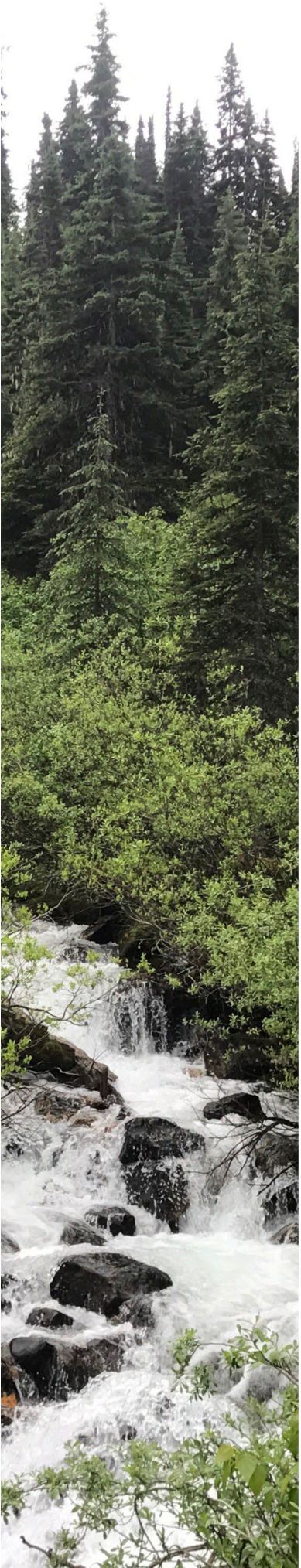

BRITISH COLUMBIA | Ministry of Water, Land and Resource Stewardship

# BC MINISTRY OF WATER, LAND AND RESOURCE STEWARDSHIP

## NICOLA POST 2019 - 2021 FLOOD AND WILDFIRE: HYDROLOGY LITERATURE REVIEW

Ministry Contract: GS25LUS0021
MJ Milne & Associates File: WL1-002
Polar File: 1480101
FINAL REPORT
March 2025

**M.J. Milne & Associates Ltd.**

polargeoscience ltd.

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## SUGGESTED CITATION

M.J. Milne & Associates Ltd. (Milne) and Polar Geoscience Ltd. (Polar). 2025. Nicola Post 2021 Flood and Wildfire: Hydrology Literature Review. Prepared for BC Ministry of Water, Land and Resource Stewardship. Milne File No. WL1-002, Polar File No. 116501.

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March 31, 2025

Milne File: WL1-002
Polar File: 1480101

Tracy Thomas
BC Ministry of Water, Land and Resource Stewardship
Land Use Planning and Cumulative Effects
441 Columbia Street
Kamloops, BC, V2C 2T3

Dear Ms. Thomas:

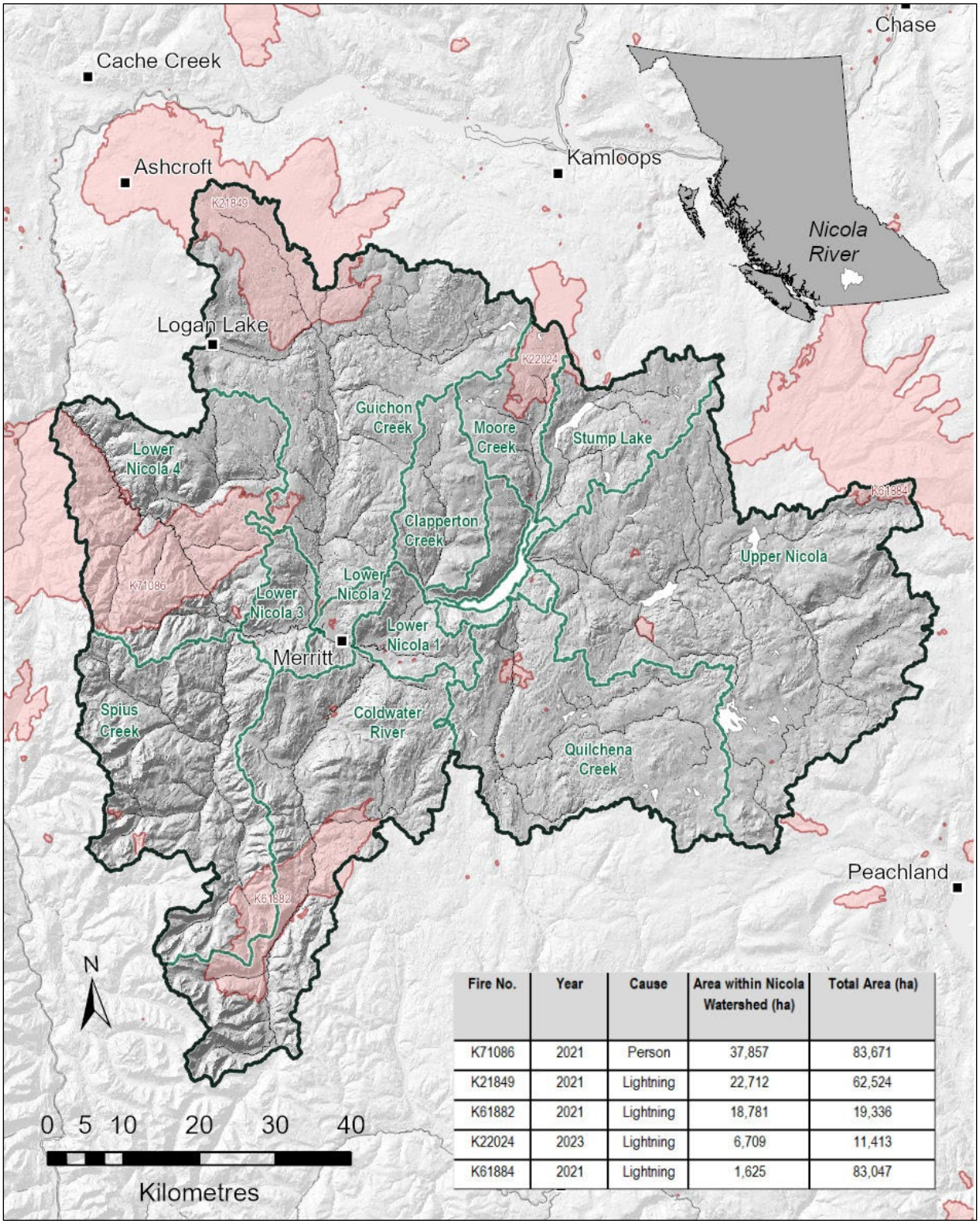
Re: **NICOLA POST 2021 FLOOD AND WILDFIRE: HYDROLOGY LITERATURE REVIEW**

## 1.0 INTRODUCTION

M.J. Milne & Associates Ltd. (Milne) and Polar Geoscience Ltd. (Polar) are pleased to provide this supplementary report that updates the State of the Watershed (SOW) reports for the Nicola River watershed prepared by Polar (2021, 2022a, 2022b, and 2022c)[1]. The SOW reports were commissioned by the BC Ministry of Water, Land and Resource Stewardship (WLRS) to inform the Nicola Watershed Planning Initiative (NWPI) that began in 2020. It should also be noted that a group of First Nations and other fisheries specialists from provincial and federal governments, known as the Salmon Ecosystem Table (SET), was assembled in 2024 to also inform the NWPI. As part of its mandate the SET will prioritize post fire and post flood related stream and fisheries related restoration and conservation actions in the Nicola River watershed.

Milne and Polar were retained by WLRS to provide this update in response to the major flooding in November 2021 and several wildfires since 2019 (FIGURE 1.1). WLRS is concerned that these disturbances have altered watershed conditions, and thus may have affected some conclusions and recommendations identified within the State of the Watershed reports noted above. This report is intended to answer one key question: "What has changed in the Nicola River watershed post-fire and post-flood?"

[1] M.J. Milne & Associates Ltd. was a contributor to these reports.




| Fire No. | Year | Cause | Area within Nicola Watershed (ha) | Total Area (ha) |
|---|---|---|---|---|
| K71086 | 2021 | Person | 37,857 | 83,671 |
| K21849 | 2021 | Lightning | 22,712 | 62,524 |
| K61882 | 2021 | Lightning | 18,781 | 19,336 |
| K22024 | 2023 | Lightning | 6,709 | 11,413 |
| K61884 | 2021 | Lightning | 1,625 | 83,047 |

FIGURE 1.1 *Nicola River Watershed and location of wildfires that occurred since 2019. Wildfires larger than 1,000 ha are identified.*

As requested by WLRS, this report was prepared exclusively through an office-based literature review of reports and information provided by WLRS and available publicly, which document conditions at various times and locations in the Nicola River watershed since the State of the Watershed reports were completed. Although each of the authors of this report have had the opportunity to view the watershed by helicopter on different occasions (on December 2, 2021 and November 15, 2024), and on the ground incidentally through other consulting assignments, no field review was performed to support this report.

The geographic scope of this update is generally limited to areas affected by the November 2021 flood event, and areas within and downslope and downstream of major wildfires since 2019. However, it should be noted that reports and information are not necessarily available for all affected areas.

### 1.1 November 2021 Flood

On November 14, 2021, an atmospheric river (AR) brought two days of intense rainfall to southwestern British Columbia and the lower Fraser River watershed, including the catchments of Coldwater River and Spius Creek. During the AR, rainfall-generated runoff in these catchments was augmented by snowmelt associated with a rapid rise in temperature. This rain-on-snow event resulted in extreme flooding on November 15, 2021 that was associated with landslides, road washouts, bank erosion, and channel avulsions, as well as extensive damage in Merritt and downstream along the lower Nicola River. Although the Water Survey of Canada (WSC) records on the Coldwater River were deemed unreliable, post-flood studies estimated the instantaneous flood peak on November 15, 2021 to be approximately 400 $m^3/s$ (BGC, 2022a). This was estimated to have a 160 year return period, without accounting for future climate change projections (BGC, 2022a), and was 3.3 times higher than the next highest recorded flood on the Coldwater River at Merritt (08LG010). On the Nicola River, the 2021 flood was estimated to be 750 $m^3/s$ at the WSC gauge near Spences Bridge (08LG006), which is nearly double the estimated 100-year return period event based on the pre-2021 flood record (Davidson et. al., 2024).

The 2021 flood, more aptly described as a debris flood (BGC, 2022a), caused widespread damage and channel instability along Coldwater River, Spius Creek, and Nicola River downstream of Merritt. Given the path of the AR, damaging floods did not occur in the Nicola River watershed upstream of Merritt. TABLE 1.1 summarizes the watershed units notably affected by the November 2021 flood.

TABLE 1.1 *Watershed reporting units that were notably affected by flooding in November 2021.*

| Watershed Unit | Drainage area (ha) | Notably affected by November 2021 Flood |
|---|---|---|
| Clapperton Creek | 23,191 | |
| Coldwater River | 91,257 | ✓ |
| Guichon Creek | 119,245 | |
| Lower Nicola 1 | 14,163 | |
| Lower Nicola 2 | 8,057 | ✓ |
| Lower Nicola 3 | 11,736 | ✓ |
| Lower Nicola 4 | 78,244 | ✓ |

| Watershed Unit | Drainage area (ha) | Notably affected by November 2021 Flood |
|---|---|---|
| Moore Creek | 20,433 | |
| Nicola Lake Residual | 13,381 | |
| Quilchena Creek | 77,925 | |
| Spius Creek | 76,756 | ✓ |
| Stump Lake | 30,473 | |
| Upper Nicola | 151,016 | |

## 1.2 Wildfires since 2019

In total, 63 wildfires have been recorded in the Nicola Watershed since 2019 (Province of British Columbia, 2025a), however, 37 of these affected areas less than 10 ha, and 53 affected areas less than 100 ha. The remaining 10 largest wildfires since 2019 are listed in TABLE 1.2. Half of these wildfires affected areas in excess of 1,000 ha, and with one exception all occurred in 2021.

