



## **Quesnel River Research Centre (QRRC) Newsletter December 2020**

The Quesnel River Research Centre (QRRC) is part of the University of Northern British Columbia (UNBC) and is located near Likely, British Columbia. Since 2007 the QRRC has had an annual Open House in early fall where researchers have presented findings to the local community. Given COVID-19, there was not an Open House in fall 2020. This newsletter describes some of the research activities being undertaken at the QRRC and in the Quesnel watershed since fall 2019.

### **Contents**

- Hydrological and meteorological monitoring in the Quesnel watershed
- Seasonal turbidity patterns in Quesnel Lake
- Coring in Quesnel and Polley Lakes
- Quesnel Lake moorings and sediment traps
- Copper concentrations in Hazeltine Creek and Quesnel River
- Interaction of submerged vegetation and sediment transport under ice-covered flow conditions
- QRRC hatching Chinook rescued from the Big Bar Slide
- Additional research and monitoring activities
- Publications

### **Hydrological and meteorological monitoring in the Quesnel watershed**

*Stephen Déry and Jeremy Morris, Northern Hydrometeorology Group, UNBC*

An unusually deep snowpack in the watershed caused high river flows in the spring which caused high water levels in Quesnel Lake, especially in July when the lake reached a record level; the previous maximum was in June 1972 (Figure 1). This caused problems for several of meteorological stations and some interesting challenges for the research group in terms of maintenance (Figure 2). However, the meteorological stations performed well and provided further data for 2020. Some preliminary findings, based on data from 2016 to 2018, are presented in a paper by former UNBC MSc student Hadleigh Thompson (Thompson et al. 2020) in the *International Journal of Climatology*.

## Quesnel Lake level at Likely (ECCC)

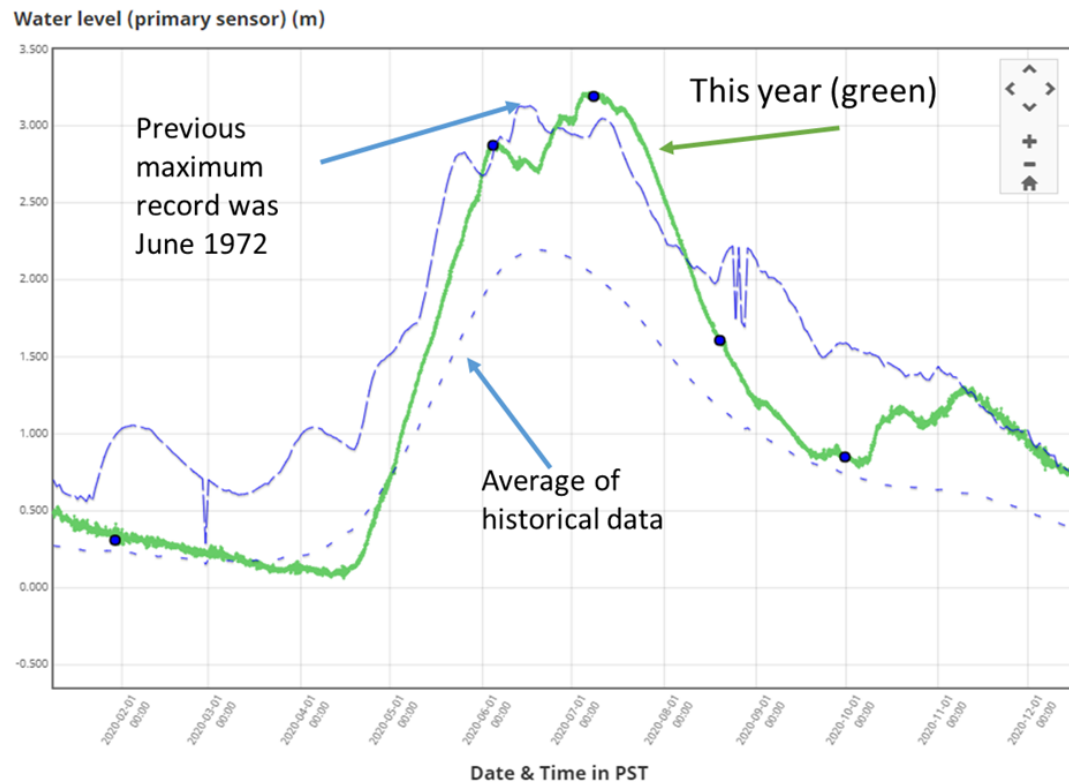


Figure 1. The surface water level of Quesnel Lake in 2020 compared to the historic average (source: Northern Hydrometeorology Group, UNBC).



Figure 2. Servicing one of several meteorological stations in the Quesnel watershed (photo: Northern Hydrometeorology Group, UNBC).

