MacHydro

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Memorandum – Desktop Hydrologic Evaluation of the Allison Community Hazardous Fuels Reduction (CHFR) Proposal

Key Findings

- Allison Creek CHFR proposal is for the harvest of 453 hectares of conifer forest with a goal of lowering wildfire risk to nearby communities by removing fuel.
- The proposed harvest plan was developed using hydrological model outputs to help determine block size and coverage.
- The likelihood of hydrologic alteration due to the CHFR proposal is projected to be low for Allison Creek at the Mouth. The planned harvest is projected to increase flows by 2–4% with negligible changes in the timing of spring freshet.
- The likelihood of hydrologic alteration is projected to be greater where harvest is concentrated (Deadman's Pass Creek and Phillips Peak Creek); peak flows are projected to increase by up to 5%.
- Hydrologic alteration from harvest is likely to decrease over time as forests regrow.
- Climate change is likely to reduce streamflow in Allison Creek, especially during the late summer and advance spring freshet timing.
- Some of the proposed harvest is in areas that are likely to be sensitive in terms of peak or late-summer streamflow contribution. Increasing stand retention in these areas would help preserve hydrologic function (i.e. shade, interception, moisture retention, evapotranspiration).
- Existing road density is high, and the lower part of the study area has easily erodible soils, so sediment generation and transport should be mitigated with proper drainage structures and Best Management Practices for erosion and sediment control.
- The desktop analysis suggests some riparian areas are likely degraded. Best Management Practices and Operational Ground Rules should be followed relative to riparian areas.

Introduction

The Community Hazardous Fuels Reduction (CHFR) Program was designed to strengthen wildfire resilience in communities facing increased fire risk. The CHFR focuses on removing vegetation within 5 km of vulnerable communities applying a timber harvest strategy to remove relatively large areas of coniferous forest. The current proposal is to harvest portions of the Allison Creek watershed in the headwaters of the Crowsnest River watershed, totalling an area of 453 ha (Figure 1).

Forest harvest alters the hydrologic processes that drive runoff generation in snowmelt-dominated mountain watersheds, potentially changing the quantity and seasonal timing of streamflow (Buttle, 2011; Green and Alila, 2012). Removal of the forest canopy reduces interception and sublimation (loss) of snowfall, increasing snow accumulation in openings, and increases the energy available for snowmelt (Burles and Boon, 2011; Pomeroy et al., 2012; Ellis et al., 2013). As an example, at the Marmot Creek Research Basin in Kananaskis Country, clearcut harvest of 21% of the Cabin Creek watershed increased annual water yield by approximately 6% and produced earlier and more variable streamflow,

whereas harvest of many small openings in the adjacent Twin Creek watershed did not measurably increase water yield (Harder et al., 2015; Rothwell et al., 2016).

Peak flows can be more sensitive to forest cover loss than annual or seasonal water yield. Johnson and Alila (2023) showed that 21% harvest could result in medium to large flood events becoming more common in the Deadman River and Joe Ross Creek watersheds in British Columbia. Modelling at Marmot Creek indicated that clearcutting 5–35% of the watershed increased seasonal streamflow by 3–5%, while peak daily flows increased by 7–8% (Pomeroy et al., 2012). The magnitude of the peak flow response depends on whether canopy loss synchronizes or desynchronizes snowmelt runoff across elevations and aspects; desynchronization can reduce the frequency and magnitude of floods, while synchronization can increase peak flows (Green and Alila, 2012; Ellis et al., 2013; Zhang and Wei, 2014). The location of harvest also matters in terms of where runoff is generated. Forest cover loss at mid to upper elevations can lead to more snow on the ground and earlier snowmelt, advancing the timing and magnitude of spring high flows (Schnorbus and Alila, 2013; Winkler et al., 2015).

Streamflow responses to harvest are also strongly mediated by subsurface storage and climate variability. Watersheds underlain by glacial till and fractured sedimentary bedrock in the southern Rocky Mountains, including the Crowsnest Pass, have large subsurface storage that can buffer runoff responses to increased water inputs (Spencer et al., 2019; Spencer et al., 2021), and can attenuate peak flows (Harder et al., 2015). Harvest-related increases in streamflow can also be damped by drier antecedent conditions associated with climate (Goodbrand et al., 2022) or affected by changes in soil properties (Saglam and Gokbulak, 2024). Over-arching climate warming can also advance snowmelt timing and reduce summer water availability and forest cover change can compound these effects (Mahat and Anderson, 2013).

The CHFR is focused on reducing fuel for wildfire. Fire is a natural disturbance in this landscape, but high severity wildfire can alter ecohydrological processes, leading to rapid runoff responses, increased surface runoff, elevated erosion and sediment delivery to streams, and greater potential for mass movement (Seibert et al., 2010; Ebel et al., 2012; Robinne et al., 2020). Following the 2003 Lost Creek wildfire in the Crowsnest Pass, suspended sediment concentrations and yields were substantially higher in burned watersheds, were further elevated by post-fire salvage logging, and varied strongly with the magnitude of snowmelt freshet and storm flows (Silins et al., 2009). The wildfire also increased stream nitrogen concentrations and export (Bladon et al., 2008), affected stream temperature (Wagner et al., 2014), and created challenges for downstream drinking water treatment (Emelko et al., 2011; Emelko et al., 2016). In contrast, low severity wildfire, either natural or prescribed, can help maintain forest ecosystem health and related services and reduce the risk of high severity wildfire (Robinne et al., 2020).

West Fraser Cochrane (COS) has retained MacDonald Hydrology Consultants Ltd. (MacHydro) to evaluate potential effects of the proposed CHFR harvest on hydrologic conditions in the Allison Creek watershed using a desktop analysis. This memorandum describes the methods used to conduct the evaluation and the results, with recommendations to minimize hydrologic effects. The scope of this work is not a full watershed assessment, rather it is intended to provide guidance to COS in relation to potential effects of proposed harvest and to refine the harvest plan.

