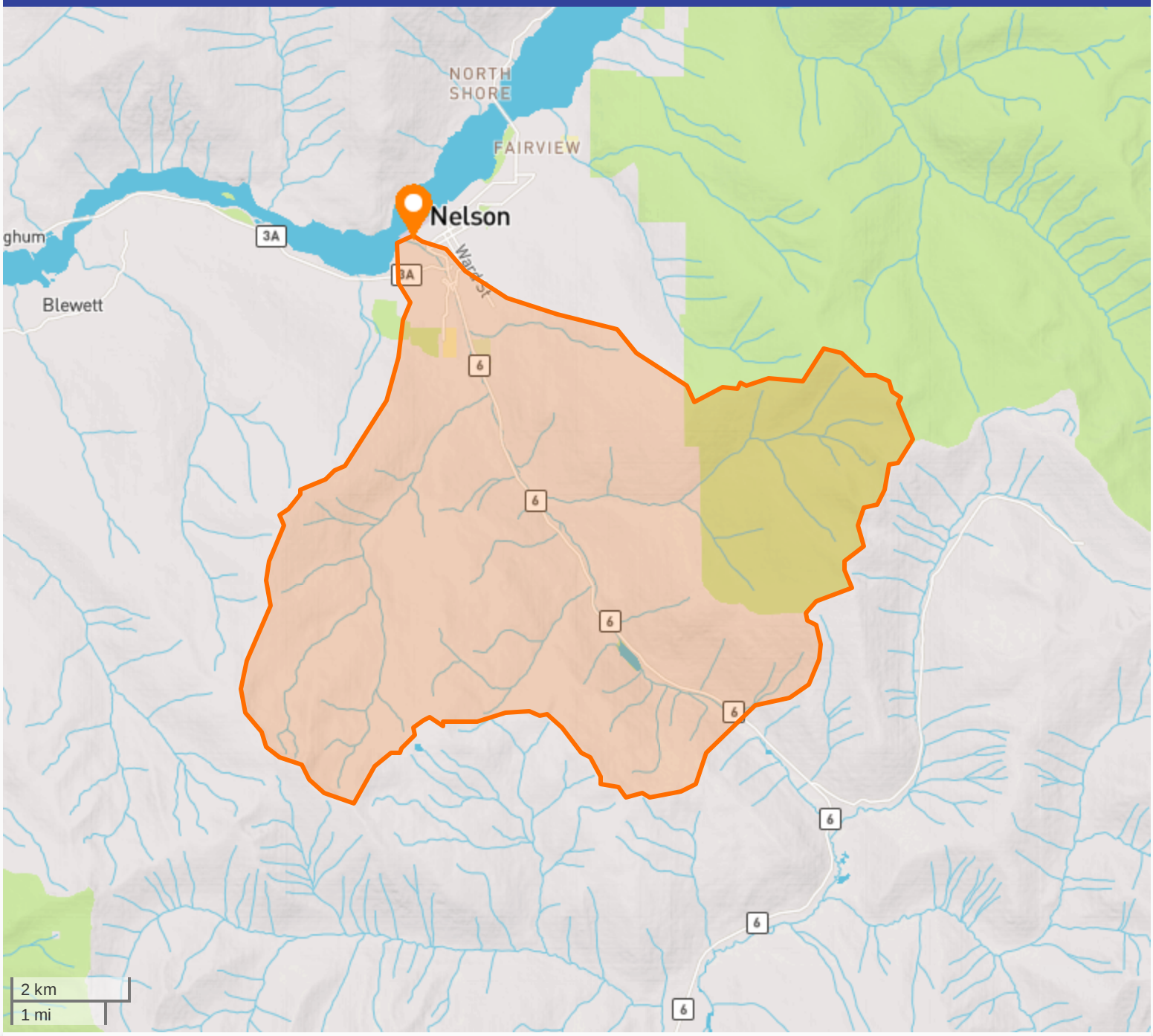
RL	Reporting Limit (default)
%T	Percent Transmittance
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
°C	Degrees Celcius
AO	Aesthetic Objective
CU	Colour Units (referenced against a platinum cobalt standard)
MAC	Maximum Acceptable Concentration (health based)
mg/L	Milligrams per litre
NTU	Nephelometric Turbidity Units
OG	Operational Guideline (treated water)
pH units	pH < 7 = acidic, ph > 7 = basic
µS/cm	Microsiemens per centimetre
ASTM	ASTM International Test Methods
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Appendix 4: Watershed assessment compiled by the Kootenay Boundary Water Tool

Cottonwood Creek

Cottonwood Creek
Kootenay River
Columbia River
Pacific Ocean

Watershed Report
November 27, 2023
WFI: 8127620



Coordinates
49.49057, -117.30315

Watershed area
64 km²

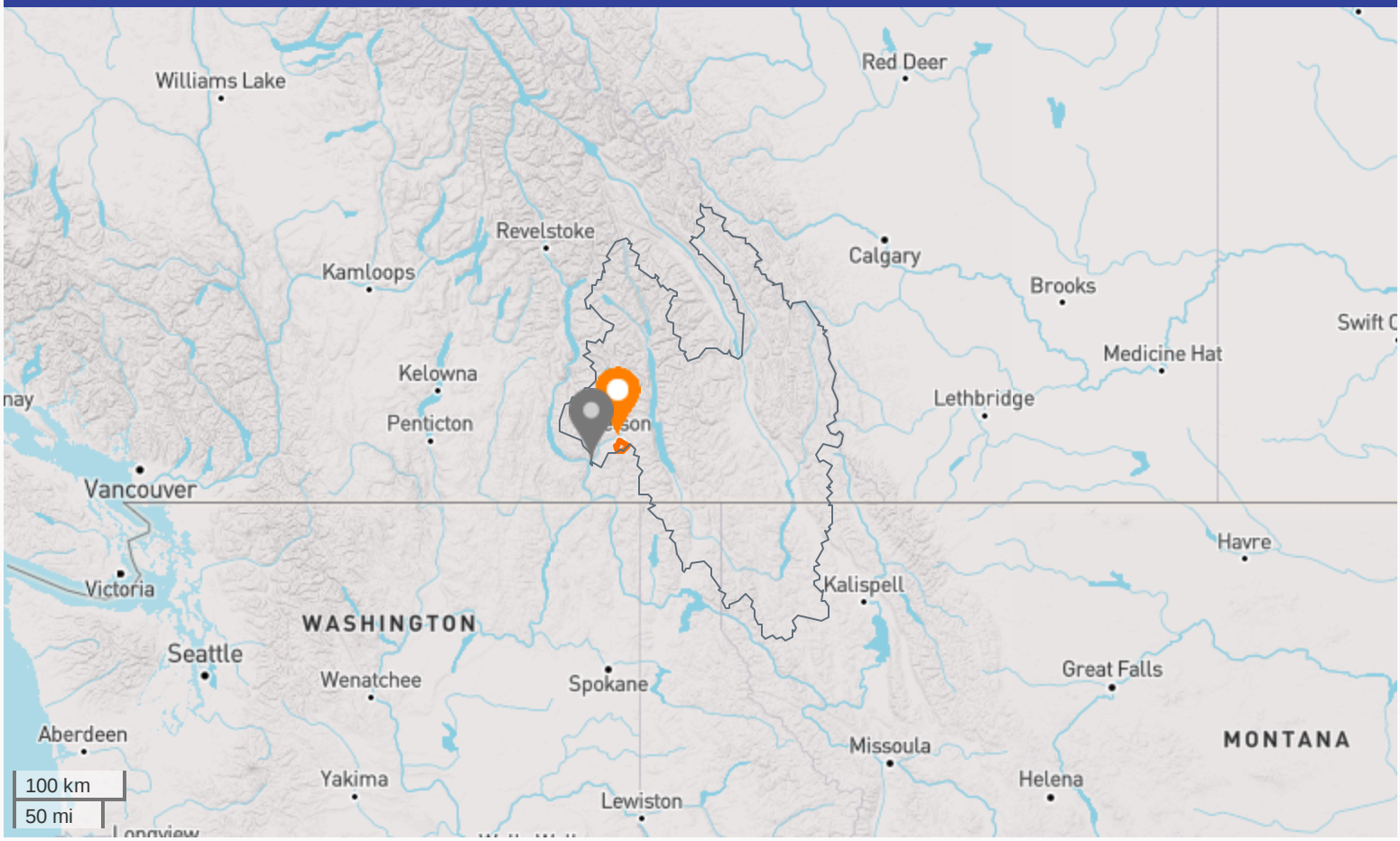
Watershed elevation
613 - 1,422 - 2,152 m
(min - mean - max)

BRITISH COLUMBIA | Ministry of Forests

KOOTENAY BOUNDARY WATER TOOL

Hydrology - Annual

The map shows the query (orange) and downstream (grey) watersheds. The table below provides an overview of the hydrology and existing authorized water allocations under the *Water Sustainability Act* within these watersheds.