### Seasonal turbidity patterns in Quesnel Lake

*Andrew Hamilton, Department of Earth and Atmospheric Sciences, University of Alberta*

The catastrophic failure of the Mount Polley copper and gold mine tailings pond dam in August 2014 was, at the time, the largest spill of mine waste ever documented. To this day, it continues to hold the record for the largest mine spill into a lake. Despite the scale of the spill, there was surprisingly little visible evidence in the months following of the turbid torrent that plunged into the West Basin of Quesnel Lake. In a recent paper published in the scientific journal *Water Resources Research*, we examined what happened below the surface in the three years following the spill.

As the lake mixed from top to bottom (called turnover) in autumn 2014, the contaminated deep water was brought to the surface, abruptly changing the colour of the clear blue lake to an abnormal bright green — a change first reported by residents of the lake. Using satellite imagery, we show for the first time the full spatial extent of this 2014 ‘greening’ event (Figure 3). Although the turbidity and green colour of the lake decreased over winter 2014/15, our water column measurements show that the turbidity of the lake increased during each subsequent spring and autumn turnover through 2017. One apparent source of seasonally elevated turbidity is resuspension of spill-related material off the bottom of the West Basin driven by basin-scale wave oscillations. This seasonal mobilization of spill waste is undesirable, as it potentially prolongs the exposure of aquatic ecosystems to contaminants. The ongoing discharge of excess mine waste water with high dissolved solid concentrations into the deep water of the West Basin via twin, multi-port diffusers represents an additional pollutant load which complicates our understanding of long-term impact of the spill. Research is underway to further investigate the seasonal turbidity signal and the ongoing discharge.



Figure 3. The entire West Basin of Quesnel Lake turned bright green following the Mount Polley mine (far left) tailings spill when contaminants previously trapped below the thermocline were mixed to the surface during 2014 autumn turnover, three months after the spill. (Image source: FormoSat2; from Hamilton et al. 2020)

## **Coring of Quesnel and Polley Lakes**

*Ellen Petticrew, Geography Program and QRRC, UNBC*

A collaborative effort between Dan Selbie (Department of Fisheries and Oceans: Cultus Lake Laboratory) and Ellen Petticrew (UNBC, QRRC) to collect gravity cores from Quesnel and Polley Lakes was undertaken between September 16<sup>th</sup> to 21<sup>st</sup> 2020. Fifteen sediment cores were collected from six sites on Quesnel Lake and three sites in Polley Lakes using a “Super Glew” gravity corer (Figure 4). The core slices will be dated and analysed for a range of variables including organic matter content, metal concentrations and some paleolimnological parameters. The top 5 cm of each core was also subsampled for bacterial composition and quantity which will be completed in Sue Baldwin’s (UBC) lab. Several of the sites were located in positions cored in 2016 with a slo-corer (Hatam et al. 2019) and will be useful to allow a comparison of sediment change over the past four years.



Figure 4. Dan Selbie removes excess water from a gravity core retrieved from Quesnel Lake before sectioning the core into slices for analysis of chemicals and other properties (photo: Ellen Petticrew).

## **Quesnel Lake moorings and sediment traps**

*Ellen Petticrew, Geography Program and QRRC, UNBC*

Instrumented moorings that have been deployed in the West Basin since 2014 were serviced in September of 2020 (Figure 5). Svein Vagle (Department of Fisheries and Oceans: Institute of Ocean Sciences) and Brody Granger (Bernard Laval’s Group, UBC) orchestrated the removal, downloading, reconfiguring and redeploying of several moorings. These moorings provide continuous records of water column conditions (turbidity, temperature, specific conductance) which allow the group to evaluate issues of particle resuspension and changing water column conditions in reference to overturn disturbance of bottom-stored tailings and inputs of materials into the West Basin (diffuser pipes and

inflowing streams). Funding for some sensor modifications were provided in 2020 by the Concerned Citizens of Quesnel Lake. Several of the moorings also support sediment traps at various depths. These traps were emptied and redeployed during the instrument servicing. These sediment traps along with several others collect material moving in the deeper water column overlying the tailings deposit. Preliminary assessment of samples collected over the period May to November 2020 in traps near Hazeltine Bay at a variety of water depths had copper values above  $400 \text{ mg kg}^{-1}$  (also see section below).



Figure 5. Mathews (QRRC) and Hutchison (DFO) at shoreline in Quesnel Lake while researchers prepare moorings (photo: Jordan Lindgren).