TABLE 1.2 *List of wildfires since 2019 that affected more than 100 ha within the Nicola Watershed.*

| Wildfire No. | Year | Description | Area within Nicola Watershed | |
|---|---|---|---|---|
| | | | ha | % |
| K71086 | 2021 | Lytton Wildfire | 37,858 | 5.27% |
| K21849 | 2021 | Tremont Creek Wildfire | 22,710 | 3.16% |
| K61882 | 2021 | July Mountain Wildfire | 18,781 | 2.61% |
| K22024 | 2023 | Rossmoore Lake Wildfire | 6,710 | 0.93% |
| K61884 | 2021 | White Rock Lake Wildfire | 1,626 | 0.23% |
| K60064 | 2021 | Near Quilchena Creek | 840 | 0.12% |
| K60230 | 2021 | Near west end of Douglas Lake | 462 | 0.06% |
| K62058 | 2021 | Near upper Spius Creek | 269 | 0.04% |
| K60058 | 2019 | Near west end of Douglas Lake | 113 | 0.02% |
| K61768 | 2023 | Near upper Spius Creek | 104 | 0.01% |

TABLE 1.3 identifies the areas of recorded wildfires since 2019, by watershed unit, year and wildfire number. Also highlighted on TABLE 1.3 are the watershed units affected by the five largest wildfires (i.e., greater than 1,000 ha). This includes:

- Coldwater River (13,979 ha or 15.3%[2]);
- Guichon Creek (24,326 ha or 20.4%);
- Lower Nicola 3 (147 ha or 1.2%);
- Lower Nicola 4 (36,197 ha or 46.3%);
- Moore Creek (6,109 ha or 29.9%);
- Spius Creek (4,802 ha or 6.3%);
- Stumplake Creek (499 ha or 1.6%); and

[2] Percentages are with regards to the total watershed unit drainage area.

- Upper Nicola (1,626 ha or 1.1%).

TABLE 1.3 *Areas of provincially recorded wildfires[3] in the Nicola Watershed since 2019, by year and wildfire. Data for the five major wildfires in the watershed are colour-coded.*

| Watershed Unit | Year | Wildfire No. | Area (ha) |
|---|---|---|---|
| **Coldwater River** | 2019 | K60153 | 2 |
| | | K61682 | 4 |
| | 2020 | K60875 | 3 |
| | | K61363 | 2 |
| | 2021 | K60062 | 31 |
| | | K60225 | 3 |
| | | **K61882** | 13,979 |
| | | K62943 | 1 |
| | | K62866 | 1 |
| | | K60042 | 17 |
| **Guichon Creek** | 2019 | K61850 | 9 |
| | 2021 | **K21849** | 22,710 |
| | | **K71086** | 1,514 |
| | | K21327 | 0 |
| | 2022 | K60004 | 18 |
| | | K60151 | 21 |
| | | K61478 | 1 |
| | | K61483 | 2 |
| | 2023 | **K22024** | 102 |
| **Lower Nicola 1** | 2021 | K60349 | 2 |
| | | K60810 | 9 |
| | 2022 | K60324 | 4 |
| | 2023 | K62759 | 4 |
| **Lower Nicola 2** | 2019 | K60079 | 23 |
| | | K60081 | 6 |
| | | K60152 | 17 |
| | | K60158 | 2 |
| | 2022 | K60004 | 10 |
| | | K60175 | 3 |
| | | K62903 | 7 |
| | 2023 | K60127 | 39 |
| **Lower Nicola 3** | 2021 | K62954 | 10 |
| | | **K71086** | 147 |
| **Lower Nicola 4** | 2019 | K60031 | 2 |
| | 2020 | K60581 | 29 |
| | | K60961 | 4 |
| | 2021 | K60293 | 99 |
| | | K62285 | 0 |
| | | **K71086** | 36,197 |
| | 2022 | K60657 | 2 |
| | | K62886 | 1 |
| | 2023 | K61692 | 1 |
| **Moore Creek** | 2022 | K60860 | 2 |
| | | **K22024** | 6,109 |
| | 2023 | K62315 | 5 |
| **Nicola Lake Residual** | 2021 | K61230 | 9 |
| | 2022 | K60860 | 11 |
| | 2023 | K60634 | 8 |
| **Quilchena Creek** | 2021 | K60064 | 840 |
| | 2023 | K61969 | 8 |
| | | K62013 | 11 |
| | | K62725 | 1 |
| **Spius Creek** | 2021 | **K61882** | 4,802 |
| | | K62058 | 269 |
| | | K62954 | 8 |
| | 2023 | K61768 | 104 |
| **Stumplake Creek** | 2019 | K20467 | 2 |
| | 2020 | K61456 | 4 |
| | 2021 | K21225 | 1 |
| | 2023 | **K22024** | 499 |
| | | K22026 | 4 |
| **Upper Nicola** | 2019 | K60023 | 3 |
| | | K60058 | 113 |
| | | K60517 | 6 |
| | 2020 | K60048 | 69 |
| | 2021 | K51924 | 20 |
| | | K60230 | 462 |
| | | K61674 | 12 |
| | | **K61884** | 1,626 |
| | | K62030 | 48 |
| | 2022 | K52728 | 9 |

| |
|---|
| **Lytton Wildfire (K71086)** |
| **Tremont Creek Wildfire (K21849)** |
| **July Mountain Wildfire (K61882)** |
| **Rossmoore Lake Wildfire (K22024)** |
| **White Rock Lake Wildfire (K61884)** |

TABLE 1.4 presents the areas of all wildfires in the Nicola Watershed between 2019 and 2023. It is clear from this that the five largest wildfires are by far the major contributors to the overall totals.

[3] This is the area within the wildfire perimeter. It includes various burn severities and may include areas unburned.

TABLE 1.4 *Areas of provincially recorded wildfires within the Nicola Watershed since 2019, summed by watershed unit and year.*

| Watershed Unit | Drainage area (ha) | Area within wildfire perimeter (ha) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2021 | 2022 | 2023 | Total (ha) | Total (%) |
| Clapperton Creek | 23,191 | - | - | - | - | - | **-** | **-** |
| Coldwater River | 91,257 | 6 | 5 | 14,015 | 1 | 17 | **14,044** | **15.4** |
| Guichon Creek | 119,245 | 9 | | 24,224 | 42 | 102 | **24,378** | **20.4** |
| Lower Nicola 1 | 14,163 | | | 11 | 4 | 4 | **19** | **0.1** |
| Lower Nicola 2 | 8,057 | 48 | | | 20 | 39 | **107** | **1.3** |
| Lower Nicola 3 | 11,736 | | | 157 | | | **157** | **1.3** |
| Lower Nicola 4 | 78,244 | 2 | 33 | 36,296 | 3 | 1 | **36,334** | **46.4** |
| Moore Creek | 20,433 | | | | 2 | 6,114 | **6,116** | **29.9** |
| Nicola Lake Residual | 13,381 | | | 9 | 11 | 8 | **28** | **0.2** |
| Quilchena Creek | 77,925 | | | 840 | | 20 | **860** | **1.1** |
| Spius Creek | 76,756 | | | 5,078 | | 104 | **5,182** | **6.8** |
| Stump Lake | 30,473 | 2 | 4 | 1 | | 503 | **510** | **1.7** |
| Upper Nicola | 151,016 | 122 | 69 | 2,168 | 9 | | **2,367** | **1.6** |
| **Total:** | **715,877** | **188** | **111** | **82,799** | **92** | **6,913** | **90,103** | **12.6** |

As shown in TABLE 1.5 and FIGURE 1.2, provincial vegetation burn severity mapping is available for four of the five largest wildfires affecting the Nicola Watershed since 2019 (Province of British Columbia, 2025b). The Lytton Wildfire (K71086) was the largest covering an area of nearly 38,000 ha (~5% of the watershed). About 20% of this overall area had high or moderate burn severity, with much of this located in the Lower Nicola 4 residual unit[4], where nearly 40% was identified as high or moderate burn severity. The Tremont Creek Wildfire (K21849) affected about 20,000 ha of the upper reaches of Guichon Creek, where 37% was mapped as high or moderate burn severity. The July Mountain Wildfire (K61882) affected nearly 19,000 ha of the Nicola Watershed, covering about 14,000 ha in the Coldwater River and 5,000 ha in the Spius Creek catchments. High and moderate burn severity totalled 44% and 39% in each of these catchments, respectively. Although the White Rock Lake Wildfire (K61884) affected over 83,000 ha, the vast majority of it was outside the Nicola Watershed. Only about 1,200 ha was located within the Upper Nicola watershed unit, with about 350 ha classed as high or moderate burn severity.

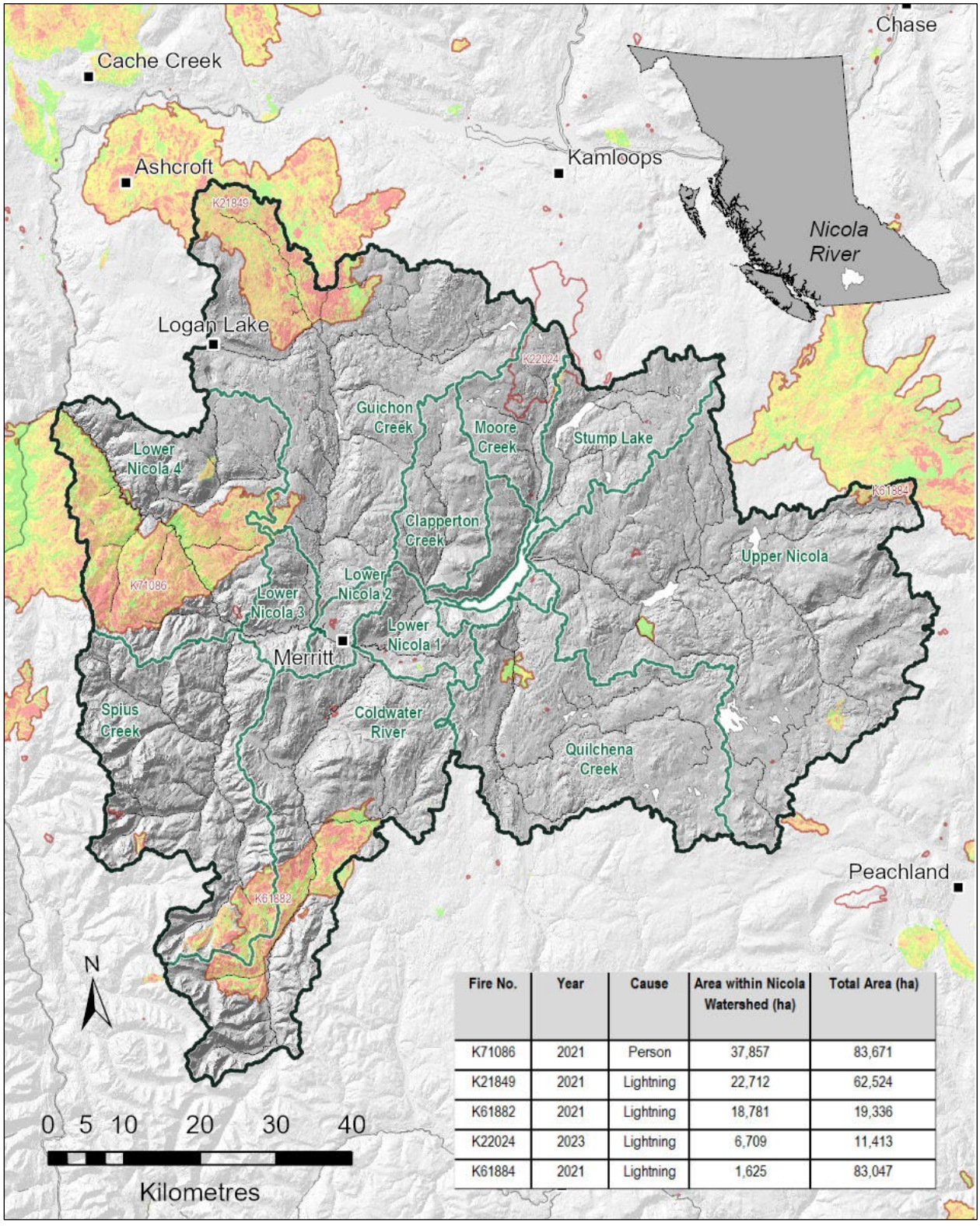
[4] Guichon Creek and Lower Nicola 3 were also affected, although to a lesser extent.