Study Area

The proposed CHFR harvest is located within the Allison Creek watershed in south-western Alberta (Figure 1), a tributary of the Crowsnest River. The watershed originates along the eastern slopes of the Rocky Mountains, flowing from alpine and high-elevation grassland reaches in the headwaters to a

primarily forested valley bottom (Figure 3). The study area was broken into five sub-watersheds for the purposes of this analysis, driven by individual streams:

- Allison Creek near the Mouth (area = 54.2 km^2)
- Allison Creek above Deadman's Pass Creek (area = 25.9 km^2)
- Deadman's Pass Creek above Chinook Lake (area = 15.9 km^2)
- Deadman's Pass Creek above Phillips Peak Creek (area = 8.7 km^2)
- Phillips Peak Creek (area = 4.4 km^2)

The proposed harvest covers 453 hectares within Allison Creek. This comprises approximately 9% of the Allison Creek drainage area. The proposed harvest is concentrated in Deadman's Pass Creek and Phillips Peak Creek where it accounts for 19% to 21.7% of the drainage areas respectively. Some recent cutblocks cover lower reaches of Allison Creek (approximately 3% of the watershed), but there has been no recent harvesting on Deadman's Pass Creek upstream of Chinook Lake. No new roads were evaluated as part of this plan.

The surficial geology of the watershed is comprised of bedrock, glaciofluvial and fluvial deposits as well as moraine. Kame terraces are present along the valley floors (Jackson et al., 2008). Elevation ranges from approximately 1,365 m above sea level (a.s.l.) at the watershed outlet to over 2,500 m a.s.l. at Mt. Tecumseh and 2,700 m a.s.l. at Crowsnest Mountain. The watershed slopes are oriented primarily east and west, with a relatively equal distribution of aspects (Figure 2).

Chinook Lake is downstream of the proposed harvest. The Allison Creek Brood Trout Hatchery is further downstream along Allison Creek, with groundwater licences to support water supply for the Hatchery. The region is used extensively by recreationalists and has multiple industrial uses, including forestry, agriculture, and oil and gas. Allison Creek is home to an isolated native Westslope Cutthroat Trout (*Oncorhynchus Clarkii Lewisi*) population.

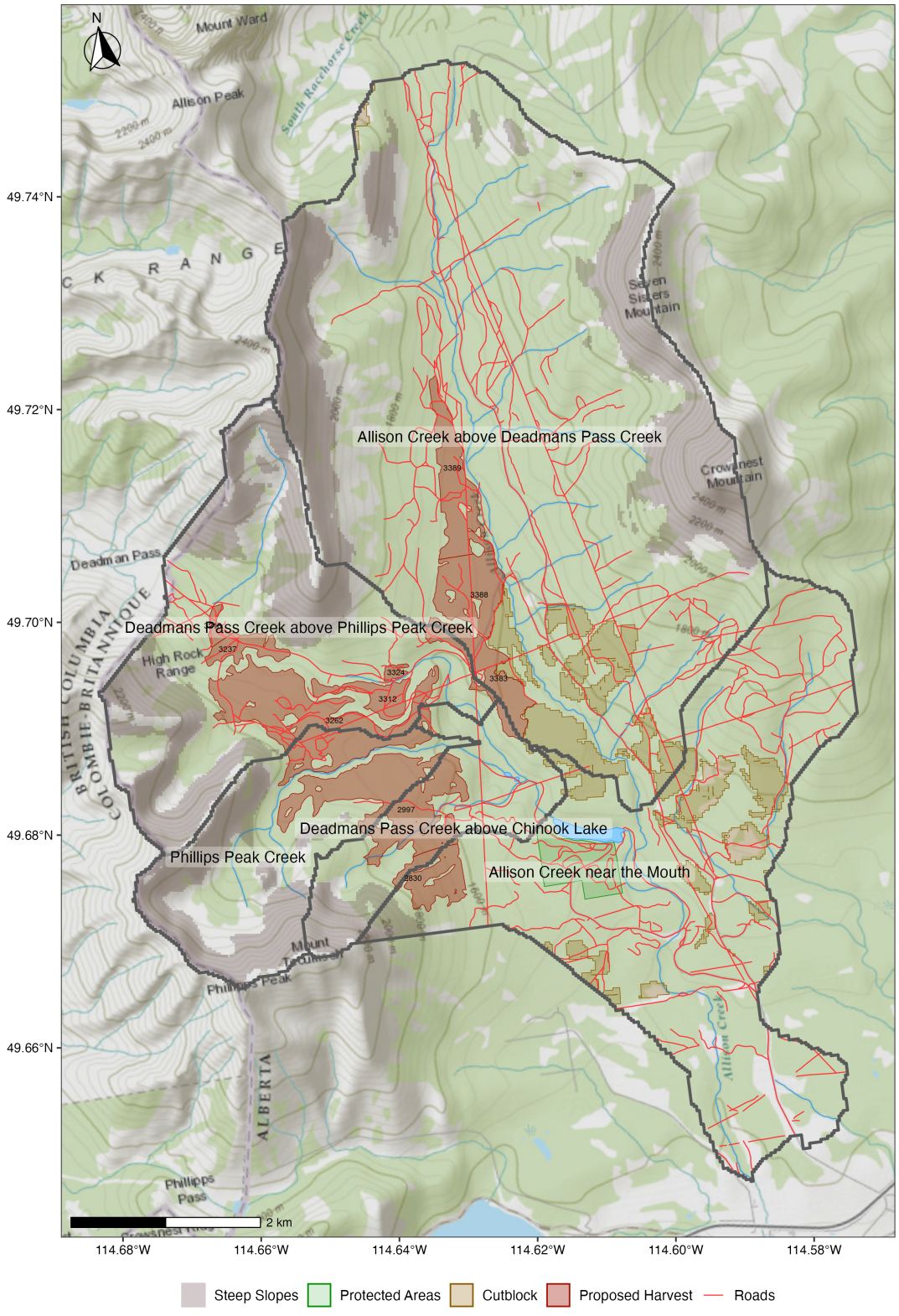


Figure 1 Study area location map showing sub-watershed boundaries (black outlines), proposed harvest blocks (brown), existing cutblocks (tan), existing roads (red), steep slopes >50% (grey), and protected areas (green).

