# Redwillow Watershed 2021 Winter Water Quality Monitoring Report

Mighty Peace Watershed Alliance
Diverse, Responsible, Connected

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Adam Norris

# Redwillow Watershed Winter Water Quality Monitoring Program 2021

Goal: To collect in-situ water quality (dissolved oxygen, temperature) and water depth data to understand the habitat suitability for overwintering fish species, particularly Arctic Grayling, in the Redwillow Watershed.

Background: Several organizations are currently involved in efforts to improve fish habitat within in the Redwillow Watershed and currently engaged in diverse monitoring activities. A comprehensive examination of the state of the Redwillow Watershed was undertaken in 2009 when Alberta Environment and Sustainable Resource Development commissioned AECOM Canada Ltd. to review fish habitat and determine how it could be restored (McGurk, Michael; Froese, M; Quach, M; Seward, 2009). The water quality sampling sites that they recommend for the Redwillow Watershed can be seen in Figure 1. The Beaverlodge River located within the Redwillow watershed, and acts as the main tributary to the Redwillow River. Alberta Environment and Parks has conducted in-situ water qauilty monitored within the Redwillow Watershed, using data loggers to monitor water temperatures at the locations indicated on Figure 2. In addition Alberta Conservation Association has also monitored

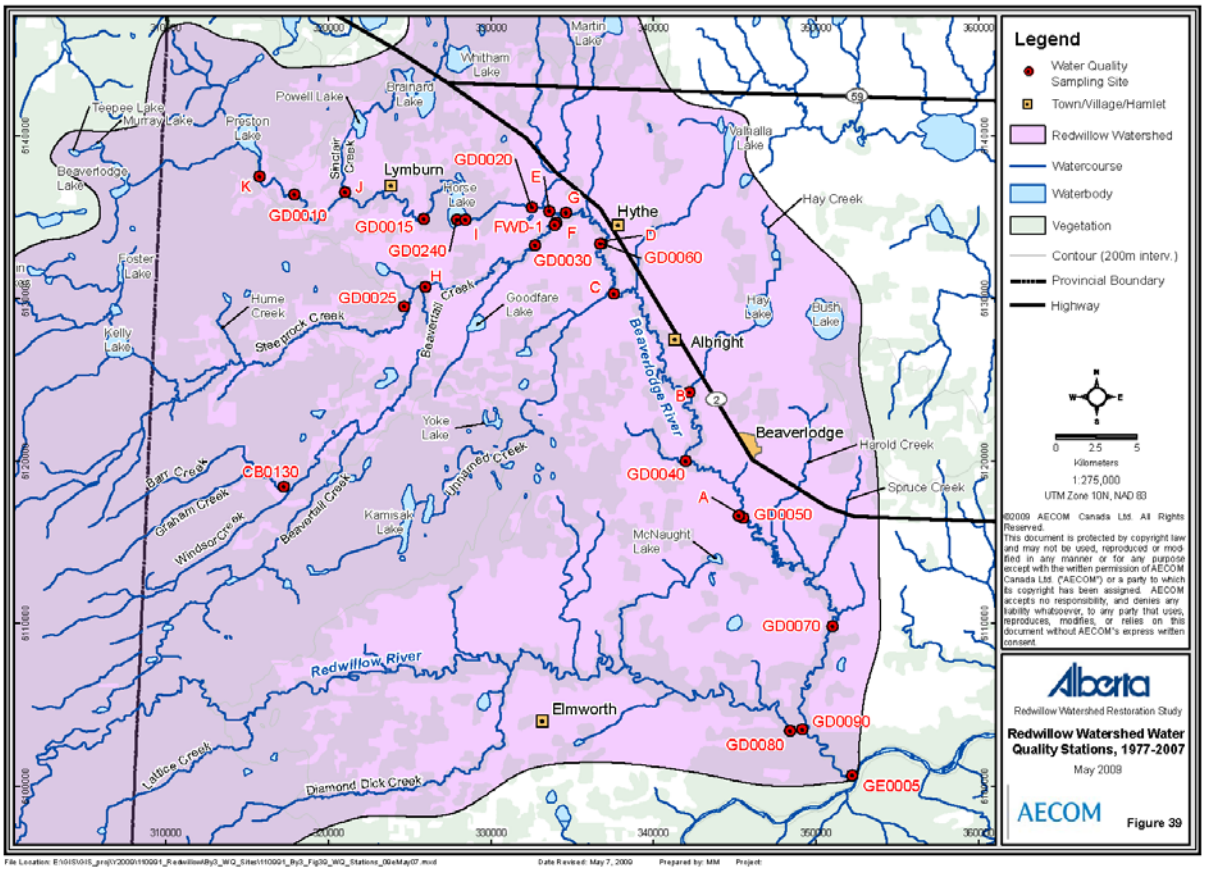


*Figure 1. Water quality sampling sites in the Redwillow Watershed. from McGurk et al. 2009. They suggest GD0010, GD0020, GD0025, GD0030, GD0040, GD0060, GD0070, GD0080 and GD0090 as sites for a water quality monitoring program.*

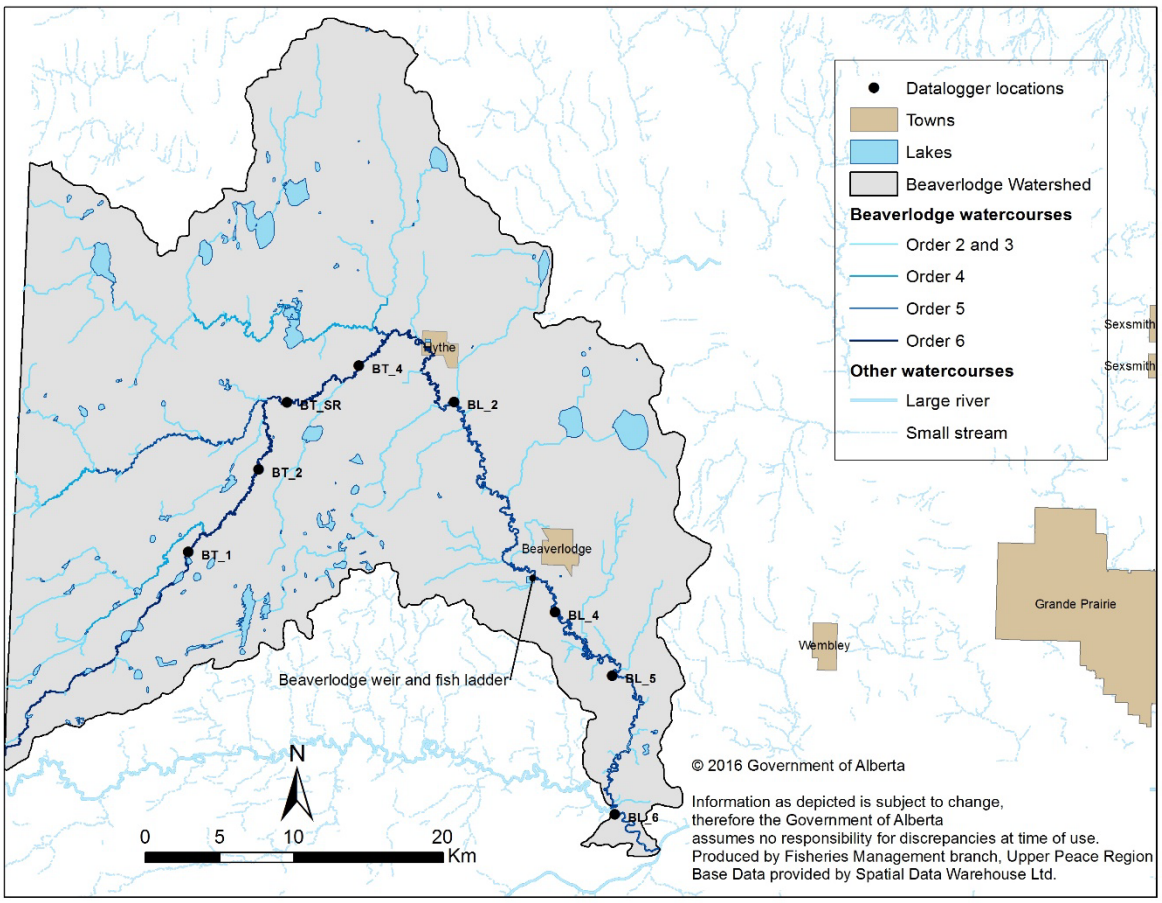


*Figure 2. Alberta Environment and Parks temperature monitoring locations in the Redwillow Watershed.*

temperature and dissolved oxygen at various locations throughout the Redwillow Watershed.