TABLE 1.5 *Areas of four of the largest recorded wildfires within the Nicola Watershed since 2019, by burn severity. Burn severity data is unavailable for wildfire K22024 (Rossmoore Lake). Source: Province of British Columbia, 2025.*

| Wildfire No. | Year | Description | Watershed Unit | Drainage Area (ha) | Area within wildfire perimeter[5] (ha) | Burn Severity (ha/%[6]) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | High | Medium | Low | Unburned |
| K71086 | 2021 | Lytton Wildfire | Nicola Watershed | 715,877 | 37,972 | 7,993 ha 21.1% | 6,560 ha 17.3% | 17,151 ha 45.2% | 6,267 ha 16.5% |
| | | | Guichon Creek | 119,245 | 1,536 | 66 ha 4.3% | 171 ha 11.1% | 910 ha 59.2% | 390 ha 25.4% |
| | | | Lower Nicola 3 | 11,736 | 150 | 8 ha 5.5% | 18 ha 12.3% | 91 ha 60.7% | 32 ha 21.4% |
| | | | Lower Nicola 4 | 78,244 | 36,286 | 7,919 ha 21.8% | 6,371 ha 17.6% | 16,151 ha 44.5% | 5,845 ha 16.1% |
| K21849 | 2021 | Tremont Creek Wildfire | Nicola Watershed | 715,877 | 22,764 | 5,560 ha 24.4% | 2,953 ha 13.0% | 11,012 ha 48.4% | 3,239 ha 14.2% |
| | | | Guichon Creek | 119,245 | 22,764 | 5,560 ha 24.4% | 2,953 ha 13.0% | 11,012 ha 48.4% | 3,239 ha 14.2% |
| K61882 | 2021 | July Mountain Wildfire | Nicola Watershed | 715,877 | 18,882 | 5,876 ha 31.1% | 2,225 ha 11.8% | 7,108 ha 37.6% | 3,673 ha 19.5% |
| | | | Coldwater River | 91,257 | 14,055 | 4,486 ha 31.9% | 1,712 ha 12.2% | 5,187 ha 36.9% | 2,670 ha 19.0% |
| | | | Spius Creek | 76,756 | 4,827 | 1,390 ha 28.8% | 514 ha 10.6% | 1,920 ha 39.8% | 1,003 ha 20.8% |
| K61884 | 2021 | White Rock Lake Wildfire | Nicola Watershed | 715,877 | 1,644 | 175 ha 10.7% | 173 ha 10.5% | 869 ha 52.9% | 426 ha 25.9% |
| | | | Upper Nicola | 151,016 | 1,644 | 175 ha 10.7% | 173 ha 10.5% | 869 ha 52.9% | 426 ha 25.9% |

[5] This area is calculated as the sum of the areas under each burn severity rating. This may be slightly different than the areas reported above, which are from another provincial dataset.

[6] Percentage of area within the wildfire perimeter with the indicated burn severity.




| Fire No. | Year | Cause | Area within Nicola Watershed (ha) | Total Area (ha) |
|---|---|---|---|---|
| K71086 | 2021 | Person | 37,857 | 83,671 |
| K21849 | 2021 | Lightning | 22,712 | 62,524 |
| K61882 | 2021 | Lightning | 18,781 | 19,336 |
| K22024 | 2023 | Lightning | 6,709 | 11,413 |
| K61884 | 2021 | Lightning | 1,625 | 83,047 |

FIGURE 1.2 *Nicola River Watershed showing the available burn severity mapping for wildfires that occurred since 2019 (Province of British Columbia, 2025b). Wildfires larger than 1,000 ha are identified.*

## 2.0 INFORMATION REVIEWED

Information reviewed for this report includes:

- Nicola State of the Watershed (SOW) reports covering:
    - Coldwater River and Spius Creek (Polar, 2021),
    - Quilchena Creek (Polar, 2022a),
    - Clapperton Creek, Moore Creek, Stumplake Creek (Polar, 2022b), and
    - Lower Nicola River (Polar, 2022c).
- Reports regarding flooding along Coldwater and Nicola Rivers (BGC, 2022a & 2022b; Gillett et al., 2022).
- Provincial wildfire perimeters (Province of British Columbia, 2025a) and wildfire severity mapping (Province of British Columbia, 2025b). Severity mapping in the Nicola Watershed was available for the following:
    - Lytton Wildfire (K71086),
    - White Rock Lake Wildfire (K61884),
    - July Mountain Wildfire (K61882), and
    - Tremont Creek Wildfire (K21849).
- Reconnaissance post-wildfire natural hazard assessments of the following wildfires:
    - Lytton Wildfire (K71086) (Giles, 2021a),
    - White Rock Lake Wildfire (K61884) (Giles, 2021b),
    - July Mountain Wildfire (K61882) (Giles, 2021c), and
    - Tremont Creek Wildfire (K21849) (Giles, 2022).
- Detailed post-wildfire natural hazard assessments of the following wildfires:
    - Lytton Wildfire (K71086) (BGC, 2021b & 2023; Westrek, 2022), and
    - White Rock Lake Wildfire (K61884) (Clark Geoscience Ltd., 2022).
- Review of groundwater literature relevant to the Nicola Watershed (AE, 2020 and WWAL, 2023).
- Published journal articles examining hydrogeomorphic processes in the Nicola Watershed (Davidson et al., 2023; Hancock and Wlodarczyk, 2024).
- Presentations to the City of Merritt regarding flood mitigation planning and water quality monitoring (Associated Engineering, 2022a and 2022b).
- Summary of restoration activity (FBC, 2022).

# 3.0 STATE OF THE WATERSHED REPORTS

## 3.1 Summary of Key Water Related Issues

The State of the Watershed (SOW) reports (Polar 2021, 2022a, 2022b, and 2022c) identified several key water related issues within the Nicola Watershed as of 2021 and 2022 (TABLE 3.1). Although each watershed unit had unique issues identified, several common themes emerged. They include the potential for:

1. Reduced water supply and instream flows with climate change;
2. Reduced or impaired riparian function and associated increase in channel sensitivity and water quality degradation due to land clearing, livestock use, and forestry activities;
3. Increased flood frequency and magnitude with climate change and land use, such as forestry;
4. Water quality degradation in general, but specifically due to potential contamination by highway or pipeline spills and chronic road runoff to streams;
5. Erosion and stream sedimentation, generally;
6. Flooding and channel instability, particularly following the November 2021 flood along Lower Nicola[7]; and
7. Conflicting lake level management objectives[8].

## 3.2 Summary of Recommendations

Several recommendations were provided in the SOW reports, some which were relevant and applicable across all watershed units (i.e., watershed-wide), and some that were specific to the watershed unit. These recommendations are outlined below and also listed in Section 5, where their relevance and priority in light of the major flood and wildfires is identified.

[7] Note that the Coldwater River and Spius Creek State of the Watershed Report was prepared prior to the November 2021 flood and its effects on channel conditions.

[8] Specifically at Stump Lake.

TABLE 3.1 *Summary of priority issues identified in the State of the Watershed Reports (Polar 2021, 2022a, 2022b, and 2022c).*

| Watershed Unit | | Drainage area (ha) | Priority Issues | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reduced supply of water for human-use & instream flows for fish with climate change | Increased frequency and magnitude of floods associated with climate change and land use (e.g., forestry) | Degradation of water quality | Contamination of water from highway spills, pipelines or chronic road runoff[9] | Reduced or impaired riparian function, increased channel sensitivity, and potential degradation of water quality | | | Erosion and sedimentation | Flooding and channel instability | Lake level management |
| | | | | | | | Associated with land clearing | Associated with livestock | Associated with forestry | | | |
| Clapperton Creek | | 23,191 | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓[10] | ✓[11] | |
| Coldwater River | | 91,257 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | [12] | |
| Guichon Creek[13] | | 119,245 | | | | | | | | | | |
| Lower Nicola Residual | Lower Nicola 1 | 14,163 | ✓ | | | | | | | | | |
| | Lower Nicola 2 | 8,057 | ✓ | | | ✓ | | | | ✓[14] | ✓ | |
| | Lower Nicola 3 | 11,736 | ✓ | | | ✓ | | | | ✓ | ✓ | |
| | Lower Nicola 4 | 78,244 | ✓ | | | ✓ | | | | ✓ | ✓ | |
| Moore Creek | | 20,433 | ✓ | ✓ | | | ✓ | | ✓ | | | |
| Nicola Lake Residual[13] | | 13,381 | | | | | | | | | | |
| Quilchena Creek | | 77,925 | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | |
| Spius Creek | | 76,756 | ✓ | ✓ | | | | ✓ | ✓ | | | |
| Stumplake Creek | | 30,473 | ✓ | ✓ | ✓[15] | | ✓ | | ✓ | | | ✓[16] |
| Upper Nicola[13] | | 151,016 | | | | | | | | | | |

[9] For Lower Nicola 2-3: There is a potential for contamination from 2021 flood debris (e.g., infrastructure, vehicles).

[10] Extensive coupled sediment sources are present along Clapperton Creek.

[11] On Clapperton Creek, channel instability and loss of natural function on the terminal fan due to channelizing prohibits natural flood dissipation and sedimentation. Nicola River downstream of Coldwater River (i.e., Lower Nicola 2-4) were unstable. As such, banks are eroding and ongoing channel adjustment is expected. Continued bank erosion in areas not armoured with riprap is anticipated. Moreover, coupled slopes that were undermined during the 2021 flood are increasingly unstable and are expected to be sources of chronic sediment delivery to the river in the near-term. The human need for a transportation corridor in the Lower Nicola River valley also represents an encroachment within the active channel margins of the Nicola River. This can affect fluvial processes and potentially result in undesirable adverse effects on fish and fish habitat both locally and downstream.

[12] The Coldwater River and Spius Creek State of Watershed Report was prepared prior to the November 2021 flood.

[13] Guichon Creek, Nicola Lake Residual, and Upper Nicola were outside the scope of Polar's State of the Watershed reports.

[14] 2021 wildfires resulted in loss of forest canopy, loss of organic soil, and increase in soil hydrophobicity. This increases potential for erosion & sedimentation and likelihood of debris flow/floods.