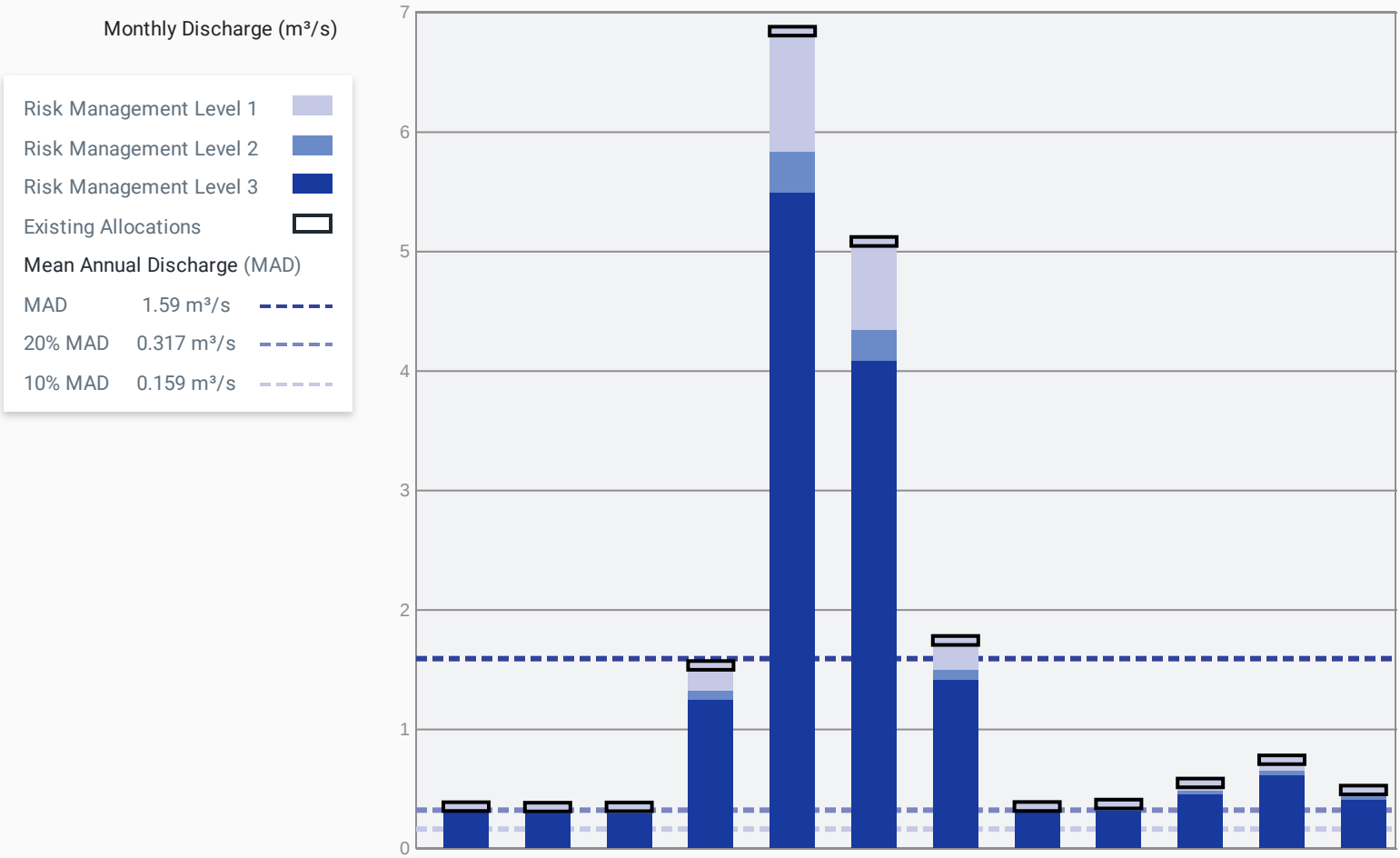
	Query Watershed	Downstream Watershed
Area (km²)	63.6	50104
Mean Annual Discharge (m³/s)	1.59	874
Allocations (m³/s)	0.059	16656410
Allocations (%)	3.7	1,906,034.6
Reserves & Restrictions	Present*	Present*
Annual Runoff (m³/yr)	50,021,753	27,577,480,594
Current Total Allocations (m³/yr) (Water licence & Short Term Use Approvals)	1,854,678	525,636,319,338,066
Seasonal Flow Sensitivity**	Winter, Summer	Winter, Summer

The downstream watershed is defined at the location where the queried drainage meets with another drainage of comparable size. For information further downstream, please generate an additional report at a location of interest. Predictions for small watersheds (generally smaller than 50 sq. km.) may be less accurate due to the lack of hydrometric data available for watersheds of this size.
* For more information on water reserves or restrictions present in the watershed, please visit the links below or contact FrontCounter BC.
Water Reservations: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-reservations
Water Restrictions: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-allocation-restrictions
FrontCounter BC: www.frontcounterbc.ca **Email:** FrontCounterBC@gov.bc.ca **Toll Free**: 1-877-855-3222 **Outside North America:** ++1-778-372-0729
**Ptolemy, R. Environmental Flow Protection in British Columbia. Presentation to 2015 IFC Panel, April 29, 2015.

Hydrology - Monthly

Cottonwood Creek

The chart and table show information on modeled hydrology and existing allocations in the query watershed. This location is shown with an orange marker and watershed outline in the map on page 2.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of MAD	23.2%	22.9%	23.1%	97.9%	432.8%	321.7%	111.0%	23.3%	24.6%	35.7%	47.9%	32.0%
Flow Sensitivity	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Existing Allocations (m³/s)	0.058	0.058	0.058	0.058	0.059	0.06	0.06	0.06	0.059	0.058	0.058	0.058
Mean Monthly Discharge (m³/s)	0.368	0.364	0.366	1.55	6.86	5.1	1.76	0.37	0.39	0.566	0.76	0.507
Potential Allocation (m³/s, Risk Mgmt 1)	0	0	0	0.175	0.97	0.705	0.204	0	0	0.027	0.056	0.018
Potential Allocation (m³/s, Risk Mgmt 2)	0.016	0.015	0.015	0.252	1.313	0.96	0.292	0.014	0.019	0.055	0.094	0.043
Potential Allocation (m³/s, Risk Mgmt 3)	>0.016	>0.015	>0.015	>0.252	>1.313	>0.96	>0.292	>0.014	>0.019	>0.055	>0.094	>0.043

Notes

Methods: Monthly discharge estimates have been generated from a hydrologic model. Existing allocation volumes have been summarized from government water licence and short term approval databases. Potential allocations are determined using criteria established in the Province of BC Environmental Flow Needs (EFN) Policy. Risk management levels have been calculated assuming the presence of fish. If the source can be classified as non-fish bearing, this may affect risk management levels. For more information on the EFN policy: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-policies/environmental-flow-needs

Risk Management Levels: The Province of BC Environmental Flow Needs Policy establishes risk management levels to be used in the evaluation of applications for water rights. Risk Management Levels and associated Risk Management Measures are discussed on page 5 of this report.