Previous telemetry work by Alberta Conservation Association has provided an understanding of Arctic Grayling (*Thymallus arcticus*) habitat, their migration patterns and generalized spawning areas. (Tchir et al., 2003). Concerns about the degraded state of the watershed as evidenced by the extirpation of Arctic Grayling, brought many organizations together to pursue watershed restoration. The Mighty Peace Watershed Alliance led this process, including restoration of fish habitat connectivity in the Redwillow Watershed by addressing the seasonal fish passage barrier caused by the weir on the Beaverlodge River (Redwillow Watershed Restoration Project Team, 2015). The Town of Beaverlodge installed the weir to maintain water levels to support municipal water withdrawals. Since the completion of the natural passage channel design in 2018, Matrix Solutions Ltd. has been monitoring fish passage at the Beaverlodge weir and monitored in-situ water quality (Table 1).

An improvement in water quality parameters in recent years, such as dissolved oxygen, has indicated that fish habitat is improving (Table 1; Figure 3). Nevertheless, several questions remain such as

- 'Is the recorded increase in dissolved oxygen due to higher than average water flows in 2018 and 2019?'

- 'Or are the improvements in DO due to ongoing efforts to restore fish habitat through watershed restoration activities?' (Redwillow Watershed Restoration Project Team, 2015).

*Table 1. Temperature and Dissolved Oxygen data recorded on the Beaverlodge River and tributaries as part of fish passage monitoring.*

| Location | Date | Parameter | Minimum | Maximum | Mean |
|---|---|---|---|---|---|
| D/S Beaverlodge weir[1] | 29/6/2020-8/8/2020 | Temperature (C) | 13.3 | 24.0 | 18.7 |
| | | Dissolved Oxygen (mg/L) | 6.3 | 8.8 | 7.2 |
| Beaverlodge River[2] | 13/5/2019-25/9/2019 | Temperature (C) | 10.0 | 21.9 | 16.0 |
| Beavertail Creek[3] | 13/5/2019-25/9/2019 | Temperature (C) | 8.8 | 20.4 | 14.9 |
| Redwillow River[4] | 13/5/2019-25/9/2019 | Temperature (C) | 6.8 | 21.7 | 14.3 |

[1]Datasonde installed below downstream riffle at Beaverlodge weir
[2] UTM: 11 U 344771E 6118552N
[3] UTM: 11 U 332325E 6133125N
[4] UTM: 11 U 327562E 6106902N