[15] In Stump Lake and downstream.

[16] Lake levels in Stump Lake were affecting landowners and environmental values around and in the lake, as well as downstream.

### 3.2.1 SOW Watershed-wide Recommendations (Polar, 2021, 2022a, 2022b, and 2022c)

1. **Update and improve understanding of water supply & demands (now and into future):** To address the issue of water quantity, low flows and climate change, further knowledge is required around current water availability and use as well as future availability and use with projected changes in climate and land use/population growth. Efforts at understanding water demands that were spearheaded by the Nicola Watershed Community Round Table [e.g., Nicola River Watershed Present and Future Water Demand Study (Summit Environmental Consultants Ltd., 2007)] should be re-examined and updated. Similarly, efforts at understanding current and future water supply on a stream-by-stream basis (e.g., Water Management Consultants, 2008) should be re-examined and updated using current hydrological modelling approaches and hydroclimatic data, which has advanced considerably over the past decade. Storage of surface water remains one of the more effective means of augmenting low flows. It is recommended that previous work on this topic (Summit, 2002) be re-examined to determine if and where feasible and effective storage opportunities could be developed.

2. **Educate public and promote riparian protection:** Development on IR and private lands has had effects on riparian function, which can affect fish habitat and water quality. In order to improve conditions over the long-term, there is a need to educate or remind those who live and work along streams of the implications of land use activities involving vegetation removal or disturbance within riparian areas. In addition, it may be beneficial to provide support and incentives for restoring riparian areas (e.g., advice, planting materials, fencing, labour), and perhaps establishing riparian development or land use constraints. Options of purchasing land in sensitive areas for protection may also be considered.

3. **Reduce range impacts on riparian areas:** Riparian disturbance associated with livestock under range tenure is commonly observed in the watersheds, especially near watering locations. The impacts near such locations can result in streambank erosion, sedimentation and water quality contamination, which may be detrimental to downstream water users and fish. Tackling the issue is especially challenging given the long history and tradition of range use in the Nicola River area. Any approach to mitigating livestock impacts would likely require and an educational component (to inform tenure holders of the implications of uncontrolled livestock access to streams), additional constraints on their tenure along with support in the implementation of such constraints, and perhaps monetary penalties for non-compliance.

4. **Assess the geomorphology of major tributaries and the Nicola River to identify potential restoration opportunities:** The desktop channel assessment provided by Polar (2021, 2022a, 2022b, and 2022c) summarized conditions on a stream-by-stream basis at the time of the assessment. If further resolution is required (e.g., for identification of specific restoration opportunities), it is recommended that detailed reach- and/or site-specific assessments be performed. Such assessments could include historical analysis and channel mapping, supported by historical aerial photos and imagery. This would serve to identify unstable

reaches and estimate rates of bank erosion over time. Patterns of geomorphic change and rates of erosion are particularly important to know when evaluating the effectiveness of restoration or mitigation efforts. Field review by air and on the ground is also recommended to provide further resolution on existing hazards and risks in the watershed.

### 3.2.2 SOW Recommendations Specific to Coldwater River and Spius Creek (Polar, 2021)

1. **Protect water quality from accidents, spills and leaks:** Particularly within the Coldwater River watershed, potential spills from highway accidents and pipeline leaks as well as chronic inputs of road runoff (with possible contaminants[17]) could have an adverse effect on water quality, water supply and fish habitat. It is recommended that spill prevention, mitigation and response be examined in order to limit any potential exposure of Coldwater River to contaminants. This may include the stockpiling of spill containment materials within close proximity to the river, increased training of road maintenance staff in water protection measures, and examining fish-friendly options for highway de-icing. Furthermore, baseline water quality sampling of Coldwater River at strategic locations along the highway should be considered to provide a reference in the event of an accidental spill.
2. **Promote information sharing:** The FSW Objectives in the Coldwater River and Spius Creek GAR Orders provide an important step towards increasing awareness of fisheries values and fostering improved forest practices. However, for long-term success, there should be on-going and transparent dialogue between the province and forest tenure holders. This dialogue may include discussion on data sharing, operational challenges of meeting objectives, potential refinement or clarification of objectives, education and training needs for both government staff and forest professionals, and options for monitoring whether objectives are being met and are effective.
3. **Conduct road-risk assessments of all roads:** It is important to recognize that the FSW GAR Order only applies to new resource roads not existing ones. However, based on the experience of the assessment team, there are potentially many existing resource roads that can have adverse watershed effects by changing local runoff patterns, potentially increasing slope stability and increasing sedimentation potential. It is recommended that any investigation of sediment-related risks in the watersheds consider a field-based evaluation of resource roads, including permitted roads, Forest Service Roads and non-status roads. While the permitted roads are actively managed by forest tenure holders, the latter two types are often overlooked even though they can pose significant risk.
4. **Conduct detailed assessments of higher risk areas:** If the province requires further details for decision making or planning purposes, additional investigation, supported by field review,

[17] May include salts, sediment, debris, polynuclear aromatic hydrocarbons (PAHs), nitrates, phosphorous, lead, zinc, iron, copper, cadmium, chromium, nickel, manganese, bromide, cyanide, sodium, calcium, chloride, sulphates, petroleum products, polychlorinated biphenyl (PCB), pesticides, pathogenic bacteria, rubber, and asbestos (Polar, 2021).

should be considered. Areas that present higher water related risk, which may deserve additional attention include:

a. Brook Creek and East Upper Maka Creek where high hydrologic response and sedimentation potentials are due to recent major wildfires;

b. Lower Maka Creek, lower Prospect Creek, and Spius Creek where high sedimentation and/or channel response potentials are identified; and

c. Coldwater River (lower, middle and upper) where sedimentation potential is high and channel response potential is moderate to high, in large part from widespread riparian disturbance over many years[18].

5. **Improve protection of water resources during forest development:** In areas where elevated ECAs have been identified (e.g., Brook Creek and East Upper Maka Creek), it may be desirable for the province to identify the duration over which higher hydrologic response potential exists. This can be done by extending the 2021 ECA modelling to include future projections with or without planned forest development. Such modelling ideally would project ECAs on an annual basis within each watershed unit (and above H60) for at least 50 years into the future. This may be done in collaboration with forest tenure holders, who are actively updating ECAs for operational purposes.

### 3.2.3 SOW Recommendations specific to Quilchena Creek (Polar, 2022a)

1. **Conduct detailed assessments of higher risk areas:** If the province require further details for decision making or planning purposes, additional investigation, supported by field review, should be considered. Areas that present higher water related risk, which may deserve additional attention include Lower Quilchena Creek (stream km 111-148) where sedimentation potential and channel response potential are high, in large part from widespread riparian disturbance over many years.

2. **Improve protection of water resources during forest development:** To reach a low hydrologic response potential, the rate of forest harvest should be managed to promote hydrologic recovery and allow a continual decline in ECAs. Moreover, we recommend sustainable management of the timber harvest land base to create a range of seral stages that will increase resiliency against future epidemics, wildfire, and climate change.

### 3.2.4 SOW Recommendations specific to Clapperton Creek, Moore Creek and Stumplake Creek (Polar, 2022b)

1. **Conduct detailed assessments of higher risk areas:** If the province require further details for decision making or planning purposes, additional investigation, supported by field review,

[18] This recommendation pre-dates the 2021 flood and is now withdrawn given that channel conditions have markedly changed.

should be considered. Areas that present higher water related risk, which may deserve additional attention include:

a. Lower Clapperton Creek (stream km 101-121) where sedimentation potential and channel response potential are high, in large part from widespread riparian disturbance over many years.

b. Lower Moore Creek (stream km 122-135) where sedimentation potential is moderate and channel response potential is high, in large part from widespread riparian disturbance over many years.[19]

c. Stump Lake could be investigated to determine the controlling factors for observed high water levels and the role of the "improved" lake outlet in reducing lake shore flooding at the potential risk to downstream stakeholders. Furthermore, water quality remains a potential concern that should be monitored.

2. **Improve protection of water resources during forest development:** To reduce past forest development related effects on hydrologic response in each of the three watersheds, and particularly Clapperton and Moore Creeks, forest management should be conducted in a manner that promotes hydrologic recovery in MS and ESSF stands to offset the effects on snow accumulation and melt rate. In order to manage for a long-term sustainable and resilient water supply, forest management should include the promotion of a range of seral stages and consider including more selective harvesting.

3. **Reduce land use impacts on riparian areas:** Development on private land, including roads and sub-divisions has adversely affected the natural function of Clapperton Creek fan to dissipate energy associated with flow and sediment loads. As a result, there has been an increase in sediment delivery to high value fish habitat along the lower Nicola River. We recommend that the effects of sediment transport and deposition on fish and fish habitat be assessed along lower Clapperton Creek and lower Nicola below the confluence. Based on these findings, opportunities to restore natural function on the fan may be worthwhile and should be considered. Such opportunities might include buying property or establishing agreements with property owners along the creek in order to designate a portion of the fan for natural flood dissipation and sedimentation.

### 3.2.5 SOW Recommendations specific to the Lower Nicola River (Polar, 2022c)

1. **Educate the public and promote of riparian restoration and protection:** The riparian zone along the Nicola River has been subject to development on IR and private lands and was heavily impacted during the November 2021 flood. The loss of riparian vegetation has increased erosion, led to the loss of pool and off-channel habitat, and affected water quality. In order to improve conditions over the long-term, there is a need to promote a return of

[19] There is potential that this issue has been exacerbated by the Rossmoore Lake wildfire (K222024) in the upper portion of the Moore Creek catchment.

riparian function through modified land use practices and re-establishment of native riparian/floodplain vegetation. There also appears a need to educate or remind those who live and work along streams of the implications of land use activities involving vegetation removal or disturbance within riparian areas. In addition, it may be beneficial to provide support and incentives for restoring riparian areas (e.g., advice, planting materials, fencing, labour), and perhaps establishing riparian development or land use constraints. One restoration option is to recreate a mature lined valley by planting Cottonwood and other pioneer species in the floodplain. The floodplain could be repatriated by establishing setbacks at appropriate distances from the Nicola River. Options of purchasing land in sensitive areas for protection may also be considered. Moreover, conservation easements, already used by the Alberta government and the Nature Conservancy, could be adopted by the BC government to acquire land on the floodplain.

2. **Protect water quality from accidents, spills and leaks:** Infrastructure and property were entrained by the Nicola River during the November 2021 flood event, potentially resulting in contamination. Moreover, incidental spills from highway accidents and pipeline leaks as well as chronic inputs of road runoff (with possible contaminants) could have an adverse effect on water quality, water supply and fish habitat. It is recommended that spill prevention, mitigation and response be examined in order to limit any potential exposure of Nicola River to contaminants. This may include the stockpiling of spill containment materials within close proximity to the river, increased training of road maintenance staff in water protection measures, and examining fish-friendly options for highway de-icing. Furthermore, baseline water quality sampling of the Nicola River at strategic locations along the highway should be considered to provide a reference in the event of an accidental spill.

3. **Assess the geomorphology of the Nicola River to identify potential restoration and risk mitigation opportunities**: In light of the substantive changes to the morphology of the Lower Nicola River following the November 2021 flood event, the channel is currently unstable. As such, geomorphic monitoring is recommended to assess the rate at which channel stability improves. This will likely require an imagery review, utilization of LiDAR data (as it becomes available), channel mapping, and field work to document baseline conditions. Such monitoring could include evaluating changes in channel planform, sediment texture, aggradation/degradation, and woody debris distribution. Additionally, consideration should be given to the implications of highway construction on restricting natural channel migration patterns. For example, Brierley and Fryirs (2022) emphasize the pitfalls associated with a "command-and-control" approach to river management.