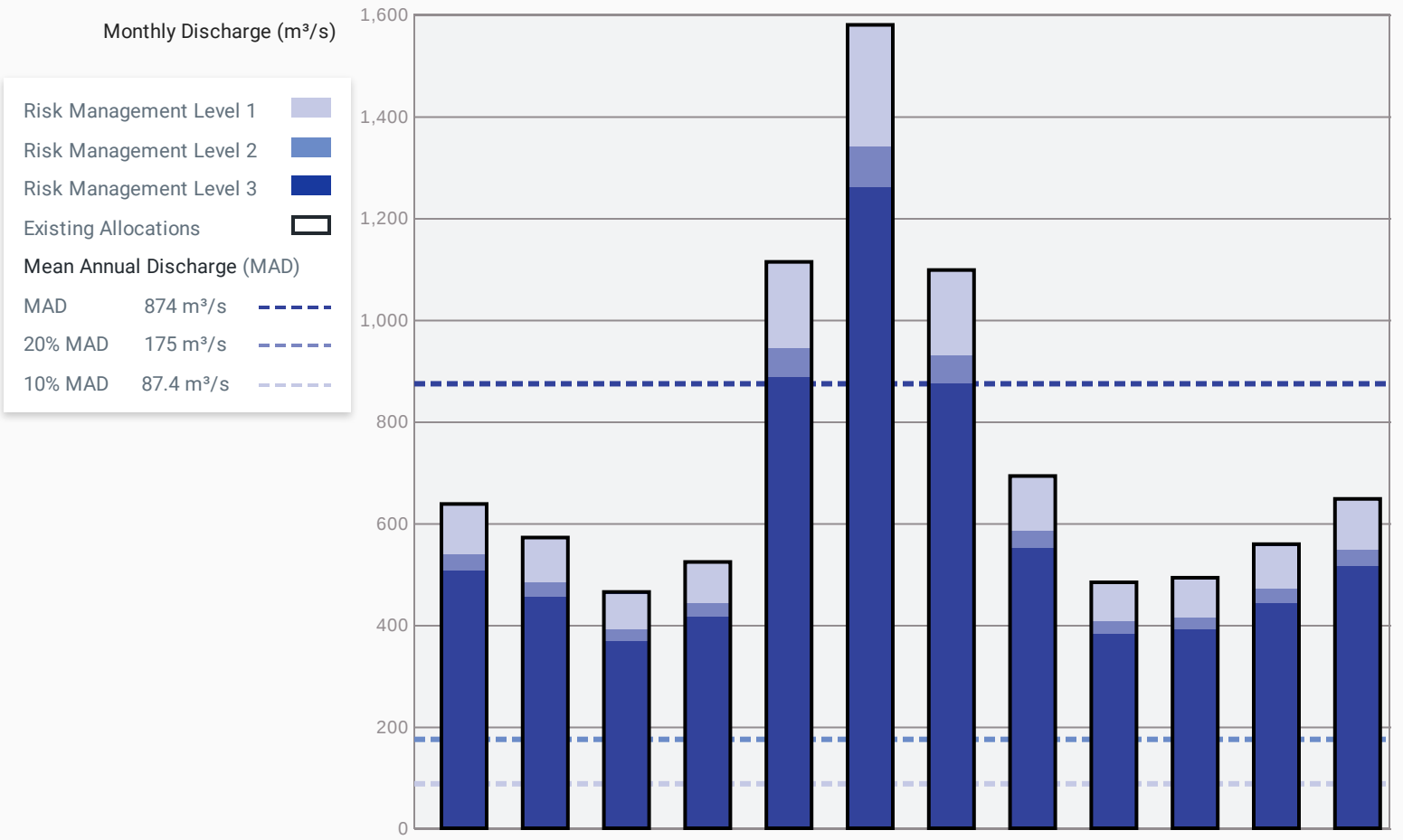
Accuracy: The query watershed is within the Kootenay Boundary Region. The hydrologic modeling study conducted in this region employed a water balance approach to estimate runoff in ungauged basins. The model used 143 watersheds with hydrometric gauges, and included detailed information on watershed climate, evapotranspiration, topography, vegetation and land cover. The model was calibrated using stream flow measurements from the Water Survey of Canada, and validated using a leave-one-out cross validation. Error metrics calculated for the entire model domain are: Mean error = 4.3%, Median Error = 0.3%, Mean Absolute Error = 14.8%, Watersheds within +/- 20% = 79%.

Allocations: Existing allocation volumes are determined from digital databases and include BC Water Sustainability Act licences and short term approvals. These represent a maximum amount of water authorized, not actual use. In many cases, licences may have additional terms and conditions to those represented in the digital version which are not represented. This may result in existing allocation volumes being presented as larger than are actually approved, either in total (on an annual basis) or for individual months. On subsequent pages of this report, information on each licence occurring in the watershed is provided, along with links to scanned copies of complete water licence information. For more information on specific areas of concern, please contact Water Stewardship Staff via FrontCounter BC. Contact information for FrontCounter BC is provided on page 2 of this report.

Hydrology - Monthly

Kootenay River

The chart and table show information on modeled hydrology and existing allocations in the **downstream watershed**, where the subject drainage meets with another drainage of comparable size. This location is shown with a grey marker and watershed outline in the map on page 2.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of MAD	72.6%	65.0%	52.7%	59.5%	127.1%	180.4%	125.2%	78.8%	55.0%	56.0%	63.5%	73.6%
Flow Sensitivity	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Existing Allocations (m³/s)	16,667,802	16,520,299	16,667,802	16,667,802	16,667,806	16,667,808	16,667,809	16,667,809	16,667,806	16,667,803	16,667,802	16,667,801
Mean Monthly Discharge (m³/s)	634	568	461	520	1,110	1,576	1,094	689	480	489	555	644
Potential Allocation (m³/s, Risk Mgmt 1)	0	0	0	0	0	0	0	0	0	0	0	0
Potential Allocation (m³/s, Risk Mgmt 2)	0	0	0	0	0	0	0	0	0	0	0	0
Potential Allocation (m³/s, Risk Mgmt 3)	>0	>0	>0	>0	>0	>0	>0	>0	>0	>0	>0	>0

Notes

Methods: Monthly discharge estimates have been generated from a hydrologic model. Existing allocation volumes have been summarized from government water licence and short term approval databases. Potential allocations are determined using criteria established in the Province of BC Environmental Flow Needs (EFN) Policy. Risk management levels have been calculated assuming the presence of fish. If the source can be classified as non-fish bearing, this may affect risk management levels. For more information on the EFN policy: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-policies/environmental-flow-needs

Risk Management Levels: The Province of BC Environmental Flow Needs Policy establishes risk management levels to be used in the evaluation of applications for water rights. Risk Management Levels and associated Risk Management Measures are discussed on page 5 of this report.

Accuracy: The query watershed is within the Kootenay Boundary Region. The hydrologic modeling study conducted in this region employed a water balance approach to estimate runoff in ungauged basins. The model used 143 watersheds with hydrometric gauges, and included detailed information on watershed climate, evapotranspiration, topography, vegetation and land cover. The model was calibrated using stream flow measurements from the Water Survey of Canada, and validated using a leave-one-out cross validation. Error metrics calculated for the entire model domain are: Mean error = 4.3%, Median Error = 0.3%, Mean Absolute Error = 14.8%, Watersheds within +/- 20% = 79%.

Allocations: Existing allocation volumes are determined from digital databases and include BC Water Sustainability Act licences and short term approvals. These represent a maximum amount of water authorized, not actual use. In many cases, licences may have additional terms and conditions to those represented in the digital version which are not represented. This may result in existing allocation volumes being presented as larger than are actually approved, either in total (on an annual basis) or for individual months. On subsequent pages of this report, information on each licence occurring in the watershed is provided, along with links to scanned copies of complete water licence information. For more information on specific areas of concern, please contact Water Stewardship Staff via FrontCounter BC. Contact information for FrontCounter BC is provided on page 2 of this report.

Risk Management Levels and Measures

Guide to interpreting potential allocation amounts in each environmental flow needs risk level as defined in the Province of BC Environmental Flow Needs Policy.