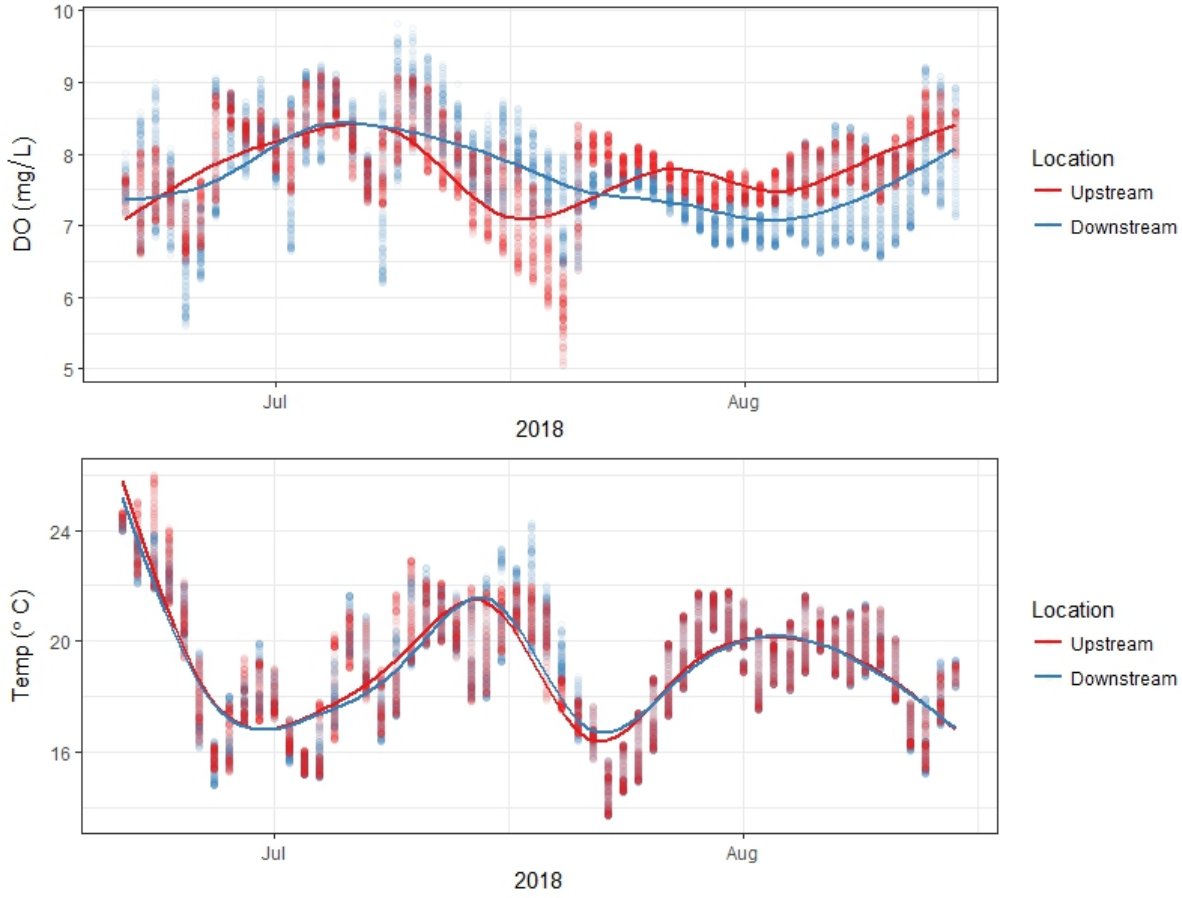


*Figure 3. Data from temperature and dissolved oxygen loggers installed upstream and downstream of the Beaverlodge River weir.*