   BGC Engineering Inc. (BGC) completed several assessments within the Nicola River Watershed, several of which pre-date the November 2021 flood event. These projects include but are not limited to an evaluation of geohazards and geotechnical assessments in the Lower Nicola, floodplain mapping, flood frequency analysis, and hydraulic modelling. Following the November 2021 flood event, BGC was retained by BC Ministry of Transportation and Infrastructure (now BC Ministry of Transportation and Transit) to conduct a corridor scale, hydrotechnical and geotechnical hazard characterization and risk prioritization for the Nicola

Valley, drawing on their previous work in the watershed (Holm, pers. comm, 2022). Moving forward, we recommend that all provincial agencies, regional and local government and First Nations search for opportunities to effectively collaborate and share information to avoid a duplication of efforts.

4. **Conduct post-wildfire risk assessment:** BGC Engineering Inc. was retained by FLNRORD to conduct a post-wildfire geohazard risk assessment following the Lytton Creek wildfire; however, their assessment area was limited to the Nicoamen River Watershed, Lytton Creek Watershed, Thom Creek Watershed, and the Devil's Creek Watershed (BGC Engineering Inc., 2021). At the time of the SOW report preparation, no post-wildfire assessment of the Lytton Creek wildfire had been conducted in the Nicola River Watershed (Bohay, pers. comms, 2022). In order to understand the risks posed by the wildfire on values in the Nicola River watershed, a post-wildfire hydrologic assessment is recommended[20].

5. **Investigate sediment dynamics and its role in channel behaviour:** We recommend that a sediment source survey program be developed to understand the rate and significance of sediment contributions to the river and its tributaries, particularly along channel segments affected by the November 2021 flood and in the areas affected by the Lytton Creek wildfire. The assessment should consider the degree of coupled slopes, area undergoing active erosion, and rate of erosion along the channel. Outcomes from the assessment could be used to develop mitigation strategies to reduce sediment inputs into the channel for the benefit of fish and fish habitat.[21]

6. **Synthesis of State of Watershed Findings.** Several SOW reports have been conducted as of 2022 in several of the Nicola River sub-units. A synthesis that integrates the findings from all previous assessments into a unified document, with some gap filling where necessary, would serve as a valuable resource for the province and stakeholders and assist in watershed level understanding and effective communication.

## 4.0 LITERATURE REVIEW

The following summarizes reports supplied by WLRS and identified during the course of this assignment. Summaries are organized chronologically and by the following topics: 1) Flooding and geomorphic change, 2) Wildfire hazards and risks, and 3) Groundwater, and 4) Other topics of relevance. Each of the summaries is followed by "takeaway" messages that are considered most relevant to the scope and objectives of this update.

[20] This assessment was completed by BGC (2023). The recommendation is withdrawn.

[21] Major efforts in line with this recommendations are reported by Davidson et al. (2023) and Hancock and Wlodarczyk (2024).

## 4.1 Flooding & Geomorphic Change

**Nicola Coldwater Rivers Floodplain Mapping Project (BGC, 2022b)**

This is a presentation provided by BGC Engineering Ltd. to the Nicola Restoration Committee on November 17, 2022. The purpose of the floodplain mapping project was to develop high quality floodplain maps for the Nicola and Coldwater Rivers. Detailed floodplain maps are to assist with long term risk management along the corridors, and tie into multi-geohazards management programs. Detailed floodplain mapping builds on earlier "base level" floodplain maps and includes the 2021 AR event. Detailed flood hazard mapping includes bathymetric surveys to produce regulatory floodplain maps that include flood construction levels. Three types of flood hazards were characterized at the corridor scale: channel avulsion, bank erosion, and inundation. The mapping project was to be completed by January 2024 but project status is unknown as floodplain maps were not provided for this review.

**Takeaway:** **Floodplain mapping is an important tool in the identification of potential hazards associated with channel avulsion, bank erosion and inundation. Maps can and should be used for regulatory, design, and protection purposes.**

**Human influence on the 2021 British Columbia floods (Gillett et al., 2022)**

This paper examines the cause of the 2021 atmospheric river flood event on the Nicola River and the role of human-induced climate change. The summary is essentially the abstract transcribed as all points relevant to this study are included in the abstract in a clear and concise way.

When characterized in terms of storm-averaged water vapour transport, atmospheric river events of a magnitude seen in 2021 are approximately one in ten year events, and these events have been made 60% more likely by human-induced climate change. When characterized by two-day precipitation, the event was more extreme, approximately a 1 in 50 to 1 in 100 year event, and the probability of events at least this large has been increased by 45% by human-induced climate change. The 2021 AR event was exacerbated by antecedent conditions including snow cover at upper elevations and rapidly rising temperatures. Based on a complex model that integrates multiple climatic drivers, the authors found that the probability of extreme streamflow events between October and December has likely increased between 120 and 330% based on human induced climate change. This study highlights the role of human induced climate change in large flood events on the Nicola River and emphasizes the need to increase resiliency in the face of more frequent events of this kind in the future.

**Takeaway:** **The occurrence of the AR event in November 2021 resulted in the costliest weather related extreme in the history of British Columbia. The occurrence of the event and the extent of damage motivated a large amount of research, modelling, assessment, and mapping that has increased awareness around the cause of similar events over time, and the trend with respect to the occurrence of similar and likely larger and more frequent events in future. The increase in awareness in this regard was one of the goals of the author(s) of this paper, which suggests a positive result, generally.**

**A Tale of Two Tributaries (Hairbedian, 2023)**

This is a presentation provided by BGC Engineering Ltd. to the Nicola Restoration Committee on October 19, 2023. The presentation compared and contrasted historic and more recent flood events on the Coldwater River and Nicola River in terms of contributing factors, timing, and magnitude. It also examined the expected effect(s) of climate change on both flood frequency and flood magnitude under a worst-case climate scenario. Flood events on the Nicola River are typically driven by spring snowmelt, whereas floods on the Coldwater River are driven by both spring snowmelt, and or rain or rain on melting snow. The largest flood events on the Coldwater River are caused by rain and or rain on melting snow. Typically, flooding does not occur on the Nicola River in years that flooding occurs on the Coldwater River, and vice versa. This relates to the type of event that drives flooding on each of the two systems – spring snow melt only on the Nicola, and rain or rain on melting snow in the Coldwater. The one year that saw major flooding on both systems was 2021 when flows on the Nicola were near double the next highest flow on record. It is assumed that events on the Coldwater River and Nicola River in November 2021 were both driven by rain on melting snow.

A review of historical peak flows on the two systems revealed that little change has occurred over time. However, change is expected in future with a changing climate. Using simulated flows based on an representative concentration pathway (RCP) climate change scenario of 8.5 ("business as usual" scenario), the trend shows an overall reduction in spring freshet flows, an up to 5 times increase in the magnitude of fall/winter rain and rain on snow driven events, and a shift in the Nicola from snowmelt dominated flood events in the spring, to rain and rain on snow driven events in the fall. Using RCP 8.5 for 200 year events, their models predict a 60–75% increase in magnitude on the Nicola, Coldwater, Coquihalla and Spius systems. The results demonstrate what is conceivable on each system if a business as usual scenario is maintained.

**Takeaway:** **This presentation provided an interesting comparison and contrast between the Nicola and Coldwater Rivers. Both have the potential to produce damaging floods through the City of Merritt, and climate change is expected to increase both the frequency and magnitude of flood events on each system, in future. Climate change scenarios and expected outcomes should be used in floodplain mapping, construction/reconstruction regulations, and the design of flood protection structures and mechanisms.**

**Geomorphic Change on the Nicola River (Davidson, 2023)**

This is a presentation to the Nicola Restoration Committee on January 19, 2023, focussing on geomorphic changes observed along the lower Nicola River (i.e., below Nicola Lake). The presentation identifies three recent large floods on the Nicola that occurred in 2017 (336 $m^3/s$), 2018 (340 $m^3/s$), and 2021 (750 $m^3/s$). The first two occurred in early May (i.e., freshet), whereas the 2021 flood occurred mid-November in response to an AR with rain-on-snow. By mapping channels on historical air photos, the author demonstrates the stream channel adjustments (i.e., erosion and meander migration) that occurred in response to the floods. A total of 139 reaches were identified with unique channel and floodplain characteristics. The 2021 flood caused the Nicola River to widen from 53 m to 58 m (+5 m)

between Coldwater River and Spius Creek, and from 65 m to 97 m (+32 m) between Spius Creek and the Thompson River. Such increases in width to depth ratios tend to adversely affect fish and fish habitat. Overall, the patten and severity of erosion was positively related to channel gradient and confinement (i.e., more erosion was observed on steeper more confined reaches). This is not surprising given that shear stress responsible for erosion increases with water depth (which is increased the more the channel is confined) and gradient. Further, as valley sides eroded and contributed to sediment deposits downstream, more erosion was triggered.

**Takeaway:** **The extreme flood on the Nicola River in 2021 resulted in variable erosion and channel adjustment, however these effects were increasingly severe in steeper, and more confined reaches. Future land use along the river should consider the potential for future erosion, particularly with extreme floods.**

**What controls river widening? Comparing large and extreme flood events (Davidson et al., 2023)**

This paper characterizes the widening of the Nicola River following two floods, including a 50-year return period event in 2017 (identified as "large") and a 100-year + return period event in 2021 (identified as "extreme"). Based on digitization of pre- and post- flood imagery, river widening between Merritt and Spences Bridge is reported to be on average 19% after the large flood and 40% after the extreme flood. In order to understand the contributing factors responsible for the observed widening, the authors statistically examine 11 predictor variables for their significance. Interestingly, the factors responsible for widening under the large and extreme flood are different. For large floods, channel pattern appears most important, whereas for extreme floods, it is a combination of unit stream power, gradient and valley confinement. Further, the most severe widening in an extreme flood can occur at locations with historically low migration rates; thus, historical assessments alone should not be used to inform assessments of future erosion susceptibility. The authors suggest that future assessments of erosion susceptibility consider gradient and confinement, and where discharge is known, stream power may be used to refine predictions.

**Takeaway:** **On the Nicola River, channel adjustment to extreme floods with return periods greater than about 100-years (e.g., 2021 flood) is notably different than floods less than about a 100-year return period. In extreme floods, channel widening is strongly related to unit stream power, channel gradient and valley confinement. These factors should be considered when assessing future erosion susceptibility and the suitability of varying land uses along the river.**

**The role of wildfires and forest harvesting on geohazards and channel instability during the November 2021 atmospheric river in southwestern British Columbia, Canada (Hancock and Wlodarczyk, 2024).**

In this retrospective study, the authors identify the locations of 1,300 geohazards that were associated with the November 2021 atmospheric river (AR) which affected roughly 70,000 km$^2$ of southwest British Columbia. Mapped geohazards included debris flows, debris floods, debris slides, shallow landslides across several watersheds, including Coldwater River and Spius Creek. Using multiple lines of evidence, including field observations, imagery, and LiDAR data collected pre- and post-flood, point locations for each hazard and volumetric changes in sediment along selected stream reaches were identified. The authors correlate these with watershed conditions at the time of the AR. These conditions were described as areas 1) burned by wildfire, 2) logged, or 3) with the presence of resource roads. No effort was made to describe the severity of disturbance, the levels of forest (or hydrologic) recovery post-logging, and/or the quality of the roads identified, nor antecedent moisture and snow conditions.