Water volumes presented as "Potential Allocations" within this report are determined in consideration of the Province of BC Environmental Flow Needs Policy. Within the Policy, risk management measures are suggested to assess or mitigate potential effects of withdrawals from a stream, and provide an ecosystem perspective on environmental flow needs. The measures are associated with risk levels 1, 2, and 3 and are intended to guide where more caution may be needed in reviewing an application or making a decision.

Where there are known species or habitat sensitivities, more detailed, site-specific studies may be required. Where detailed assessments or studies exist, they will supersede policy recommendations.

Risk management levels, for assessing new applications to withdraw water, are determined for each month using the relationship of mean monthly flows to the mean annual discharge, and also using a stream size threshold based on mean annual flows. The calculations presented within this report assume all streams are fish-bearing. Where no water is indicated as available under a risk level, the stream may be very flow sensitive during that time, or the stream may have existing allocations in excess of the relevant threshold.

Inter-annual hydrologic variability may affect the amount of water available in a given year. The impact of this variability on water allocations should be considered separately from the information presented in this report.

The following risk management measures may be appropriate for consideration before a decision is made, could be completed by regional staff to inform a decision, or could be a condition of the licence or approval.

Risk management measures may differ for short-term approvals vs. licences and may vary in relation to withdrawal amounts.

Risk Management Level 1

Measures to assess or mitigate potential effects on low sensitivity flow periods:

1. Assess veracity of information and ensure appropriate methods are used (Resources Information Standards Committee)
2. Consider downstream users and species/habitats

Risk Management Level 2

Measures to assess or mitigate potential effects on moderate sensitivity flow periods:

In addition to Level 1 measures:

1. Establish adequate baseline hydrological data before withdrawals
2. Prepare reconnaissance-level fish and fish habitat impact assessment (e.g., Section 4.1.10.1 in Lewis et al. 2004)
3. Issue seasonal licence, or restrictions during low flow periods
4. Development of off-stream storage
5. Inclusion of a daily maximum or inst. withdrawal e.g., greater consideration of instantaneous demand over averages
6. Limit pump intake size
7. Monitor and report water use during higher risk flow periods (e.g., install flow gauge)
8. Monitor low flows and limit withdrawals when flows drop below a certain level
9. Ministry staff to conduct audit of basin use/beneficial use review
10. Refuse application to withdraw water

Risk Management Level 3

Measures to assess or mitigate potential effects on height sensitivity flow periods:

In addition to Level 2 measures:

1. Issue limited licence term, allowing for review and potential adjustment (e.g., 5 years)
2. Prepare detailed habitat assessment (e.g., Lewis et al. 2004; Hatfield et al. 2007)

References

Hatfield, T., A. Lewis, and S. Babakaiff. 2007. Guidelines for the collection and analysis of fish and fish habitat data for the purpose of assessing impacts from small hydropower projects in British Columbia.
Lewis, A., T. Hatfield, B. Chilibeck, and C. Roberts. 2004. Assessment methods for aquatic habitat and instream flow characteristics in support of applications to dam, divert, or extract water from streams in British Columbia. Prepared for Ministry of Water, Land & Air Protection and Ministry of Sustainable Resource Management.
A. Lewis. 2002. Rationale for Multiple British Columbia Instream Flow Standards to Maintain Ecosystem Function and Biodiversity. Draft for Agency Review. Prepared for Ministry of Water, Land and Air Protection and Ministry of Sustainable Resource Management.
Resources Information Standards Committee: https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/natural-resource-standards-and-guidance/inventory-standards
Water Policies, including Environmental Flow Needs: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-policies

Allocations

Existing allocations in the watershed summarized by purpose and source.

Water rights in British Columbia are administered under the *Water Sustainability Act*. The existing water allocations in the watershed are summarized by water source, type, and whether the purpose is consumptive or not. On the following pages, each individual water right is listed with information on the specific water source and quantity, ordered by seniority.

Annual Volume	Consumptive Surface Water (m³)	Non-consumptive Surface Water (m³)	Consumptive Groundwater (m³)	Non-consumptive Groundwater (m³)
	21,783	0	0	0
	1,782,841	6,167	0	0
	0	893,711	0	0
	50,054	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0

Agriculture
Commercial
Industrial
Municipal
Oil & Gas
Power
Other

Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
PRIVATE INDIVIDUAL NAME Irrigation: Private from Ward Creek	C042215 File # 0265065	PD27468	7/27/1912		530 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Corner Spring	C039588 File # 0013975	PD27401	9/8/1919		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Stedile Springs	C047481 File # 0042669	PD27416	9/5/1922		2.27 m³/day	M
PRIVATE INDIVIDUAL NAME Domestic from Stedile Springs	C047481 File # 0042669	PD27417	9/5/1922		2.27 m³/day	M, N
PRIVATE INDIVIDUAL NAME Irrigation: Private from Stedile Springs	C047481 File # 0042669	PD27416	9/5/1922		888 m³/year	M
PRIVATE INDIVIDUAL NAME Irrigation: Private from Stedile Springs	C047481 File # 0042669	PD27417	9/5/1922		888 m³/year	M, N
PRIVATE INDIVIDUAL NAME Domestic from Kinder Spring	C067690 File # 0052624	PD27420	2/23/1924		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Irrigation: Private from Kinder Spring	C067690 File # 0052624	PD27420	2/23/1924		1,641 m³/year	T
PRIVATE INDIVIDUAL NAME Irrigation: Private from Bradshaw Creek	C041995 File # 0317538	PD27415	7/15/1925		826 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Latta Spring	F017172 File # 0062761	PD27423	8/3/1925		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Latta Spring	F017173 File # 0062761	PD27423	8/3/1925		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ymir Spring	F016206 File # 0086538	PD27422	5/20/1929		1.14 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ymir Spring	F016207 File # 0086538	PD27422	5/20/1929		1.14 m³/day	T
Multiple Licence Holders Domestic from Hawes Spring	C133941 File # 0091062	PD27413	5/3/1930		4.55 m³/day	T
1324188 B.C. Ltd. (169979) Incidental - Domestic from Selous Creek	F009633 File # 0091487	PD27431	6/7/1930		2.27 m³/day	T
1324188 B.C. Ltd. (169979) Irrigation: Private from Selous Creek	F009633 File # 0091487	PD27431	6/7/1930		3,219 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Armstrong Brook	C038252 File # 0309437	PD27421	12/17/1934		3.41 m³/day	T

Water Licence Flag Description

D: Multiple PODs for PUC/qty at each are known/PODs on different sources
M: Max licenced demand for purpose/multiple PODs/qty at each POD unknown
P: Multiple PODs for PUC/qty at each are known/PODs on same source
T: Total demand one POD

Other

N: Licence volumes not used in calculations
R: Rediversion

For more information on water licences:

Water Licence Query Tool: http://a100.gov.bc.ca/pub/wtrwhse/water_licences.input
Water Rights Databases: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-licences-approvals/water-rights-databases

Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
PRIVATE INDIVIDUAL NAME Domestic from Armstrong Brook	C104737 File # 0118791	PD27421	12/17/1934		3.41 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	F019581 File # 0137425	PD27450	10/7/1939		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	F019583 File # 0270435	PD27450	10/7/1939		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C103800 File # 0139699	PD27450	5/11/1940		4.55 m³/day	T
Klines Motors Ltd (4705) Power: Commercial from Giveout Creek	C042419 File # 0143127	PD27450	3/12/1945		max rate: 0.028 m³/sec	T, N
PRIVATE INDIVIDUAL NAME Domestic from Posnekoff Brook	F016061 File # 0178098	PD27435	4/24/1950		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Zytar Spring	F015432 File # 0183576	PD27412	5/3/1950		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Hawes Spring	C106709 File # 0183581	PD27413	5/5/1950		2.27 m³/day	T
Hbarh Holdings Ltd (150494) Domestic from Cottonwood Creek	C020864 File # 0195367	PD27408	6/17/1952		2.27 m³/day	M
Hbarh Holdings Ltd (150494) Domestic from Cottonwood Creek	C020864 File # 0195367	PD27409	6/17/1952		2.27 m³/day	M, N
Hbarh Holdings Ltd (150494) Irrigation: Private from Cottonwood Creek	C020864 File # 0195367	PD27408	6/17/1952		1,542 m³/year	M
Hbarh Holdings Ltd (150494) Irrigation: Private from Cottonwood Creek	C020864 File # 0195367	PD27409	6/17/1952		1,542 m³/year	M, N
PRIVATE INDIVIDUAL NAME Comm. Enterprise: Enterprise from Giveout Creek	C044421 File # 0197917	PD27445	12/19/1952		20.5 m³/day	T
PRIVATE INDIVIDUAL NAME Lwn, Fairway & Grdn: Watering from Giveout Creek	C044421 File # 0197917	PD27445	12/19/1952		1,085 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C044422 File # 0328578	PD27445	12/19/1952		2.27 m³/day	T
Klines Motors Ltd (4705) Comm. Enterprise: Enterprise from Giveout Creek	C044423 File # 0328579	PD27445	12/19/1952		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	F040540 File # 0198597	PD27444	2/16/1953		2.27 m³/day	T