### **Copper concentrations in Hazeltine Creek and Quesnel River**

*Phil Owens, Environmental Science Program and QRRC, UNBC*

We continue to monitor the quality of the fine sediment that is being transported in the Quesnel River. Over the last year, we collected bulk samples of the suspended sediment passing the QRRC on a weekly or bi-weekly basis, thus adding to the samples collected since fall 2014. As with every other year since the spill, concentrations of copper exceeded the Federal sediment quality guideline value for the protection of freshwater aquatic life of  $197 \text{ mg kg}^{-1}$  (= parts per million, ppm) in spring of 2020. The timing of the annual exceedance of the guideline corresponds with work by UBC MASc student Brody Granger on the resuspension of the tailings material at the bottom of Quesnel Lake. Brody's work builds on that described above by Andrew Hamilton and others.

This summer we also sampled the fine sediment stored in the river gravels in Hazeltine Creek and along the Quesnel River from the QRRC to upstream of Quesnel. Preliminary assessment of the results suggests that copper values in Hazeltine Creek near Quesnel Lake exceed the  $197 \text{ mg kg}^{-1}$  guideline, with one sample collected in June being about  $600 \text{ mg kg}^{-1}$ .

### **Interaction of submerged vegetation and sediment transport under ice-covered flow conditions**

*Mahboubeh Barahimi Varnousfaderani, Ph.D. candidate, Natural Resources and Environmental Studies, UNBC*

The presence of vegetation is a key element in rivers. Vegetation reduces flow velocity near channel beds and has effects on erosion, sediment transport, resistance to flow, and aquatic habitat diversity. On the other hand, ice cover/ice jam appears in many rivers during the winter period in cold regions. Some types of aquatic vegetation and some portion of plants overwinter with stems and represent roughness elements during cold seasons and under the iced-cover surface. Historically, ice cover in rivers has led to an increase in water level, and sometimes extensive flooding and damage of properties.

The goals of my experimental study are to investigate the interaction of submerged vegetation and sediment transport process in rivers in the presence of ice cover. As humans tend to settle near rivers, the impact of ice-covered rivers and sediment transport is one of the important factors in engineering design and construction. Results of this study will help engineering design and development of water resources and river restoration projects.

Using one of the long outdoor flumes at the QRRRC, I used grass-shaped artificial flexible vegetation with different heights (Figure 6), three different non-uniform grain sizes sand for the channel bed, and styrofoam panel as a replica of ice cover. A SonTek IQ was installed to measure the approaching flow velocity, water depth and discharge during the experiment. In addition, a down-looking Acoustic Doppler Velocimeter (ADV), developed by Nortek was used to measure instantaneous three-dimensional velocity components.



Figure 6. Underwater photo of plastic structures to represent submerged vegetation in a flume at the QRRRC. Water flow is from left to right (photo: Mahboubeh Barahimi Varnousfaderani)

### **QRRRC Hatching Chinook Rescued from the Big Bar Slide**

*Michael Allchin, QRRRC Manager, UNBC*

The QRRRC has found itself reprising its former role as a Department of Fisheries and Oceans (DFO) chinook salmon hatchery this year. Sometime in the winter of 2018 – 2019, approximately 85,000 m<sup>3</sup> of rock fell from a bluff 125 m above a narrow point in the Fraser Canyon near Big Bar, 50 km to the south-west of 100 Mile House (Figure 7). This event created a new 5-m-high waterfall, presenting an impassable obstacle to fish attempting to migrate upstream during high-flow conditions in the spring and early summer.

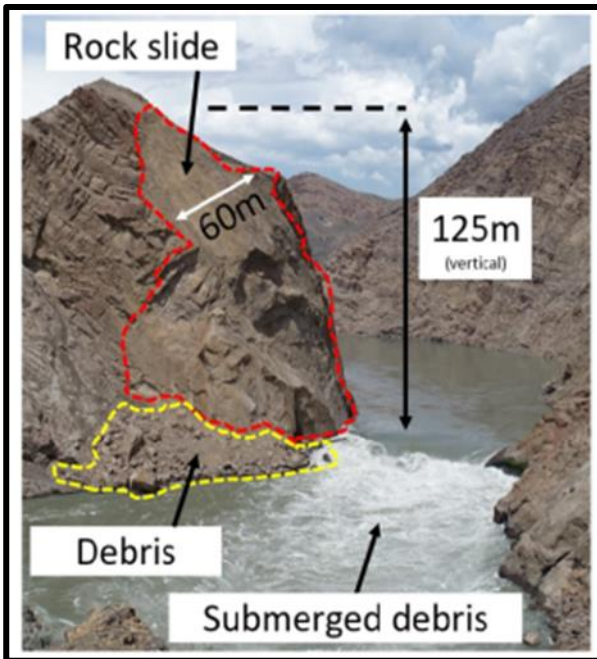


Figure 7. The Big Bar Slide (source of photo: DFO / Min. FLNRORD)

Given the key importance of Fraser River salmon to indigenous communities and natural ecosystems throughout much of BC, and against a background of generally declining populations during recent decades, DFO, provincial agencies and First Nations organizations have developed a range of approaches to mitigate the impacts of the slide on fish returning to their spawning-rivers. One of these involves rescuing salmon from below the slide: the fish first undergo genetic testing to determine the population to which they belong (i.e., the river in which they were born), before being stored at the Nechako White Sturgeon Conservation Centre in Vanderhoof until they are ready to spawn.