In the Coldwater River watershed, including Brook Creek, the authors identify 117 geohazards and associated 24% of these with lateral channel instability (i.e., immediately downstream of major sediment inputs channel instability was observed), 29% were in areas affected by recorded wildfires, and 24% were in areas previously logged or with the presence of resource roads.

In the Spius Creek watershed, 103 geohazards were mapped, of which 38% were associated with lateral channel instability, 60% were in areas burned by wildfire, and 2% were in areas logged or near resource roads.

The authors do not infer causality between geohazard occurrence and wildfire, logging and/or resource roads, but nevertheless identify the potential relationship, and suggest that further examination is required. With half of all geohazards identified on disturbed landscapes (wildfire, logging and resource roads), and the other half on "undisturbed" landscapes, it seems that the precipitation and snowmelt associated with the AR remain the major contributor to the geohazards that occurred. Despite this, the authors do identify that channel instability was clearly more prevalent in disturbed landscapes. Interestingly, of the 400 resource road and logging-related geohazards identified throughout southwest BC, about half were associated with undocumented and unmaintained (likely non-status) roads. In order to address these risks, substantial effort will be required to not only identify and assess the risks, but also to take the necessary action to reduce the risks. The authors conclude that with increasing wildfire and AR severity anticipated with a warming climate, an increase in geohazards is likely to follow.

**Takeaway:** **The likelihood of hazards such as debris flows, debris floods, debris slides, shallow landslides may be increased by natural (e.g., wildfire) or human disturbances (e.g., forest harvesting and road construction) as well as climate change. Among the hazards identified, a significant number are associated with**

**non-status roads. To reduce these hazards, efforts will be required to identify, assess, and mitigate these across the landscape.**

## 4.2 Wildfire Hazards & Risks[22]

Post wildfire hazard and risk assessments are summarized in the following section. Reconnaissance level assessments were completed for the four largest fires discussed in this report, and more detailed assessments were completed for two areas in the Lytton fire. Areas with elevated hazard and/or risk were identified in all of the reports, some outside of the Nicola River watershed. Areas of actual or potential elevated hazard or risk are shown in FIGURE 4.1.

### 4.2.1 Reconnaissance Assessments

**Lytton Wildfire (K71086)(Giles, 2021a)**

This reconnaissance-level post-wildfire natural hazard assessment was prepared in September 2021 shortly after the Lytton Wildfire affected an estimated 83,671 ha, including over 37,972 ha of the Nicola Watershed[23], predominantly in Lower Nicola 4. The wildfire was largely confined to the south side of the lower Nicola River, partially or completely burning the tributary catchments of Skaynaneichst Creek, Skeikut Creek, Shakan Creek, and Manning Creek. However, the wildfire also burned a considerable portion on the north side of the valley near Agate, including the catchments of Gordon Creek and Poison Creek. As Highway 8 follows the north side of the river, the moderately steep burned slopes directly above the highway pose some hazard given soil and gully erosion and subsequent sedimentation following relatively light rains in mid-September 2021. Overall, the post-wildfire hazard and risk to Highway 8 was rated as moderate. To mitigate risks, Giles (2021a) recommended 1) that all drainage structures along Highway 8 within the wildfire perimeter are cleaned and functional; and 2) further detailed assessment be conducted in the burned catchments and open slopes above Highway 8.

**Takeaway:** **The Lytton Wildfire posed a moderate risk to Highway 8 due to the potential for soil erosion and gully instability. Increased frequency of inspections and maintenance of all drainage structures within or downslope of the wildfire were recommended.**

[22] It should be noted that in the post-wildfire hazard and risk assessments reviewed herein, none considered fish and aquatic habitat values.

[23] This value refers to the total area within the wildfire perimeter. Approximately 6,267 ha (or 16.5%) was unburned within this area.

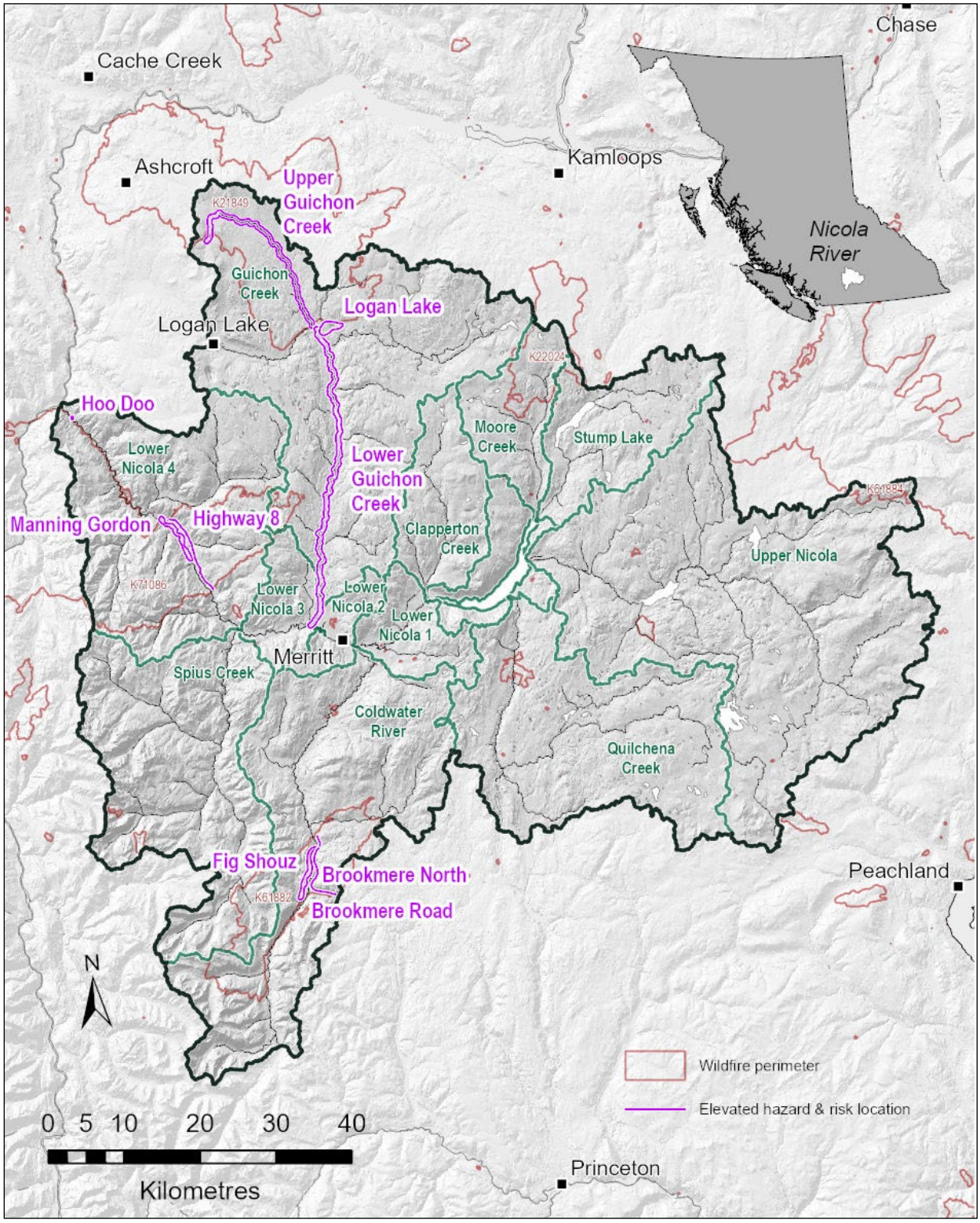



FIGURE 4.1 *Nicola River Watershed and locations identified with elevated post-wildfire hazard and/or risk.*

**White Rock Lake Wildfire (K61884) (Giles, 2021b)**

This reconnaissance-level post-wildfire natural hazard assessment was prepared in October 2021 shortly after the White Rock Lake Wildfire affected an estimate 83,342 ha of the Thompson Plateau. While this wildfire was severe and extensive, only 1,644 ha was affected[24], mostly at low and moderate burn severities, within the Chapperon Creek catchment within the Upper Nicola Watershed. Areas burned were largely previously harvested and the effects of the burn were expected to be incremental and localized. The post-wildfire flood hazard and risk for Chapperon Creek was rated low.

**Takeaway: The White Rock Lake Wildfire affected a portion of Chapperon Creek within the Upper Nicola River watershed. The post-wildfire flood hazard is low.**

**July Mountain Wildfire (K61882) (Giles, 2021c)**

This reconnaissance-level post-wildfire natural hazard assessment was prepared in early November 2021 shortly after the July Mountain Wildfire affected an estimated 19,335 ha of the Nicola Watershed[25], located near Coquihalla Highway 5 from Juliet Creek to Voght Creek[26]. Approximately 14,055 ha of the wildfire was located in the Coldwater River watershed[27], affecting the tributary catchments of Juliet Creek, Bottletop Creek, Brook Creek, Shouz Creek, and Voght Creek. The remaining 4,827 ha was located in the Spius Creek watershed[28], specifically affecting Maka Creek. Elements-at-risk from the wildfire included Highway #5, several cabins on Murray Lake, and numerous residential and agricultural properties along Voght Creek and Kane Valley Road.

Approximately 15% of Coldwater River watershed fell within the wildfire perimeter, and within this area, about half burned at moderate and high severity. The riparian area along the floodplain of Coldwater River, however, was not heavily affected by the fire. Impacted tributaries catchments to the Coldwater River included:

- Juliet Creek: About 36% of its catchment was burned at moderate or high severity.
- Bottletop Creek: Nearly all of this catchment was within the wildfire perimeter, with about 35% burned at moderate or high severity.
- Brook Creek: About 17% of this catchment fell within the wildfire perimeter, with about 45% burned at moderate or high severity.

[24] This value refers to the total area within the wildfire perimeter. Approximately 426 ha (or 25.9%) was unburned within this area.

[25] This value refers to the total area within the wildfire perimeter. Approximately 3,673 ha (or 19.5%) was unburned within this area.

[26] A small portion also affected Spearing Creek, a tributary of the Similkameen River.

[27] This value refers to the total area within the wildfire perimeter. Approximately 2,670 ha (or 19.0%) was unburned within this area.

[28] This value refers to the total area within the wildfire perimeter. Approximately 1,003 ha (or 20.8%) was unburned within this area.

- Shouz Creek: This catchment was entirely within the wildfire, with 75% burned at moderate or high severity.
- Voght Creek: About 12% of this catchment fell within the wildfire perimeter, and within that area 45% was moderate or high burn severity.

Approximately 22% of Maka Creek, a tributary to Spius Creek, was burned, with 41% affected by moderate or high burn severity.

Post-wildfire hazards and risks were identified for the following four main elements:

1. Coquihalla Ditch (north of Shouz Creek and the Brookmere interchange): Potential for excessive runoff and shallow slides pose a moderate risk to the Coquihalla Ditch.
2. Shouz Creek Sub-basin: Given the extensive burn, increased streamflows and sediment yield are expected, which pose a moderate risk to the Shouz Creek FSR crossing (900 mm culvert) and low risk to Coldwater Road and Coquihalla off-ramp road.
3. Larson Hill Slopes: Given the extensive burn within the catchments of East Fig Creek, South Fig Creek, and South Larson Creek, elevated streamflows and sediment yields are expected, which pose moderate risks to the Coquihalla at several culvert crossings.
4. Brookmere Road: Given the effects of the wildfire, elevated streamflows and potential shallow open-slope slides pose a moderate risk to ditches and culverts along Brookmere Road for up to 5 years.