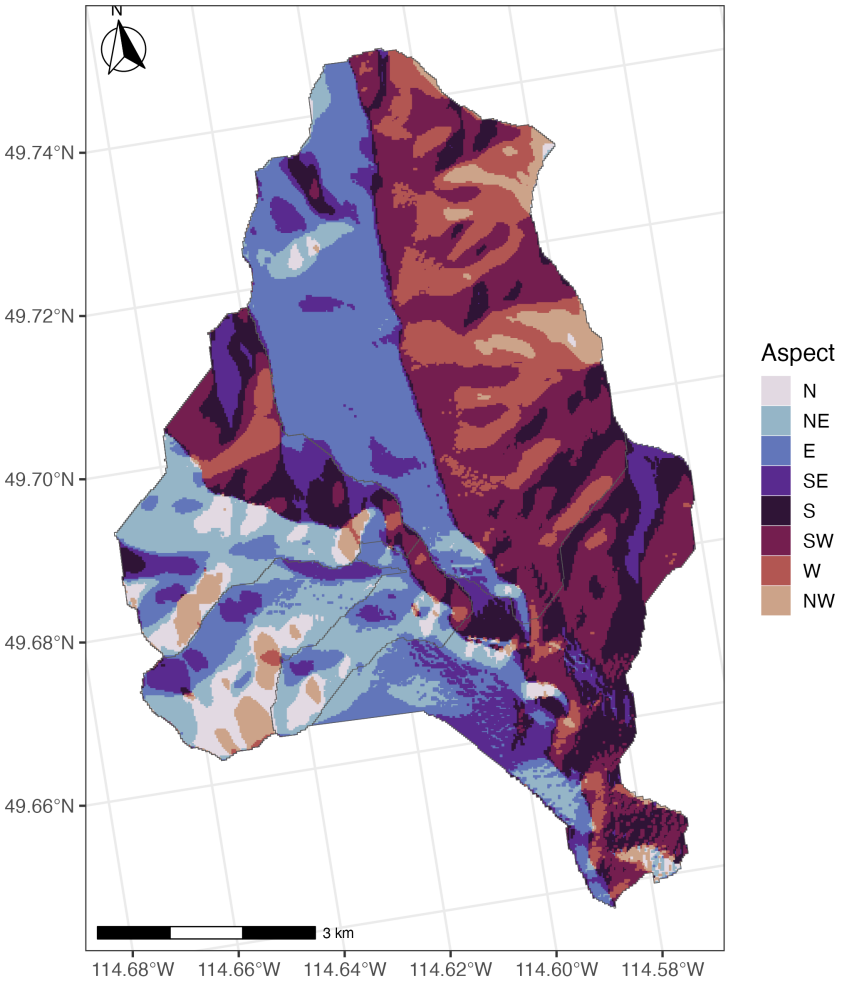


Figure 2 Aspect distribution across the study area.

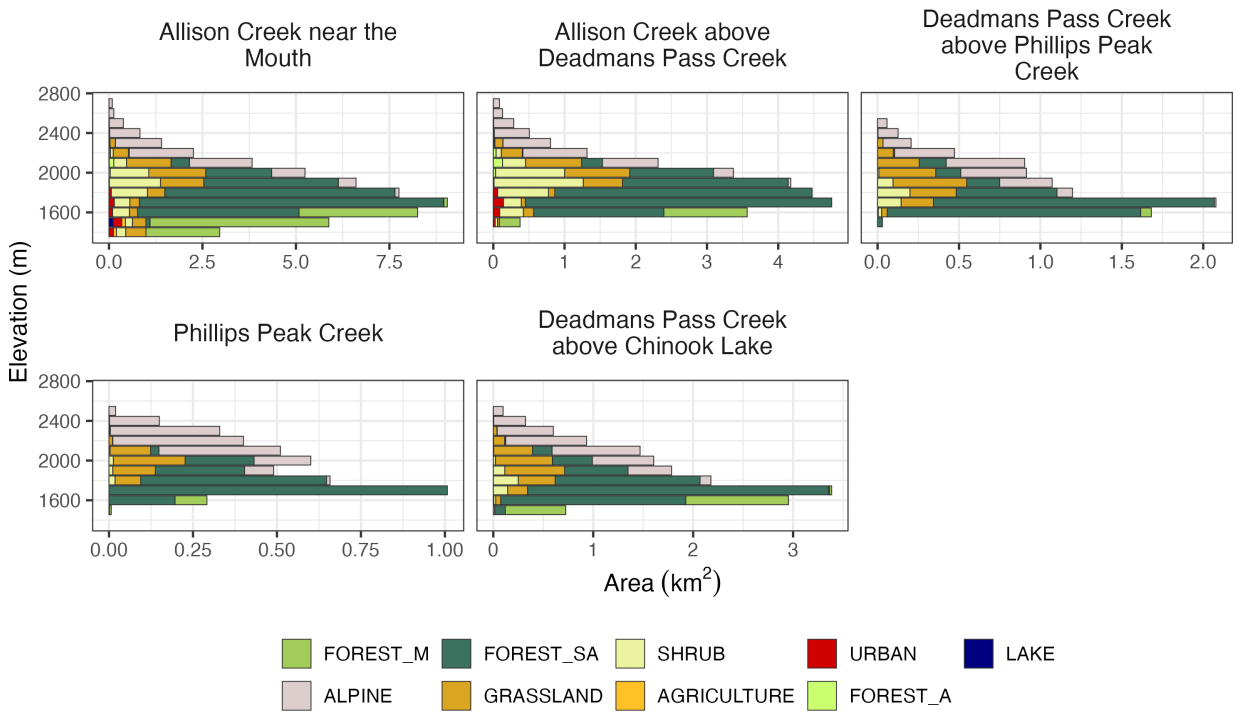


Figure 3 Hypsometry (elevation by area) by land cover type across all five study sub-watersheds.

Methodology

Geospatial Analysis

The geospatial analysis includes components of a GIS indicator-based watershed assessment procedure for snowmelt-dominated hydrologic regimes (Lewis et al., 2016) adapted for the Southern Alberta Rocky Mountain context. GIS indicators related to streamflow, erosion potential, and riparian function were calculated. The watersheds are also described in terms of their physiographic characteristics, which provides insight into how these areas could respond to disturbance.