Water Licence Flag Description

D: Multiple PODs for PUC/qty at each are known/PODs on different sources
M: Max licenced demand for purpose/multiple PODs/qty at each POD unknown
P: Multiple PODs for PUC/qty at each are known/PODs on same source
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Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
PRIVATE INDIVIDUAL NAME Irrigation: Private from Giveout Creek	F040540 File # 0198597	PD27444	2/16/1953		185 m³/year	T
City of Nelson - Operations and Engineering (123525) Waterworks: Local Provider from Selous Creek	C021894 File # 0198727	PD27432	2/28/1953		1,659,323 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C059544 File # 0200499	PD27440	7/6/1953		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C059545 File # 0370396	PD27440	7/6/1953		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	F018407 File # 0213601	PD27439	9/24/1956		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	F018411 File # 0220408	PD27441	5/16/1958		2.27 m³/day	M
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	F018411 File # 0220408	PD27443	5/16/1958		2.27 m³/day	M, N
Nelson Area Waldorf School Association (40551) Domestic from King Spring	F019091 File # 0221384	PD27429	7/7/1958		6.82 m³/day	T
Multiple Licence Holders Domestic from Cottonwood Creek	C025410 File # 0221379	PD27411	7/8/1958		2.27 m³/day	T
Hbarh Holdings Ltd (150494) Irrigation: Private from Schesnuk Creek	C026734 File # 0220790	PD27430	7/11/1961		3,084 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Johnstone Spring	C106694 File # 0242652	PD27418	2/14/1962		2.27 m³/day	T
Multiple Licence Holders Domestic from Johnstone Spring	C106710 File # 0243813	PD27418	2/14/1962		2.27 m³/day	T
Multiple Licence Holders Domestic from Towner Creek	C068980 File # 0248701	PD27424	3/20/1963		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C028755 File # 0249982	PD27442	5/24/1963		13.6 m³/day	T
PRIVATE INDIVIDUAL NAME Land Improvement: General from Giveout Creek	C028755 File # 0249982	PD27442	5/24/1963		617 m³/year	T, N
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C030641 File # 0262851	PD27442	6/2/1965		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C030568 File # 0263075	PD27442	6/3/1965		2.27 m³/day	T

Water Licence Flag Description

D: Multiple PODs for PUC/qty at each are known/PODs on different sources
M: Max licenced demand for purpose/multiple PODs/qty at each POD unknown
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Other

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Water Rights Databases: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-licences-approvals/water-rights-databases

Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
PRIVATE INDIVIDUAL NAME Comm. Enterprise: Enterprise from Giveout Creek	C049159 File # 0263434	PD27442	7/6/1965		22.7 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C049159 File # 0263434	PD27442	7/6/1965		2.27 m³/day	T
Multiple Licence Holders Comm. Enterprise: Enterprise from Giveout Creek	C049160 File # 0346006	PD27442	7/6/1965		6.82 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Mawer Spring	C032640 File # 0273463	PD27428	5/23/1967		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ward Creek	C041588 File # 0281402	PD27471	7/11/1968		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ward Creek	C041873 File # 0285322	PD27470	3/26/1969		4.55 m³/day	T
0983380 B.C. Ltd. (143271) Domestic from Mawer Spring	C035057 File # 0285516	PD27428	5/5/1969		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Kaspar Brook	C036419 File # 0290404	PD35150	9/26/1969		2.27 m³/day	T
Multiple Licence Holders Domestic from Cerny Spring	C036698 File # 0296690	PD27426	6/29/1970		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Salmo River	C117825 File # 0300099	PD28695	8/27/1970		2.27 m³/day	T
Multiple Licence Holders Domestic from Salmo River	C117826 File # 4004534	PD28695	8/27/1970		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Irrigation: Private from Allan Spring	C104735 File # 0305902	PD27419	8/20/1971		617 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Morton Brook	C065941 File # 0310796	PD27425	9/1/1972		4.55 m³/day	T
Multiple Licence Holders Lwn, Fairway & Grdn: Watering from Cottonwood Creek	C047292 File # 0317458	PD27474	8/7/1973		24,670 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Bradshaw Creek	C044802 File # 0317690	PD27415	8/27/1973		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Cottonwood Creek	C044431 File # 0317839	PD27411	9/18/1973		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Irrigation: Private from Cottonwood Creek	C044431 File # 0317839	PD27411	9/18/1973		1,542 m³/year	T

Water Licence Flag Description

D: Multiple PODs for PUC/qty at each are known/PODs on different sources
M: Max licenced demand for purpose/multiple PODs/qty at each POD unknown
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Other

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Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
Multiple Licence Holders Irrigation: Private from Cottonwood Creek	C044432 File # 0317840	PD27411	9/18/1973		1,542 m³/year	T
PRIVATE INDIVIDUAL NAME Comm. Enterprise: Enterprise from Giveout Creek	C044424 File # 0317884	PD27445	9/21/1973		6.82 m³/day	T
PRIVATE INDIVIDUAL NAME Comm. Enterprise: Enterprise from Giveout Creek	C044425 File # 0317885	PD27445	9/21/1973		11.4 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Gentry Creek	C044928 File # 0322228	PD27433	11/30/1973		2.27 m³/day	T
Breejord Holdings Inc (175993) Domestic from Ward Creek	C047089 File # 0323434	PD27469	7/16/1974		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C116032 File # 0323473	PD27448	7/26/1974		2.27 m³/day	T
Klines Motors Ltd (4705) Comm. Enterprise: Enterprise from Giveout Creek	C049158 File # 0328292	PD27450	1/29/1975		45.5 m³/day	T
Klines Motors Ltd (4705) Comm. Enterprise: Enterprise from Giveout Creek	C049157 File # 0328328	PD27445	2/7/1975		9.09 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C068938 File # 0328975	PD27447	6/16/1975		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Graves Spring	C048644 File # 0329493	PD27414	9/15/1975		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Fermi Spring	C053828 File # 0330058	PD25689	1/2/1976		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ward Creek	C056250 File # 0330602	PD27472	5/4/1976		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ward Creek	C056251 File # 0369535	PD27472	5/4/1976		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Ward Creek	C050464 File # 0340292	PD27467	9/21/1976		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C058700 File # 0365856	PD27451	6/25/1979		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C057548 File # 0355010	PD27442	7/23/1979		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C056947 File # 0355246	PD27450	8/24/1979		2.27 m³/day	T

Water Licence Flag Description

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Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C057212 File # 0355243	PD27450	8/24/1979		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C057213 File # 0355245	PD27450	8/24/1979		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C109364 File # 0367319	PD27442	10/1/1980		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C060953 File # 0369130	PD27449	8/19/1981		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Graves Spring	C060681 File # 0369396	PD27414	10/28/1981		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C061594 File # 0370027	PD27447	3/1/1982		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C059968 File # 4000063	PD27446	6/14/1982		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C060063 File # 4000123	PD27450	8/4/1982		6.82 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C060030 File # 4000134	PD27450	8/27/1982		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Angie Spring	C064898 File # 4000248	PD27436	2/28/1983		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Sparky Spring	C066058 File # 4001015	PD27437	1/2/1986		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Lisa Spring	C100520 File # 4001828	PD28091	8/21/1989		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C100529 File # 4001856	PD27450	9/19/1989		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Kramar Spring	C100546 File # 4001928	PD60897	1/18/1990		2.27 m³/day	T
Sjoa Creekside Designs Ltd. (81703) Domestic from Corner Spring	C100255 File # 4002108	PD27401	9/18/1990		2.27 m³/day	T
Nelson Golf & Recreation Society (8585) Land Improvement: General from Hawes Spring	C100656 File # 4002109	PD27413	9/24/1990		5,551 m³/year	M, N
Nelson Golf & Recreation Society (8585) Land Improvement: General from Bradshaw Creek	C100656 File # 4002109	PD27415	9/24/1990		5,551 m³/year	M, N