To mitigate risks, Giles (2021c) recommended 1) increased review and maintenance of drainage structures on Coquihalla Highway and Brookmere Road for up to five years; 2) increased monitoring of small stream catchments in the Brookmere interchange and Larson Hill areas given the potential for slides and increased sediment yields; and 3) all resource roads affected by the wildfire should receive increased monitoring for up to five years.

**Takeaway:** **The July Mountain Wildfire posed several identified risks along the Coquihalla Highway that were associated with potentially increased runoff, soil erosion, shallow slides, and increased sediment yield and debris, all of which could compromise stream crossings. Increased frequency of inspections and maintenance of all drainage structures within or downslope of the wildfire were recommended for up to five years.**

**Tremont Creek Wildfire (K21849) (Giles, 2022)**

This reconnaissance-level post-wildfire natural hazard assessment was prepared in February 2022 after the Tremont Creek Wildfire affected an estimated 63,548 ha of the Thompson Plateau, including over 22,764 ha of the Nicola Watershed[29], entirely within in the Guichon Creek catchment. Elements-at-risk post-wildfire within the Nicola Watershed include Highway 97C/97D, industrial, agricultural

[29] This value refers to the total area within the wildfire perimeter. Approximately 3,239 ha (or 14.2%) was unburned within this area.

and residential development, BC Hydro transmission lines, pipelines and Tunkwa Provincial Park. Of several streams affected by the wildfire, three within the Nicola Watershed were identified: Guichon Creek, Chartrand Creek and Logan Lake Creek[30]. Approximately 75% of the Guichon Creek catchment was burned, with 50% of that as high or moderate severity. About 56% of the Chartrand Creek catchment was burned, with 60% of that as high or moderate severity. Logan Lake Creek's catchment was 68% burned with 72% as high or moderate severity. For each stream post-wildfire there is a high likelihood of flooding (both during spring freshet and in response to rainstorms) for up to five years. This is expected to affect low-lying areas, including: 1) along Guichon Creek south from Tunkwa Lake to the junction of Highways 97C and 97D and downstream along its floodplain and alluvial fan (where flooding has previously occurred); 2) along Chartrand Creek near Ard Nigh Road and Highway 97D; and 3) along Logan Lake Creek around the lake and downstream near Chartrand and Ponderosa Avenues. In order to mitigate these risks, increased monitoring and maintenance of culverts and drainage structures is recommended.

**Takeaway:** **The Tremont Creek Wildfire was expected to increase runoff in several areas within the Guichon Creek watershed. Increased frequency of inspections and maintenance of all drainage structures within or downslope of the wildfire were recommended.**

### 4.2.2 Detailed assessments

**Post-Wildfire Natural Hazards Risk Assessment, Shackan Indian Reserve 11 (Westrek, 2022)**

This detailed post-wildfire risk assessment was completed for the Shackan Indian Reserve No. 11, a portion of which was burned in the Lytton Creek fire in 2021. Due to the timing of the request by government to do the work, no field work was done. The scope of the work was therefore as follows:

- Evaluate the post-wildfire natural hazard and risk assessment at the desktop study level for residences, occupied public or private buildings, and infrastructure such as highways, arterial roads, and railways on the Shackan Indian Reserve No. 11.
- Provide recommendations to owners, agencies and stakeholders where the risk from post-wildfire natural hazards may be elevated, and to allow them to undertake more detailed assessments or take steps to address the risks before the hazardous events occur.

The partial risk analysis work was carried out as per steps outlined in BC Land Management Handbook #69 (Hope et al., 2015).

A total of 5 watershed and 4 face units were identified for analysis. Some smaller drainages are present within the face units but they were too small to delineate at this level of assessment. Identified watersheds include: Skeikut Creek, Shakan Creek, Agate Creek, Manning Creek, and Skuhun Creek. A variety of elements were identified within the area affected by the Lytton Creek wildfire, including:

[30] The latter two streams are tributaries to Guichon Creek which have their confluences near the community of Logan Lake.

residential structures, private and public infrastructure. Elements at risk were assessed either individually or as a group where the risk rating was the same.

This analysis identified moderate to very high risk conditions on Skeikut Creek, Shakan Creek, Agate Creek, Manning Creek, and Face Units 1 and 2. Risk was associated with flood and debris-laden flow damage to public roads, Forest Service Roads (FSR), and in one case a private access road. In all cases it was recommended that the agencies or entities responsible for the management of the roads inspect their infrastructure and upgrade or replace as required. In the case of Face Unit 3, high and very high risks associated with debris-laden runoff and/or debris flow damage to Highway 8 was identified. To address these risks, it was recommended that the BC Ministry of Transportation and Infrastructure (now Transit) inspect their culverts along the section of Highway 8 within Face Unit 3 and upgrade or repair as necessary. Low and very low risk conditions were identified in Face Unit 4.

**Takeaway:** **The occurrence of the Lytton Creek fire and others in the Nicola River watershed since 1999 has increased risk to public safety, and both public and private infrastructure within and downslope/downstream of affected areas. Damaging hydrogeomorphic events are expected during heavy convective or frontal rainfall events, and some have already occurred. While some hydrogeomorphic risk may have existed in these areas pre-fire, risk has increased post-fire and additional events are expected in future.**

**Lytton Creek Fire (K71086) Detailed Post-Wildfire Natural Hazard Risk Assessment, Nicola Valley, BC (BGC, 2023)**

This detailed post-wildfire risk assessment was completed for priority "study" areas burned in the Lytton Creek wildfire between Cook's Ferry and Nooaitch Indian Reserve (IR) No. 10. Ten priority "study" areas were identified based the presence of private land and structures, and input from Nicola Valley First Nations as well as observations of recent debris flow events. Risks to highway users within the study area were previously assessed by BGC for MOTI in January of 2023.

The assessment followed methods outlined in BC Land Management Handbook #69 (Hope et al., 2015). The assessment identified high and very high risks in seven of the ten priority areas, and documented the occurrence of at least ten post Lytton Creek wildfire hydrogeomorphic events. Risks identified were associated with expected debris flow and/or debris flood events and impacts or effect on private land, structures and access roads. Recommended mitigation strategies, general and specific, include:

- educational/warning signage in the fire area,
- community meetings to inform residents of hazard areas and risks from future events,
- outreach materials, such as infographic sheets, sent to valley residents and workers,
- relocation of primary and/or secondary structures,
- excavation of wider/deeper channels, and
- construction of deflection berms.

**Takeaway:** **As above, the occurrence of the Lytton Creek fire and others in the Nicola River watershed since 1999 has increased risk to public safety, and both public and private infrastructure within and downslope/downstream of affected areas. Damaging hydrogeomorphic events are expected during heavy convective or frontal rainfall events, and some have already occurred. While some hydrogeomorphic risk may have existed in these areas pre-fire, risk has increased post-fire and additional events are expected in future.**

## 4.3 Groundwater

**Groundwater Literature Review: Nicola Water Pilot, Upper Nicola Areas Based Planning Project (AE, 2020)**

Associated Engineering Ltd. (AE) was asked by the BC Ministry of Forests to complete a literature review of potential land use effects on groundwater quality and quantity in the Upper Nicola River sub-basin. The purpose of the review was to capture the current state of scientific understanding of the potential effects of defined land uses on groundwater quality and quantity, and provide an interpretation of how these land uses may affect the Upper Nicola sub-basin in particular. Current literature was gathered and assembled into seven categories including: Agriculture – cattle, Agriculture – crops, Forestry – clearcut, Forestry – other techniques, Range Land, Residential, and Light industry. To satisfy project objectives AE reviewed a minimum of three peer-reviewed publications for each land use category, completed some statistics, completed a hydrogeological interpretation for each land use, assigned an importance, and reported out. The project assigned relative importance ratings to each of the land use activities based on extent and hydrogeological interpretation, as follows:

Agricultural crops – high relative importance – the potential effect of this land use on groundwater quality and quantity is high, and effects are highly dependent upon whether best management practices around post crop harvest soil sampling, nutrient management, and irrigation are being followed.

Agriculture cattle - moderate relative importance – the review was focussed on feedlots in particular and only one was identified in the Upper Nicola sub-basin. Feedlots were rated as having moderate relative importance based on potential effects if not properly located and managed. There is potential for more feedlots in the Upper Nicola in future.

Range land - moderate relative importance – the literature review suggests that the effect of range lands on water quality and quantity is low, but increasing numbers of livestock may revert some areas into more feedlot like conditions increasing potential effects on groundwater.

Forestry clearcut - moderate relative importance – although this activity covers a large proportion of the sub-basin the net effect on water quantity is positive, and effects on water quality appear temporary in nature (3 to 7 years).

Forestry other - low relative importance – no selective or strip cut forest harvesting techniques are being used in the Upper Nicola sub-basin.

Residential - low relative importance – there is very little residential land use in the Upper Nicola sub-basin.

Light industry - low relative importance – like residential, very little light industry land use occurs in the Upper Nicola sub-basin.

**Takeaway: While not specific to post fire and post flood conditions in the Nicola River watershed, the report provides a summary of potential land use effects on groundwater quality and quantity, and contains an assemblage of current groundwater related literature. Some extrapolation of findings to other parts of the Nicola River watershed is possible.**

**Nicola Watershed Groundwater Literature Review (WWAL, 2023)**

This literature review, prepared in November 2023, describes current knowledge on groundwater resources in the Nicola Watershed, identifies data gaps, and provides prioritized recommendations to improve understanding and management of environmental impacts. The review is based on 44 reports, only seven of which were prepared in 2021 or later. None of the seven reports, however, address any topics associated with the flooding in November 2021 or wildfires post-2019.

Some of key findings, relevant to the SOW reports include:

- According to provincial observation wells, groundwater levels are relatively stable, as far back as 1968.
- Future climate change projections that are expected affect streamflows are also likely to affect groundwater aquifers.
- Surface water – groundwater interactions have been established for most supply wells used by the City of Merritt, but not elsewhere.
- Human effects on groundwater quantity and quality vary by basin and type of land use, and tend to be focussed along the major valley bottoms.
- Several data gaps remain, including current water demands and water budgets, identified environmental flow needs for major tributary streams other than Coldwater River, aquifer vulnerability mapping and other data-related topics.

Several recommendations were provided to improve understanding and management of: 1) groundwater supply, 2) groundwater quality, 3) land uses, and 4) administrative procedures. Some of the key recommendations are listed below:

*Groundwater supply*

- Establish environmental flow needs (EFNs) and critical environmental flow thresholds for Nicola River and its major tributaries.
- Map the likelihood of hydraulic connection between wells and streams.
- Examine options for increasing water storage.
- Increase number of long-term observation wells, particularly in areas currently not well represented (e.g., mid-Coldwater River, mid- and upper-Guichon Creek, Upper Nicola at Glimpse Lake).
- Examine long-term observation well data and relate these data to climatic, hydrometric and groundwater use data.
- Improve aquifer mapping.

*Groundwater quality*

- Map groundwater vulnerability along major valley bottoms.
- Promote the use of well protection plans for major water supply systems.
- Assess flood risk to water supply system wells supplying First Nation communities or regulated by Interior Health.

*Land Use*

- Prioritize source water protection plans for water supply systems by land use impacts upslope.
- Examine water quality impacts from agriculture and industrial land uses.
- Improve the permitting process for various land activities, to consider effects on groundwater.
- Promote increased education and awareness of groundwater in the Nicola Watershed.