Variables describing watershed vulnerability to potential disturbance include percent forested area (the proportion of the watershed covered by forest, where higher forest cover translates to higher potential hydrologic response to harvest), drainage density ruggedness (the dimensionless product of drainage density and total elevation relief, indicating potential for rapid runoff delivery), and area-weighted percentage of lakes and wetlands (storage that can buffer streamflow response).

Variables describing erosion potential include the percentage of easily erodible soils (glacio-fluvial or glacio-lacustrine deposits that lack cohesion) and the extent of steep coupled slopes (slopes >50% gradient within 50 m of a stream). The higher the proportion of these features, the higher the potential for sediment generation and delivery.

Landscape disturbance indicators include road density (km/km^2); roads close to water (road length within 100 m of a stream, per unit area (km/km^2)), roads on steep coupled slopes (km/km^2), disturbance on steep coupled slopes (%), and Equivalent Clearcut Area (ECA, %). ECA broadly represents the extent of forest disturbance and regrowth, where higher values indicate more disturbance. ECA was calculated under current and proposed harvest conditions following standard methods (Winkler and Boon, 2017).

Hydrologic Recovery was estimated following the methods outlined in Green et al., (2021). The provincial planning ECA threshold is 30%.

Riparian condition indicators include proportion of stream length within protected areas (%), percentage of logged or disturbed terrain within 30 m of a stream (%), proportion of range tenure overlapping the stream network (%), and proportion of crown land (%). These indicators assess the potential that riparian health has been impacted by prior disturbance or may be affected by proposed activities.

Hydrological Modelling

This study used a process-based hydrological model of the study area to estimate potential effects on streamflow due to historical and potential future harvest, as well as under future climate scenarios. The semi-distributed model is an adapted version of the HBV-EC model, emulated within the Raven Hydrological Modelling Framework version 4.1 (Craig et al., 2025), simulating streamflow and other hydro-climatic variables at a daily timestep from 1980–2020.

The model simulates canopy interception, snow accumulation and melt, evaporation, soil infiltration, percolation, and baseflow. Precipitation is partitioned into rain or snow based on air temperature. Snowmelt is calculated using a spatially corrected temperature index model accounting for aspect, slope, and day length. Potential evapotranspiration was calculated using the Priestley–Taylor equation.

Four landcover scenarios investigated the impact of landcover change on hydrologic processes:

- Fully Forested: A conceptual scenario representing conditions in which the watershed is fully forested with mature trees, serving as the theoretical baseline without any human disturbance.
- Current Conditions: A representation of current land cover, including existing cutblocks, regenerating forest, roads, and other features.
- Proposed Harvest: This scenario represents landcover if all proposed harvest blocks are cut (453 ha). This scenario was developed with West Fraser.
- Future Regrowth: The watershed condition, representative of approximately 30 years into the future, where all recently disturbed areas outside of the 2 km buffer (including proposed harvest blocks) have regrown to a juvenile stage. This scenario was included to assess how hydrologic effects are expected to change as harvested areas regenerate over time.

The model considers a climate change scenario using the SSP 4.5 median ensemble of 24 CMIP6 General Circulation Models from 2021–2080, split into three 30-year periods (1991–2020, 2021–2050, and 2051–2080). This "middle-of-the-road" emissions pathway provides a central estimate of future climate conditions.

Five hydrologic indicators were produced to capture streamflow response, as summarized in Table 1. Changes were evaluated relative to the Fully Forested scenario under the historical (1991–2020) period.

To identify where in the watershed forest removal has the greatest potential influence on streamflow, the sensitivity of peak flows and summer (August–September) low flows to forest cover loss was also mapped across the study area, expressed as the change in simulated runoff (mm/day; Figure 4 and Figure 5). The change in simulated runoff was calculated comparing fully forested and fully non-forested condition.

Table 1 Hydrologic indicators used to identify changes in hydrologic regime and function.

Variable	Description
Mean Annual Flow	The average annual streamflow, representative of total annual water yield.
Mean Aug–Sept Flow	Average August–September streamflow, representative of summer low flows and a critical period for aquatic ecosystems.
2-Year Peak Flow	Annual peak flow with a 50% annual exceedance probability. Typically, the bank-full flow associated with sediment transport and channel morphology.
20-Year Peak Flow	Flood magnitude with a 5% annual exceedance probability. Provides insight on extreme floods that can harm property and human life.
Peak Flow Timing	Average Julian day of peak daily streamflow, representative of the timing of spring snowmelt-driven runoff.

Results

Geospatial indicators for each of the five study watersheds under the proposed harvest scenario are shown in Table 2. Watersheds are 52–64% forested, have little lake or wetland storage to buffer peak flows, and have low proportions of steep coupled slopes (5–9%). Erodible soils are limited (0–4%) except in the lower portion of Allison Creek (12% at the Mouth). Kame terraces and glaciofluvial sediments are notable throughout the Allison Creek watershed. Landscape disturbance is moderate at the scale of Allison Creek near the Mouth, where ECA is 11% under the proposed harvest, an increase of approximately 8% from current conditions. Disturbance is higher locally, with ECA reaching 16% in Deadman's Pass Creek above Phillips Peak Creek, 19% in Deadman's Pass Creek above Chinook Lake and 22% in Phillips Peak Creek. Road density is high (2.26–3.29 km/km^2) in all watersheds except Phillips Peak Creek (0.61 km/km^2), and the density of roads close to water is highest in Allison Creek (0.47–0.50 km/km^2). Disturbed riparian area is 14% across the whole watershed with highest disturbance in Deadman's Pass Creek above Chinook Lake (21%) and Phillips Peak Creek (34%). None of the watershed is within protected areas, and range tenure overlaps 94–100% of the area.

These indicators highlight that in general the watersheds have a relatively low sensitivity to forest disturbance. While there are few steep slopes and low steep coupled slopes to deliver sediment to streams, there are few lakes and wetlands to trap sediment and attenuate peak flows, and localized areas with considerable erodible soils. This is exacerbated by the high existing road density, including ATV trails, many of which are located close to riparian areas, as well as considerable cattle grazing. These factors suggest that sediment generation is of concern in the Allison Creek watershed.

Table 2 Geospatial indicators for the five study watersheds under the proposed harvest scenario.