Water Licence Flag Description

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Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
Nelson Golf & Recreation Society (8585) Lwn, Fairway & Grdn: Watering from Hawes Spring	C100656 File # 4002109	PD27413	9/24/1990		11,101 m³/year	M
Nelson Golf & Recreation Society (8585) Lwn, Fairway & Grdn: Watering from Bradshaw Creek	C100656 File # 4002109	PD27415	9/24/1990		11,101 m³/year	M, N
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C100717 File # 4002140	PD27442	11/19/1990		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C101716 File # 4002228	PD27442	5/15/1991		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Comm. Enterprise: Enterprise from Kencourt Spring	C104446 File # 4002420	PD65520	3/17/1992		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Kencourt Spring	C104446 File # 4002420	PD65520	3/17/1992		2.27 m³/day	T
Nelson Area Waldorf School Association (40551) Camps & Pub Facil: Institutions from Silver Spring	C105749 File # 4002669	PD66994	11/24/1992		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C108477 File # 4003060	PD27450	8/2/1994		4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giovanni Spring	C110096 File # 4003312	PD71299	8/25/1995		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C110097 File # 4003313	PD71300	8/25/1995		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Irrigation: Private from Giveout Creek	C110097 File # 4003313	PD71300	8/25/1995		6,167 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C112894 File # 4003793	PD27442	1/5/1998		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C114491 File # 4004020	PD27450	6/9/1999		2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Angie Spring	C115301 File # 4004117	PD27436	5/15/2000		2.27 m³/day	T
4451 Highway 6 Holdings LTD (159416) Domestic from Acadine Creek	C118701 File # 4004658	PD77953	7/24/2003		2.27 m³/day	T
City of Nelson - Operations and Engineering (123525) Lwn, Fairway & Grdn: Watering from Cottonwood Creek	C130716 File # 4006288	PD185700	2/26/2013		258 m³/year	M
City of Nelson - Operations and Engineering (123525) Lwn, Fairway & Grdn: Watering from Cottonwood Creek	C130716 File # 4006288	PD185702	2/26/2013		258 m³/year	M, N

Water Licence Flag Description

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Existing Allocations

Water Licences (Surface Water)

Current approved surface water rights

BC Water Sustainability Act - Water Licences - 102 Licences, 1,854,678 m³ Total Annual Volume

Licensee	Number	POD	Priority Date ↓	Expiry Date	Quantity	Flag
City of Nelson - Operations and Engineering (123525) Lwn, Fairway & Grdn: Watering from Cottonwood Creek	C131454 File # 4006340	PD186017	7/30/2013		60.0 m³/year	T
PRIVATE INDIVIDUAL NAME Domestic from Giveout Creek	C131615 File # 4006348	PD27442	2/11/2014		2.27 m³/day	T
Ministry of Transportation and Infrastructure (137860) Misc Ind'l from Cottonwood Creek	500542 File # 4007280	PD192891	2/2/2018		120 m³/year (max rate: 0.002 m³/sec)	D
Ministry of Transportation and Infrastructure (137860) Misc Ind'l from Giveout Creek	500542 File # 4007280	PD192892	2/2/2018		120 m³/year (max rate: 0.002 m³/sec)	D

Water Licence Flag Description

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Active Applications

Surface Water

Active applications for surface water licences

BC Water Sustainability Act - Water Interests - 3 Active Applications, 0 m³ Total Annual Volume

Applicant	Number	POD	Priority Date ↓	Quantity	Flag
Multiple Licence Holders Irrigation: Private from Unknown	107971 File # 20007971	PD194990		N/A	N/A
PRIVATE INDIVIDUAL NAME Domestic from Unknown	109234 File # 20009234	PD27472		N/A	N/A
Multiple Licence Holders Domestic from Unknown	119601 File # 20019601	PD28695		N/A	N/A

Water Licence Flag Description

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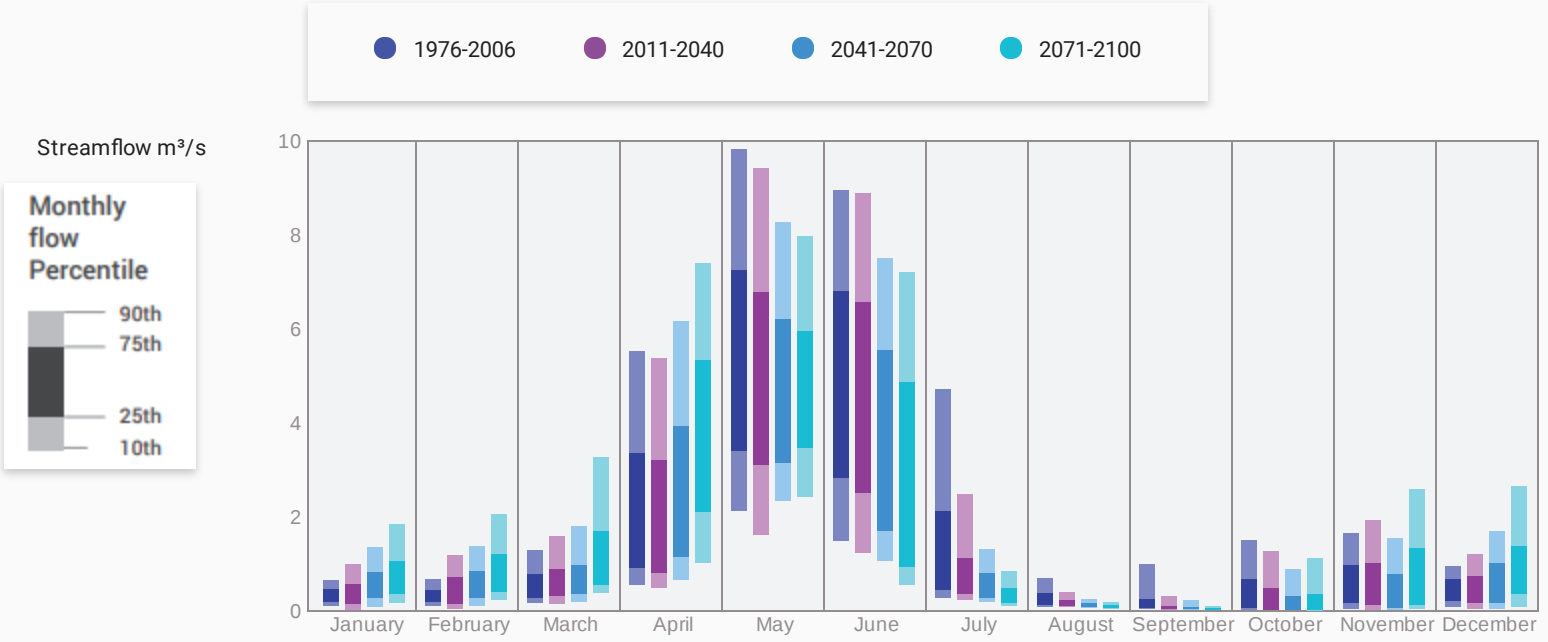
Current and Future Hydrologic Variability

Modeled hydrologic variability and future characteristics derived from process based hydrology models from Pacific Climate Impacts Consortium (PCIC)[1] and the University of Colorado (UC)[2]

The chart and table below summarize the daily output of Variable Infiltration Capacity (VIC) hydrology models to describe potential past and future hydrologic variability in the watershed. Values should be used as estimations only. If the chart and table below have only 1976-2006 values, the data is from UC. If there are future predictions, the data is from PCIC.