Figure 8. Mixing-up a fresh batch of chinook salmon eggs (photo: Gabby Lint, UNBC)

As part of a project implemented by the Upper Fraser Fisheries Conservation Alliance (UFFCA) – a First Nations organization focused on the monitoring and conservation of salmon stocks – the eggs have been transported to the QRRRC (Figure 8), where they were fertilized and incubated in running freshwater. Apart from the availability of suitable equipment at the centre (which has also been substantially upgraded to serve the project's needs), a key benefit is that its hatchery systems are fed from wells, so fish raised there will not 'imprint' onto local surface-water characteristics, this being delayed until they are released into their natal streams. The UFFCA's work – which at its peak involved caring for approximately 210,000 eggs – is being conducted with the close involvement of former QRRRC manager Rick Holmes, who runs a consultancy company in the area. Having developed from eggs to alevin to fry, the fish will be released into their 'home' rivers sometime in the summer of 2021.

#### **Additional research and monitoring activities**

- UNBC graduate student Gabby Lint started her project investigating chlorophyll a and phosphorus dynamics in Quesnel and Polley Lakes.
- The Northern Shuswap Tribal Council had staff based at the QRRRC in late fall and early winter counting coho salmon.

#### **Publications by QRRRC/UNBC researchers and colleagues on the aquatic impacts of the Mount Polley Mine spill on Quesnel Lake and watershed (most are freely accessible via the weblink):**

Petticrew EL, Albers SJ, Baldwin S, Carmack EC, Déry SJ, Gantner N, Graves K, Laval B, Morrison J, Owens PN, Selbie D, Vagle S (2015). The impact of a catastrophic mine tailings spill into one of North America's largest fjord lakes: Quesnel Lake, British Columbia. *Geophysical Research Letters*, 42, 3347-3355.

<https://doi.org/10.1002/2015GL063345>

<https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2015GL063345>

Hatam I, Petticrew EL, French TD, Owens PN, Laval B, Baldwin S (2019). The bacterial community of Quesnel Lake sediments impacted by a catastrophic mine tailings spill differ in composition from those at undisturbed locations – two years post-spill. *Scientific Reports*, 9, 2705.

<https://doi.org/10.1038/s41598-019-38909-9>

<https://www.nature.com/articles/s41598-019-38909-9>

Hamilton AK, Laval BE, Petticrew EL, Albers SJ, Allchin M, Baldwin SA, Carmack EC, Déry SJ, French TD, Granger B, Graves KE, Owens PN, Selbie DT, Vagle S (2020). Seasonal turbidity linked to physical dynamics in a deep lake following the catastrophic 2014 Mount Polley mine tailings spill. *Water Resources Research*, 56, e2019WR025790.

<https://doi.org/10.1029/2019WR025790>

<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019WR025790>

Plomp RD, Klemish JL, Pyle GG (2020). The single and combined effects of wildfire runoff and sediment-bound copper on the freshwater amphipod *Hyalella Azteca*. *Environmental Toxicology and Chemistry*, 39, 1988-1997.

<https://doi.org/10.1002/etc.4821>

<https://setac.onlinelibrary.wiley.com/doi/10.1002/etc.4821>

Thompson HD, Dery SJ, Jackson PL, Laval, BE (2020). A synoptic climatology of potential seiche-inducing winds in a large intermontane lake: Quesnel Lake, British Columbia, Canada. *International Journal of Climatology*, 40, 5973-5986.

<https://doi.org/10.1002/joc.6560>

<https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.6560>

Kostaschuk R, Aden A, Desloges JR (in press). Erosion, deposition and contamination by high-magnitude subaqueous debris flows and turbidity currents: Insights from the failure of a tailings dam near Quesnel Lake, British Columbia. *Sedimentology*.

At the time of writing there are at least seven other papers either submitted or in preparation.

**Phil Owens and Ellen Petticrew, December 2020**

**Contacts:**

[philip.owens@unbc.ca](mailto:philip.owens@unbc.ca)

[ellen.petticrew@unbc.ca](mailto:ellen.petticrew@unbc.ca)

[michael.allchin@alumni.unbc.ca](mailto:michael.allchin@alumni.unbc.ca)



Figure 9. North Arm of Quesnel Lake from Cameron Ridge (photo: Phil Owens)