Indicator	Units	Allison Creek near the Mouth	Allison Creek above Deadmans Pass Creek	Deadmans Pass Creek above Chinook Lake	Deadmans Pass Creek above Phillips Peak Creek	Phillips Peak Creek
Hydrologic Sensitivity						
Forested Area	%	64%	58%	58%	52%	53%
Drainage Density Ruggedness	km^2/km^2	1.32	1.27	0.88	0.51	1.00
Lake and Wetland Area	%	0%	0%	0%	0%	0%
Erosion Sensitivity						
Erodible Soils	%	12%	4%	2%	0%	0%
Steep Coupled Slopes	%	5%	7%	6%	5%	9%
Landscape Disturbance						
Road Density	km/km^2	3.29	3.10	2.26	2.98	0.61
Roads Close to Water	km/km^2	0.50	0.47	0.32	0.24	0.00
Roads on Steep Coupled Slopes	km/km^2	0.00	0.00	0.00	0.00	0.00
Disturbance on Steep Coupled Slopes	%	0%	0%	0%	0%	0%
Equivalent Clearcut Area	%	11%	8%	19%	16%	22%
Riparian Disturbance						
Protected Area	%	0%	0%	0%	0%	0%
Disturbed Riparian	%	14%	9%	21%	10%	34%
Range Tenure	%	94%	100%	100%	100%	100%
Crown Land	%	75%	82%	58%	49%	52%

Land cover changes shown in Table 2 translate to small changes in hydrologic indicators for Allison Creek near the Mouth (Table 3). Under the historical climate (1991–2020), the proposed harvest is likely to increase mean annual flow by 4%, the 2-year and 20-year peak flows by 4% and 3%, and mean Aug–Sep flow by 2%, with no change in peak flow timing relative to the Fully Forested scenario, and 1-3% relative to Current Conditions. Climate change is likely to have a substantially larger effect on all indicators, with mean Aug–Sep flow decreasing by 23–25% in 2021–2050 and 28–30% in 2051–2080, and the 20-year peak flow decreasing by 14–15% and 23–24%, respectively. Peak flow is projected to occur approximately 8–9 days earlier by 2051–2080. Future Regrowth is likely to result in a small decrease in streamflow indicator values relative to Fully Forested.

Table 3 Change in streamflow indicators relative to the Fully Forested landcover scenario for the period 1991-2020 for Allison Creek near the Mouth.

Allison Creek Near The Mouth

LandCover	Climate	Mean Annual Flow	Mean Aug-Sep Flow	2-Year Peak Flow	20-Year Peak Flow	Peak Flow Timing
1991-2020						
Current Conditions	Current	1%	1%	1%	0%	0.0 days
Proposed Harvest	Current	4%	2%	4%	3%	0.0 days
Future Regrowth	Current	−1%	−1%	−2%	−2%	0.0 days
2021-2050						
Fully Forested	SSP245	−10%	−25%	−12%	−15%	-2.7 days
Current Conditions	SSP245	−9%	−24%	−12%	−15%	-2.7 days
Proposed Harvest	SSP245	−7%	−23%	−9%	−14%	-3.4 days
Future Regrowth	SSP245	−12%	−26%	−14%	−17%	-2.7 days
2051-2080						
Fully Forested	SSP245	−9%	−30%	−14%	−24%	-8.1 days
Current Conditions	SSP245	−8%	−30%	−14%	−24%	-8.1 days
Proposed Harvest	SSP245	−5%	−28%	−11%	−23%	-8.7 days
Future Regrowth	SSP245	−10%	−31%	−16%	−26%	-7.4 days

Results for Allison Creek above Deadman's Pass Creek (Table 4) are similar to Allison Creek near the Mouth. The proposed harvest is likely to result in small increases of 2–3% in mean annual flow, low flows and peak flows under the historical climate, with peak flow timing advancing by less than one day relative to the Fully Forested condition. Climate change is likely to result in large decreases in low flows (24–31%) and 20-year peak flows (19–28%). By 2051–2080, the combination of the proposed harvest and climate change advances peak flow timing by 10.5 days, compared to 3.7 days under current land cover, indicating that the proposed harvest may compound the effect of climate warming on snowmelt timing at this scale. Future Regrowth has a small negative effect on streamflow indicators, resulting in slightly lower values relative to current conditions or proposed harvest.

Table 4 Change in streamflow indicators relative to the Fully Forested landcover scenario for the period 1991-2020 for Allison Creek above Deadman's Pass Creek.

Allison Creek Above Deadmans Pass Creek

LandCover	Climate	Mean Annual Flow	Mean Aug-Sep Flow	2-Year Peak Flow	20-Year Peak Flow	Peak Flow Timing
1991-2020						
Current Conditions	Current	2%	1%	1%	1%	-0.6 days
Proposed Harvest	Current	3%	2%	3%	2%	-0.6 days
Future Regrowth	Current	−1%	−1%	−1%	−1%	1.0 days
2021-2050						
Fully Forested	SSP245	−11%	−26%	−14%	−20%	3.5 days
Current Conditions	SSP245	−9%	−25%	−13%	−19%	3.5 days
Proposed Harvest	SSP245	−8%	−24%	−12%	−19%	2.4 days
Future Regrowth	SSP245	−12%	−27%	−14%	−20%	3.7 days
2051-2080						
Fully Forested	SSP245	−9%	−31%	−16%	−28%	-3.7 days
Current Conditions	SSP245	−8%	−31%	−15%	−28%	-3.7 days
Proposed Harvest	SSP245	−6%	−30%	−14%	−27%	-10.5 days
Future Regrowth	SSP245	−10%	−32%	−17%	−29%	-3.7 days

The hydrologic response is larger in Deadman's Pass Creek, where much of the proposed harvest is concentrated (Table 5 and Table 6). Under the historical climate, the proposed harvest increases mean annual flow by 5–6%, the 2-year peak flow by 5%, the 20-year peak flow by 4–5% and mean Aug–Sep flow by 3–4%, while advancing peak flow timing by 1.4–2.2 days relative to the Fully Forested condition. Climate change remains the larger driver of streamflow change, with mean Aug–Sep flow decreasing by 21–24% in 2021–2050 and 27–29% in 2051–2080. The proposed harvest could have an inverse effect relative to climate-driven declines in mean annual flow and peak flows (e.g., a 4–6% decrease in mean annual flow by 2051–2080 under the proposed harvest compared to 9–10% under current conditions), but substantially advances peak flow timing, by 14.1 days above Chinook Lake and 15.6 days above Phillips Peak Creek by 2051–2080, compared to 5.1 and 6.6 days under current land cover. Future Regrowth is likely to result in similar response to the Allison Creek watershed, with a slightly larger effect on lowering streamflow indicator values.