1976-2006	90th	0.65	0.68	1.3	5.5	9.8	8.9	4.7	0.7	1	1.5	1.7	0.94
	75th	0.47	0.46	0.79	3.4	7.3	6.8	2.1	0.39	0.26	0.69	0.99	0.67
	50th	0.32	0.29	0.5	1.8	5.2	4.8	0.91	0.22	0.11	0.21	0.51	0.43
	25th	0.2	0.19	0.3	0.92	3.4	2.8	0.46	0.13	0.06	0.06	0.17	0.22
	10th	0.12	0.11	0.19	0.56	2.1	1.5	0.27	0.09	0.04	0.03	0.05	0.09
2011-2040	90th	1	1.2	1.6	5.4	9.4	8.9	2.5	0.38	0.31	1.3	1.9	1.2
	75th	0.58	0.72	0.9	3.2	6.8	6.6	1.1	0.23	0.11	0.51	1	0.76
	50th	0.46	0.54	0.67	2	5.1	4.6	0.67	0.17	0.08	0.18	0.48	0.54
	25th	0.14	0.16	0.31	0.82	3.1	2.5	0.36	0.11	0.05	0.04	0.13	0.16
	10th	0.04	0.05	0.15	0.49	1.6	1.2	0.24	0.08	0.04	0.02	0.02	0.05
2041-2070	90th	1.4	1.4	1.8	6.2	8.3	7.5	1.3	0.26	0.23	0.89	1.5	1.7
	75th	0.83	0.85	0.98	3.9	6.2	5.6	0.8	0.18	0.09	0.33	0.8	1
	50th	0.62	0.69	0.97	2.7	5.4	3.8	0.5	0.13	0.06	0.13	0.53	0.7
	25th	0.28	0.28	0.36	1.2	3.2	1.7	0.28	0.09	0.04	0.03	0.08	0.18
	10th	0.1	0.12	0.2	0.66	2.3	1.1	0.19	0.07	0.03	0.02	0.02	0.04
2071-2100	90th	1.8	2.1	3.3	7.4	8	7.2	0.85	0.18	0.09	1.1	2.6	2.7
	75th	1.1	1.2	1.7	5.3	6	4.9	0.5	0.13	0.06	0.36	1.3	1.4
	50th	1	1.3	1.8	3.8	5.4	2.7	0.34	0.1	0.05	0.13	0.92	1.1
	25th	0.38	0.41	0.56	2.1	3.5	0.94	0.17	0.06	0.03	0.02	0.13	0.36
	10th	0.17	0.24	0.39	1	2.4	0.56	0.12	0.05	0.02	0.01	0.04	0.1

For the historical period, the hydrologic models are driven by gridded datasets generated from historical weather station data. The years 1976-2006 were selected as the most recent 30 year period with historical data available. Calculated percentiles for this historical time period are based on the sample of daily predictions for each month over this time period. These percentiles have been scaled using the hydrology estimates on page 3, but have not been adjusted for regulation and thus represent unimpeded flow conditions.
For future time periods, the hydrologic models are driven by gridded Global Circulation Models (GCMs) - CGCM3 A2 Run 1, GFDL 2.1 A2 Run 1, HadCM A2 Run 1. Calculated percentiles for the future time periods show the highest 90th and 75th percentiles from the three GCMs. The 50th percentile is the average of the 50th percentile from the three GCMs. The 25th and 10th percentiles are the lowest 25th and 10th percentiles from the three GCMs. Change between historical and future time periods were calculated using the GCM outputs and scaled using the hydrology estimates on page 3, but have not been adjusted for regulation.
Please note that future estimates of hydrologic variability are only available in the area covered by PCIC's hydrology modeling, the University of Colorado project did not forecast future hydrologic conditions.

References

1: Pacific Climate Impacts Consortium, University of Victoria, (Jan. 2014). Gridded Hydrologic Model Output. Downloaded from https://data.pacificclimate.org/portal/hydro_model_out/map/ on 2018-01-15.

2: Livneh, Ben; Bohn, Theodore J.; Pierce, David W.; Muñoz-Arriola, Francisco; Nijssen, Bart; Vose, Russell; Cayan, Daniel R.; Brekke, Levi (2015). A spatially comprehensive, hydrologic model-based data set for Mexico, the U.S., and southern Canada, 1950-2013. NOAA National Centers for Environmental Information. Dataset. doi:10.7289/V5QZ27ZG [2018-02-02]

Land Cover and Topography

Characteristics of the query watershed. For more information on watershed characterization in British Columbia please refer to Pike and Wilford (2013).

Land Cover

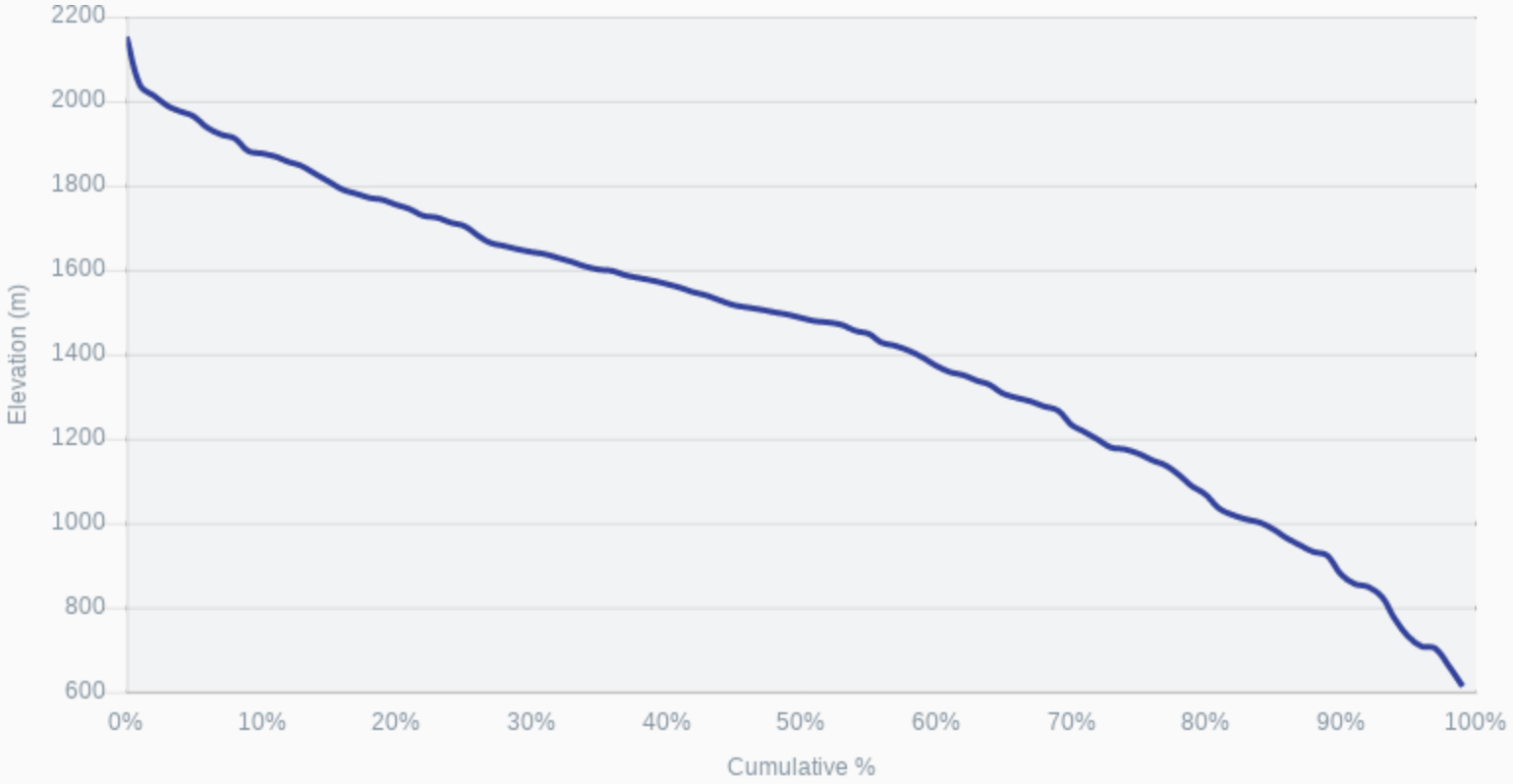
The land cover characteristics chart illustrates the composition of vegetation and land cover types in the query watershed. These land cover components are incorporated in the hydrologic model, to represent the variations in evapotranspiration rates amongst the classes.