**Takeaway:** **This literature review does not identify any reports describing conditions post-flood or post-wildfire. It does however, identify several themes and actions that may be taken to advance understanding of groundwater within the Nicola River watershed.**

## 4.4 Other Topics of Relevance

**City of Merritt Flood Mitigation Planning (Associated Engineering, 2022a)**

It is unclear as to who this presentation was provided to. It is assumed to be City of Merritt staff but could have included a wider public audience. The presentation summarized the source of the AR event, the magnitude of streamflow on the Coldwater River, and the effect on the City of Merritt. The objectives of flood mitigation planning were discussed. The results of a public survey were presented that concluded that the community values access, recreation and natural features of the rivers.

There is a history of flooding on both the Coldwater River and Nicola River within the City of Merritt so flood protection must consider both systems. Concept modelling was done on both rivers using peak flows 130 $m^3/s$ for the Nicola River, and 533 $m^3/s$ for the Coldwater River. Conceptual dikes

were "stamped" into the model to evaluate the effectiveness or flood protection and evaluate changes in river hydraulics. Other types of flood protection structures were discussed along with possible dredging of the Coldwater River through the City of Merritt. It was pointed out that dredging is not preferred by authorities and is not a flood protection structure.

Seven conceptual options for flood protection were developed and option #5 – combination diking – is preferred. Funding and approvals are being sought for the work.

**Takeaway:** **It appears that the floodplain mapping done by BGC (summarized above) is being used to model potential flooding within and around the City of Merritt. Peak flows being used to design flood protection are higher than those experienced in November 2021, but may not be consistent with those predicted by climate models, as discussed above. Under the RCP 8.5 climate scenario, up to a 5 x increase in the magnitude of fall/winter rain and rain on snow events could occur on systems like the Coldwater River along with a 65% increase in 200 year flood levels.**

**City of Merritt: Post-flood Coldwater and Nicola River Water Quality Monitoring (Associated Engineering, 2022b)**

This presentation was provided to the Nicola Restoration Table in October 2022. The presentation provides an outline of the post-flood water quality monitoring programs on the Coldwater River and Nicola River. The purpose of the monitoring was to assess water quality after effluent was discharged from the City of Merritt waste water treatment plant (WWTP) into the Coldwater River between November 22, 2021 and July 26, 2022, following damage incurred during the AR event. Sampling locations included the Coldwater River upstream and downstream of the WWTP, and the Nicola River upstream and downstream of the confluence with the Coldwater River. Results showed higher ammonia/nutrients in the Coldwater River downstream of the WWTP vs upstream, and E. *coli* was highest in the Nicola River, and this is un-related to WWTP effluent. Effluent is no longer being directly discharged into Coldwater River.

**Takeaway:** **This presentation highlights the pre-AR event vulnerability of City of Merritt infrastructure to major flood events, and need to apply protection to avoid similar effluent discharge in future. There are licensed water intakes on the Nicola River downstream of the City of Merritt and some may be used for domestic water purposes. Discharge of untreated effluent to the Nicola River via the Coldwater River could represent a potential risk to public health.**

**Summary of restoration activity (FBC, 2022)**

This summary, dated January 28, 2022, outlines two watershed restoration activities led by the Fraser Basin Council under the Healthy Watersheds Initiative. The first initiative was to construct ten beaver dam analogues (BDAs) along Howarth Creek, a tributary to Voght Creek. These structures are

constructed with excavator and "natural" materials in an effort to create relatively small storage features (i.e., small shallow ponds). The hope is that with a sufficient number of such storage features distributed across watersheds, runoff could be augmented for the summer low-flow period. Post-construction monitoring of water quality parameters was planned. The second initiative was riparian planting above riprap in October 2021. The location is not specified, but suspected to be along Coldwater River. Unfortunately, the 3000 rose, willow and alder planted were destroyed by the AR that occurred in November 2021.

**Takeaway:** **Restoration activities within an active floodplain are not without risks, as demonstrated by the riparian planting program along the Coldwater River that was destroyed by the 2021 AR event.**

## 5.0 UPDATED CONCLUSIONS & RECOMMENDATIONS

The purpose of this supplementary report is to identify what has changed in the Nicola River Watershed following the 2021 flood and several wildfires since 2019, and how has this affected the conclusions and recommendations in the SOW reports (Polar, 2021, 2022a, 2022b, and 2022c). Based on our literature review, two new priority issues have emerged, both of which are higher priority than those previously identified in the SOW reports (Section 3). A description of new priority issues is provided below. A reflection on previously identified SOW issues is also provided with statements around ongoing relevance, and strategies to address them through the NWPI or alternative pathways.

1. **Post-wildfire hazards and risks**: The first and highest priority issue in the Nicola River watershed is the increase in risk to public safety, major infrastructure and property downslope and downstream of the major wildfires from 2021 and 2023. Based on the available reports, this risk is especially heightened in the vicinity of the Lytton Wildfire (K71086) (Lower Nicola River including Gordon Creek) and July Mountain Wildfire (K61882) (Upper Coldwater River and Maka Creek), but it is also expected to be increased in the vicinity of the Tremont Creek Wildfire (K21849) (Upper Guichon Creek) and Rossmore Lake Wildfire (K22024) (Moore Creek), for which limited information was available. In general, for approximately five years post-wildfire, increased runoff generation, soil erosion, shallow slides, and increased sediment yield and debris transport are anticipated. This arises not only from the extensive loss of the forest canopy and organic soil horizon, but also the development of hydrophobicity often just below the soil surface. After several years, hydrophobicity declines, however given the extensive loss of vegetation, streamflow response to both rainfall and snowmelt-generated runoff are expected to markedly increase and likely remain high for several decades while vegetation recovers. The risks will be contingent upon the actual weather and snowpack conditions in any given year. A period of increased flood magnitude and frequency should be expected, especially along streams with large areas of their catchment burned at moderate or higher severity. In some cases, road washouts and landslides could pose real risks to public safety. In other cases, increased erosion and sedimentation could damage or degrade road infrastructure, private property, aquatic habitat, and/or water quality.

**Recommended actions:** **Evaluate the recommendations from post-wildfire risk assessment reports, as summarized in Section 4. Prioritize and implement those that provide the greatest risk reduction per unit cost. Additionally, increased frequency and intensity of monitoring and maintenance of all road crossings on streams and draws within and below burned areas should be a general rule. In the interest of public safety, local monitoring of rainstorms and issuing of potential flood and/or slope instability warnings could also be considered to protect populated areas and the public along major roads within and below burned areas.**

2. **Climate change and increased flood risks along major streams**: The November 2021 AR event resulted in the flood of record on the Coldwater and Nicola Rivers[31], which surpassed the previously highest flood by approximately 300% and 200%, respectfully. As a result of this extreme event, and the massive damage it caused, there has been considerable increase in the level of awareness or recognition of the flood potential in the Nicola River Watershed. This event not only demonstrated the potential for such flooding, but also stimulated considerable research and investigation. Some of this work focused on the role of climate change, and the results are alarming. Modelling suggests that the probability of extreme streamflow events, equal to or greater than November 2021, on the Nicola River and its tributaries has likely increased between 120 and 330% based on human induced climate change. This poses a real flood threat to many values along major streams in the watershed, including the City of Merritt, which is located on a broad alluvial fan near the confluence of the Coldwater and Nicola Rivers. Although we are aware that the City of Merritt has taken steps to recover from the November 2021 event, and improve flood conveyance and protection (e.g., dykes), there remains uncertainty around how well protected or vulnerable the City is to future floods of the magnitude projected by models, especially when accompanied by sediment transport and aggradation in channels and on alluvial fans[32].

   **Recommended actions:** **Compile and evaluate available flood projections with climate change, floodplain mapping, and flood protection engineering designs to identify the risks to the public in the City of Merritt and other populated or developed areas, including highways, along Coldwater River, Spius Creek and lower Nicola River. Notwithstanding the instinct to often rebuild in the same place as prior to the flood, it is in the public interest to ensure they are informed of the risk or residual risk following flood protection measures, as floods are expected to worsen over time. Depending on**

[31] While records are not available, November 2021 flooding in Spius Creek was likely similarly extreme.

[32] The November 2021 flood resulted in widespread inundation and erosion along Coldwater River, the legacy of which is ample sediment to be entrained in future floods.

**the collective risk tolerance of the community, restrictions on land use near major streams will increasingly require consideration.**

The key issues identified in the SOW reports generally remain valid; however, they are now ancillary to the two priority issues noted above. In summary they include:

3. **Reduced water supply and instream flows with climate change.** This issue remains valid in the Nicola River watershed and may be best addressed through the development of storage, and forest management designed to produce more and later water, where possible. The forest management side of this issue may be best addressed through legal orders in the NWPI, and incoming Forest Land Use Planning (FLP).
4. **Reduced or impaired riparian function and associated increase in channel sensitivity and water quality degradation due to land clearing, livestock use, and forestry activities.** This issue also remains valid in the Nicola River watershed and may be best addressed through legal orders in the NWPI, and incoming FLP.
5. **Increased flood frequency and magnitude associated with removal of forest cover, such as forestry and other land clearing.** This issue remains valid and may be now more important where watersheds or portions of watersheds were burned by wildfire. The forest management aspect of this issue can be dealt with through the incoming FLP process, and both can be addressed through legal orders in the NWPI.
6. **Water quality degradation, specifically due to potential contamination by highway or pipeline spills, and chronic road runoff to streams.** This issue remains valid particularly in the Coldwater River. The highway and pipeline related contamination side of this issue could be addressed through legal orders in the NWPI, whereas resource road stream sedimentation can be addressed through FLP.
7. **Erosion and sedimentation from land uses that remove vegetation cover.** This issue also remains valid and can be addressed on private and IR lands through legal orders in the NWPI, whereas riparian management on crown land can be addressed through FLP.
8. **Conflicting lake level management objectives at Stump Lake.** This also remains a valid issue as it is known that lake levels have been manipulated by local landowners and changes in outflows may be affecting downstream areas (i.e. private land). This issue could be addressed through legal orders in the NWPI.

## 6.0 CLOSURE

We trust this report completes our assignment to your satisfaction. Please let us know if you have any questions, or require any further information regarding our work.

Yours truly,
**M.J. Milne & Associates Ltd.**


03/31/25

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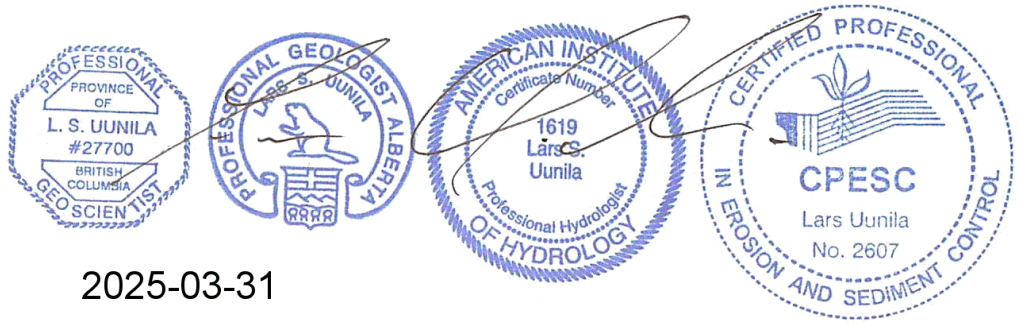


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