Table 5 Change in streamflow indicators relative to the Fully Forested landcover scenario for the period 1991-2020 for Deadman's Pass Creek above Chinook Lake.

Deadmans Pass Creek Above Chinook Lake

LandCover	Climate	Mean Annual Flow	Mean Aug-Sep Flow	2-Year Peak Flow	20-Year Peak Flow	Peak Flow Timing
1991-2020						
Current Conditions	Current	0%	0%	0%	0%	0.0 days
Proposed Harvest	Current	6%	4%	5%	5%	-1.4 days
Future Regrowth	Current	−3%	−3%	−3%	−4%	1.0 days
2021-2050						
Fully Forested	SSP245	−10%	−24%	−11%	−12%	2.0 days
Current Conditions	SSP245	−10%	−24%	−11%	−12%	2.0 days
Proposed Harvest	SSP245	−5%	−21%	−7%	−11%	1.7 days
Future Regrowth	SSP245	−13%	−26%	−14%	−14%	1.9 days
2051-2080						
Fully Forested	SSP245	−9%	−29%	−14%	−23%	-5.1 days
Current Conditions	SSP245	−9%	−29%	−14%	−23%	-5.1 days
Proposed Harvest	SSP245	−4%	−27%	−10%	−21%	-14.1 days
Future Regrowth	SSP245	−12%	−31%	−17%	−25%	-3.3 days

Table 6 Change in streamflow indicators relative to the Fully Forested landcover scenario for the period 1991-2020 for Deadman's Pass Creek above Phillips Peak Creek.

Deadmans Pass Creek Above Phillips Peak Creek

LandCover	Climate	Mean Annual Flow	Mean Aug-Sep Flow	2-Year Peak Flow	20-Year Peak Flow	Peak Flow Timing
1991-2020						
Current Conditions	Current	0%	0%	0%	0%	0.0 days
Proposed Harvest	Current	5%	3%	5%	4%	-2.2 days
Future Regrowth	Current	−2%	−2%	−2%	−3%	0.1 days
2021-2050						
Fully Forested	SSP245	−12%	−24%	−12%	−15%	0.0 days
Current Conditions	SSP245	−12%	−24%	−12%	−15%	0.0 days
Proposed Harvest	SSP245	−7%	−22%	−8%	−14%	-2.1 days
Future Regrowth	SSP245	−14%	−26%	−14%	−17%	-0.8 days
2051-2080						
Fully Forested	SSP245	−10%	−29%	−16%	−26%	-6.6 days
Current Conditions	SSP245	−10%	−29%	−16%	−26%	-6.6 days
Proposed Harvest	SSP245	−6%	−27%	−12%	−24%	-15.6 days
Future Regrowth	SSP245	−12%	−31%	−18%	−28%	-5.8 days

Proposed harvest for Phillips Peak Creek is likely to increase mean annual flow by 6%, the 2-year and 20-year peak flows by 5% and mean Aug–Sep flow by 4% under the historical climate, and advancing peak flow timing by 1.7 days relative to the Fully Forested condition (Table 7). Climate change is a larger driver than landscape change at this scale as well, with mean Aug–Sep flow decreasing by 22–29%. By 2051–2080, peak flow timing advances by 10.8 days under the proposed harvest, compared to 9.2 days under current land cover. Again, Future Regrowth is likely to result in a small negative effect on streamflow indicator values.

Table 7 Change in streamflow indicators relative to the Fully Forested landcover scenario for the period 1991-2020 for Phillips Peak Creek.

Phillips Peak Creek

LandCover	Climate	Mean Annual Flow	Mean Aug-Sep Flow	2-Year Peak Flow	20-Year Peak Flow	Peak Flow Timing
1991-2020						
Current Conditions	Current	0%	0%	0%	0%	0.0 days
Proposed Harvest	Current	6%	4%	5%	5%	-1.7 days
Future Regrowth	Current	−3%	−2%	−3%	−3%	1.5 days
2021-2050						
Fully Forested	SSP245	−9%	−24%	−9%	−5%	-0.8 days
Current Conditions	SSP245	−9%	−24%	−9%	−5%	-0.8 days
Proposed Harvest	SSP245	−4%	−22%	−6%	−3%	-2.3 days
Future Regrowth	SSP245	−12%	−26%	−11%	−8%	-0.7 days
2051-2080						
Fully Forested	SSP245	−8%	−29%	−12%	−15%	-9.2 days
Current Conditions	SSP245	−8%	−29%	−12%	−15%	-9.2 days
Proposed Harvest	SSP245	−3%	−27%	−10%	−13%	-10.8 days
Future Regrowth	SSP245	−11%	−31%	−14%	−17%	-8.6 days

The spatial sensitivity of peak flows and summer low flows to forest cover removal is shown in Figure 4 and Figure 5. Peak flow sensitivity is highest (>2 mm/day) on the mid- to upper-elevation slopes along the western side of upper Allison Creek, the eastern valley side below Seven Sisters and Crowsnest Mountain, and the western headwaters of Deadman's Pass Creek and Phillips Peak Creek. Peak flow sensitivity is lowest (<1 mm/day) along the Allison Creek valley bottom and in the lower watershed near the Mouth (Figure 4). Summer low flow sensitivity follows a similar pattern, with the largest potential effects (−0.02 to −0.04 mm/day) on the upper Allison Creek valley sides and in the western portions of Deadman's Pass Creek and Phillips Peak Creek (Figure 5).