0.0%	94.8%	0.7%	2.5%	0.4%	0.0%	0.0%	1.5%
Barren	**Coniferous**	**Deciduous**	**Developed**	**Grassland**	**Herb**	**Mixed**	**Shrub**
0 km²	60.3 km²	0.451 km²	1.62 km²	0.263 km²	0 km²	0 km²	0.928 km²

0.0%	0.0%	0.1%
Snow	**Water**	**Wetland**
0 km²	0 km²	0.065 km²

Topography

Elevation of the query watershed influences hydrology in a number of ways. The amount, and state of precipitation (as rain or snow) is influenced by elevation substantially. Likewise, temperatures will vary by elevation in value and also direction of temperature gradient throughout the course of the year.



Reference:
Pike, R.G. and D.J. Wilford. 2013. Desktop watershed characterization methods for British Columbia. Prov. B.C., Victoria, B.C. Tech. Rep. 079. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr079.htm.

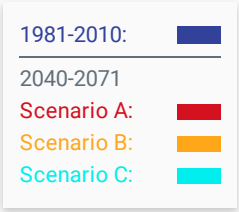
Climate

Historic normal conditions and predicted future change.

The climate of the query watershed has been characterized using ClimateWNA (Wang 2012). Charts are presented below displaying the reference time period **1981-2010** as well as three illustrative future climate change scenarios for the period 2041-2070 that have been selected to estimate a wide range of potential future change in the query watershed (Cannon, 2015).

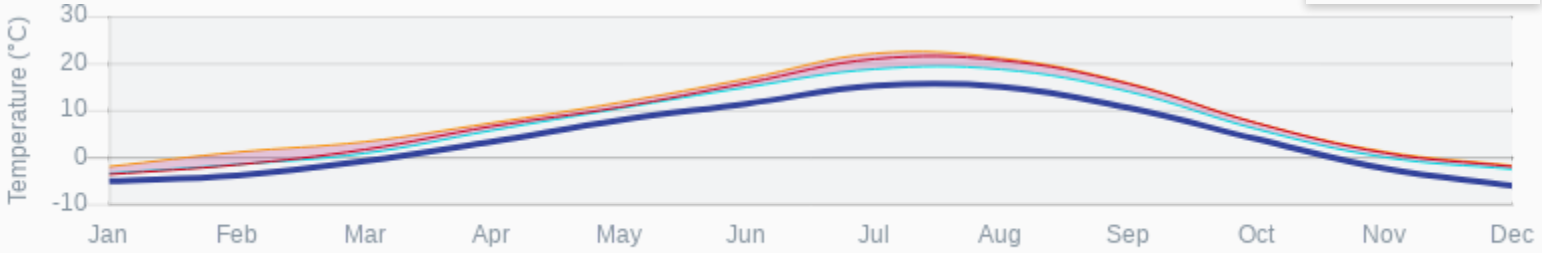
Scenario A illustrates the **ACCESS1-0-r1** global climate model (GCM), Scenario B shows the **CanESM2-r1 GCM** and Scenario C shows the **CNRM-CM5-r1 GCM**. All climate change scenarios presented are from representative concentration pathway (RCP) 8.5. These three climate models and concentration pathway were chosen to illustrate the widest spread in projected future climate for smaller subsets of the full CMIP5 ensemble, over most of Western North America.

Historic and future climate change information has been provided to assist in understanding potential changes in the basin as temperature and precipitation are intricately related to stream flow. For example, snowpack levels affect many aspects of water resources, from instream flows for fish to community water supplies to soil moisture, groundwater, and aquifer recharge. Climate studies generally indicate a trend of rising air temperatures for all seasons across BC while precipitation trends vary by season and region (Pike *et al.* 2008, Rodenhuis *et al.* 2007). Local responses to changing precipitation and temperature will differ due to BC's inherent hydrological diversity as well as varying climate trends. These charts are intended as a quick glance starting point to basin climate change assessment.



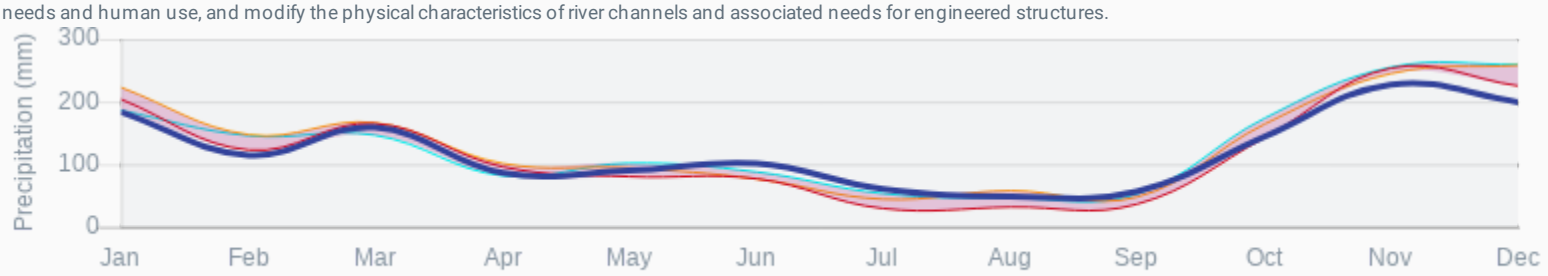
Temperature

Monthly temperatures are presented as averages of the monthly mean temperature for the query basin as a whole. Projected changes in temperature may affect the hydrology in the watershed by influencing the time of freeze and thaw, evapotranspiration rates, form of precipitation, and vegetation composition, among other factors.



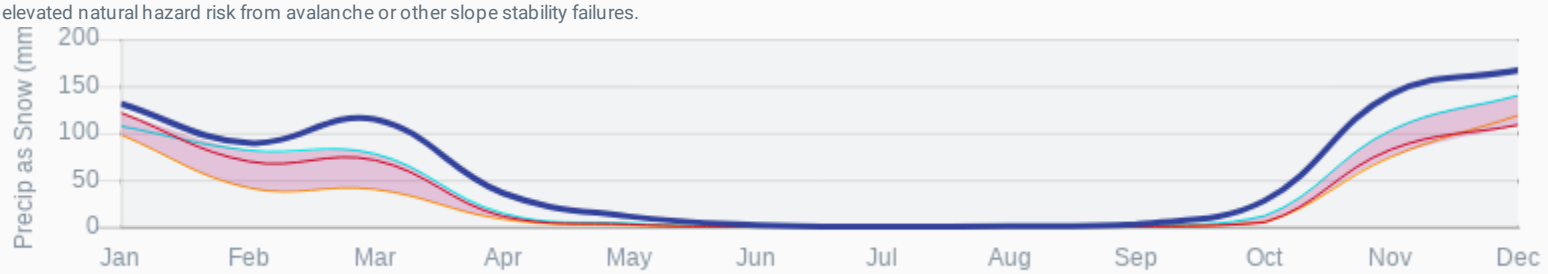
Precipitation

The precipitation in the query watershed is shown as an average unit precipitation for the watershed. Changes in precipitation timing and amount may affect the hydrology in the watershed by influencing the timing and magnitude of peak and low flow conditions. These changes may affect availability of water for environmental flow needs and human use, and modify the physical characteristics of river channels and associated needs for engineered structures.



Precipitation as snow

Precipitation as snow in the query watershed is presented as an average unit precipitation for the query basin as a whole. Changes in the amount of precipitation as snow may affect winter snowpack volumes and associated melt related hydrology in the spring. An increase in rain-on-snow events may be associated with elevated natural hazard risk from avalanche or other slope stability failures.



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