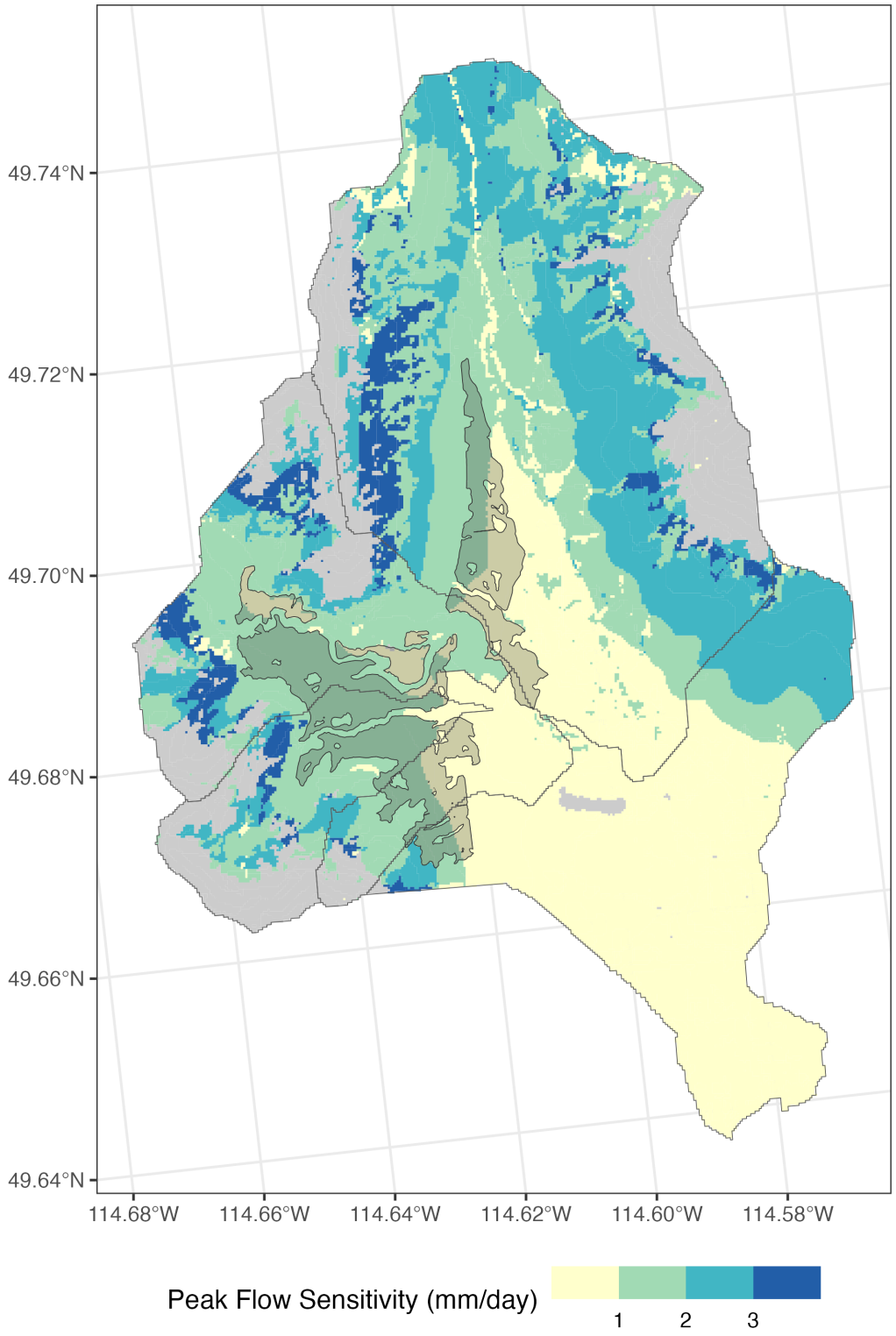


Figure 4 Peak flow sensitivity (mm/day) to forest cover removal across the study area. Black outlines show sub-watershed boundaries. Proposed harvest is shown in the shaded area. Dark blue is higher sensitivity.

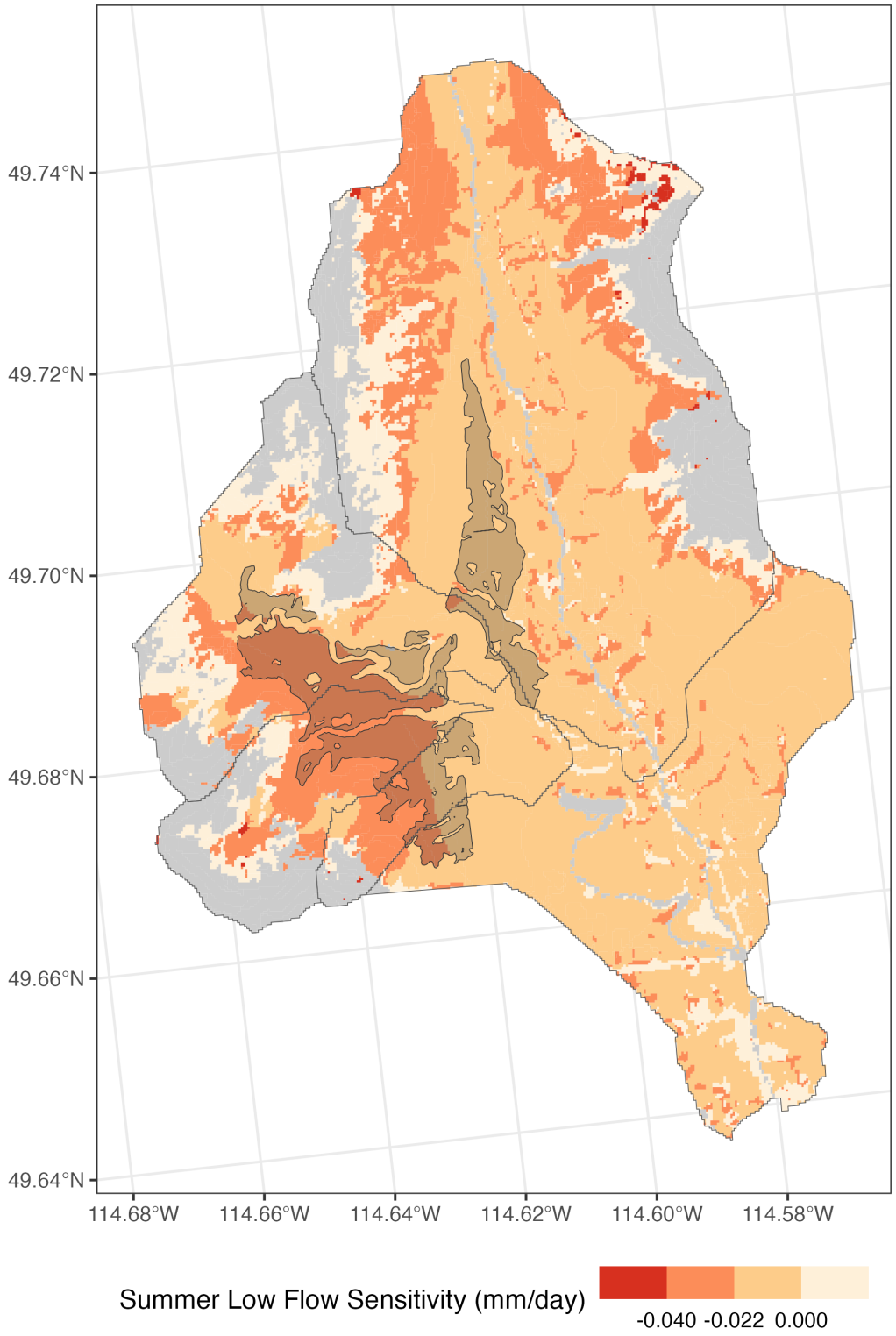


Figure 5 Summer (August–September) low flow sensitivity (mm/day) to forest cover removal across the study area. Black outlines show sub-watershed boundaries. Proposed harvest is shown in the shaded area. Red is higher sensitivity.

Likelihood of Hydrologic Alteration

An evaluation of the likelihood of hydrologic change considers the likelihood of human forms of disturbance to affect hydrologic processes. This analysis does not extend to the consequence of a harmful event and focuses only on the change in likelihood of a hydrologic event.

It is important to note that this assessment presents the change in likelihood relative to current and a hypothetical fully forested condition. This analysis considers the change in likelihood from these conditions, noting that the reference condition has an existing likelihood of harm. For example, a "low" likelihood does not mean that the likelihood of flooding is low, only that the current and/or proposed landcover condition has a low likelihood of altering flood regime.

The analysis presented herein suggests there is low likelihood of hydrologic alteration as a function of the proposed harvest in Allison Creek at the Mouth with a low-moderate likelihood of hydrologic alteration in Deadman's Pass Creek. The analysis also suggests some of the proposed harvest areas overlap with areas identified as those with elevated peak flow and summer low flow sensitivities, primarily in the Deadman's Pass Creek watershed. Climate change is likely to have relatively large effects on low flows and peak flows, with substantial reductions across streamflow indicators, especially during the late summer.

Conclusions and Recommendations

This desktop study suggests the likelihood of hydrologic alteration under the proposed harvest plan is low with increases in mean annual flow (3–6%), 2-year and 20-year peak flows (2–5%) and mean Aug–Sep flow (2–4%) under the historical climate, with peak flow timing advancing by up to approximately 2 days in Allison Creek. Greater changes are projected in Deadman's Pass Creek and Phillips Peak Creek, where the proposed harvest is concentrated.

Change in streamflow is likely to be reduced as forest cover regrows, demonstrated with the Future Regrowth Scenario. Changes of these magnitudes are not likely to meaningfully affect Chinook Lake levels; however, it is acknowledged that lake level analyses have not been completed. Sensitivity mapping shows some of the planned harvest would occur in areas that could affect peak and summer low flows, although the effect is not likely to be large based on the streamflow modelling results. Additional retention should be considered in proposed harvest areas overlapping with moderate or high peak or low flow sensitivity mapping to preserve hydrologic function.

Climate change is projected to be the dominant driver of streamflow change at all scales evaluated. Across all land cover scenarios, mean Aug–Sep flow is projected to decline by 21–27% by 2021–2050 and 27–32% by 2051–2080, and 20-year peak flows by 13–29% by 2051–2080. The proposed harvest partially offsets climate-driven declines in flow volume (e.g., mean annual flow declines of 3–6% by 2051–2080 under the proposed harvest compared to 8–10% under current conditions), but compounds the effect of climate warming on snowmelt timing. Peak flow timing is projected to advance by 9–16 days by 2051–2080 under the proposed harvest, compared to 4–9 days under current land cover.

Harvest-related increases in streamflow are likely to be reduced or reversed under the Future Regrowth Scenario. Under the historical climate, mean annual flow, mean Aug–Sep flow and peak flows are 1–4% lower than the Fully Forested condition, and peak flow timing is unchanged or delayed by up to 1.5 days. Under future climate, regrowth largely removes the compounding effect of harvest on snowmelt timing, with peak flow timing advancing by 3–9 days by 2051–2080, similar to current land cover. However, Future Regrowth produces the lowest streamflow of all scenarios under future climate,

with mean Aug–Sep flow declining by 31–32% and 20-year peak flows by 17–29% by 2051–2080. These results indicate that the hydrologic effects of the proposed harvest are likely to be temporary, while regenerating stands may reduce late-summer water availability, a critical period for habitat for cold water species.

Road density within the study area is high. Soil mapping suggests there are erodible soils in the lower portion of Allison Creek; therefore, it is possible that streamflow alteration upstream and road development could result in increased erosion. Sediment generation and transport should be mitigated with proper drainage structures and Best Management Practices for erosion and sediment control. Deactivating existing roads, prioritizing those near streams, should be considered to reduce overall density. Fully reclaiming new roads should be a priority post-harvest.

The desktop analysis suggests riparian areas are degraded, most likely by ATV use and cattle grazing, with riparian disturbance highest in Phillips Peak Creek (34%) and Deadman's Pass Creek above Chinook Lake (21%), and range tenure overlapping nearly all the study area. Managing these land uses will likely have a positive effect on riparian areas and improve the condition of streams within the study area.

Limitations and Closing

This memo was prepared using a desktop assessment, relying on shapefiles provided by COS and publicly available data. There was no field assessment completed as part of this work. As such, this study is limited in scope and does not provide a full evaluation of the current watershed condition and potential effects of forest harvest.

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Thank you for the opportunity to complete this work. Please do not hesitate to contact me if you have additional questions or concerns.

Sincerely,



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