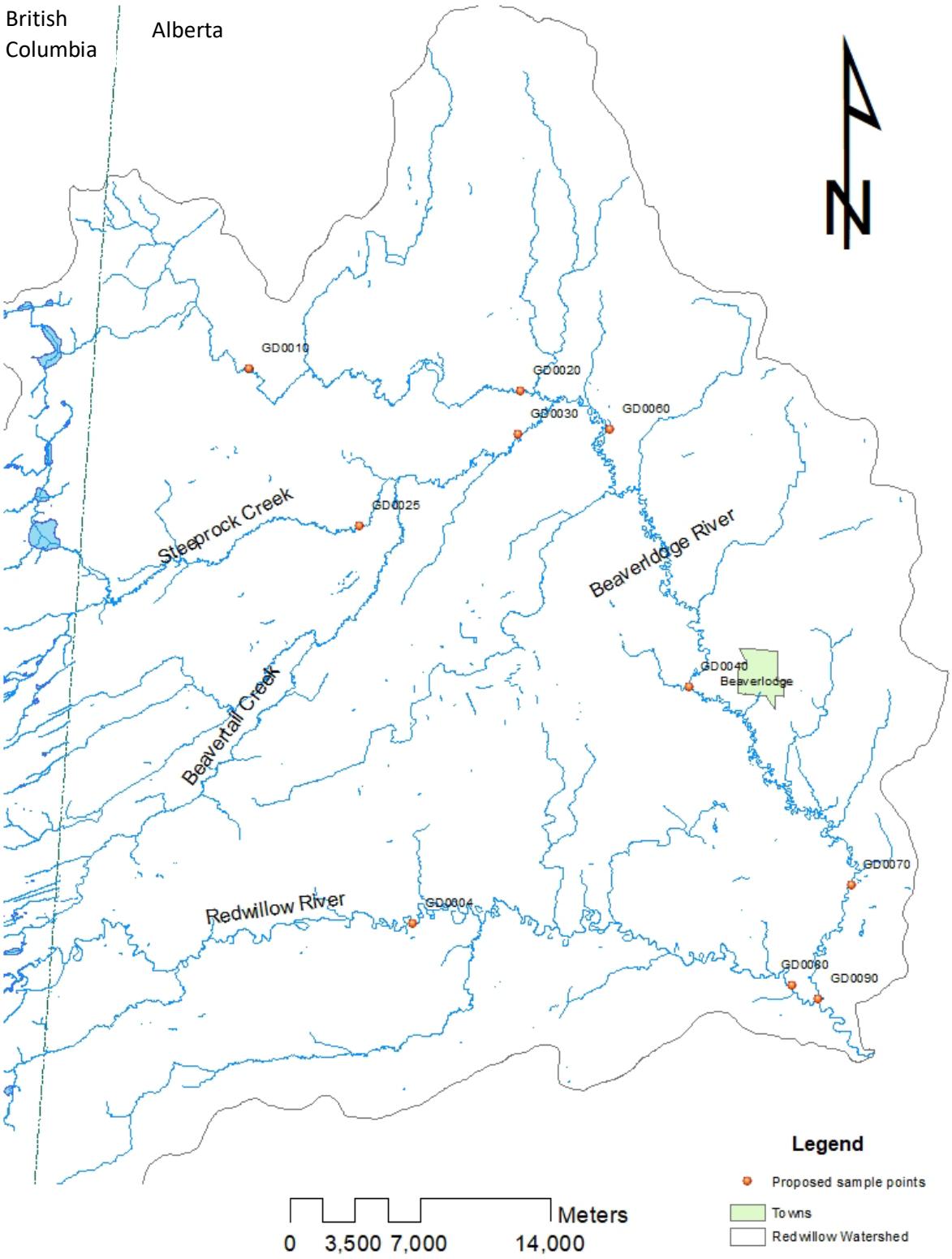


*Figure 4. Map of planned water quality sampling locations in the Redwillow Watershed for winter 2021.*

Furthermore, little is understood about the quality and quantity of winter fish habitat beyond some spot sampling (Norris, 2012). Currently summer water temperature and winter dissolved oxygen levels are the primary of concern for fish survival in the Redwillow Watershed (Adrian Meinke, pers. comm.). Therefore, a dedicated winter water quality sampling program is needed to better assess the state of winter fish habitat in the Redwillow Watershed.

Planned monitoring locations: Based on the recommendations of the AECOM report (2009) and the general alignment with other sampling programs, the following sites were identified for sampling. Within the Beaverlodge River, the following sites on the mainstem of the Beaverlodge River from upstream down toward the confluence with Redwillow River were selected: GD0010, GD0020, GD0040, GD0060, GD0070 and GD0090. Two tributaries to the Beaverlodge River were selected - GD0030 on Beavertail Creek and GD0025 on Steeprock Creek. On the mainstem of the Redwillow River an upstream site, GD004, and a site close to the confluence with Beaverlodge River, GD0080, were chosen (Figure 4). GD004, was selected not based on the recommendations of AECOM report (2009) but to provide a better understanding of the upstream Arctic Grayling spawning habitat (Tchir et al., 2003) and water quality in the Redwillow River.

Monitoring schedule: Two sondes were available for this program and, monitoring was intended to occur concurrently at two sites for 10 days. The actual schedule varied and was dictated by field conditions. At several sites it was not possible to appropriately deploy sondes due to the lack of water, i.e., the ice reached to or almost to the substrate.

Monitoring parameters: Temperature, dissolved oxygen and pH were measured. The intent of this project is to better understand winter dissolved oxygen concentrations and to help direct future efforts to improve and restore fish habitat in the Redwillow Watershed.

Datasondes (Figure 5) are a powerful tool in water quality monitoring, where sensors to measure multiple parameters are housed in one unit and can be deployed for extended periods of time to take readings at set intervals. These were deployed to make continuous measurements at 15 minute


*Figure 5. Photo of an Aqua TROLL 600 Multiparameter Sonde retrieved from https://in-situ.com/us/aqua-troll-600-multiparameter-sonde.*

intervals over the length of deployment (8-10 days). A general approach of upstream to downstream was used to with intent of identifying the best overwintering habitat for Arctic Grayling in this watershed. Previous work (McGurk, Michael; Froese, M; Quach, M; Seward, 2009; Norris, 2012) has identified hypoxic or anoxic conditions in the upper watershed, so it was anticipated that the best reaches for winter habitat were at the low end of the watershed. The sondes used were Aqua TROLL 600 Multi-parameter sondes (https://in-situ.com/en/aqua-troll-600-multiparameter-sonde). Calibration was done according to the manufacturer's specification. Holes were made in the ice and the sondes were

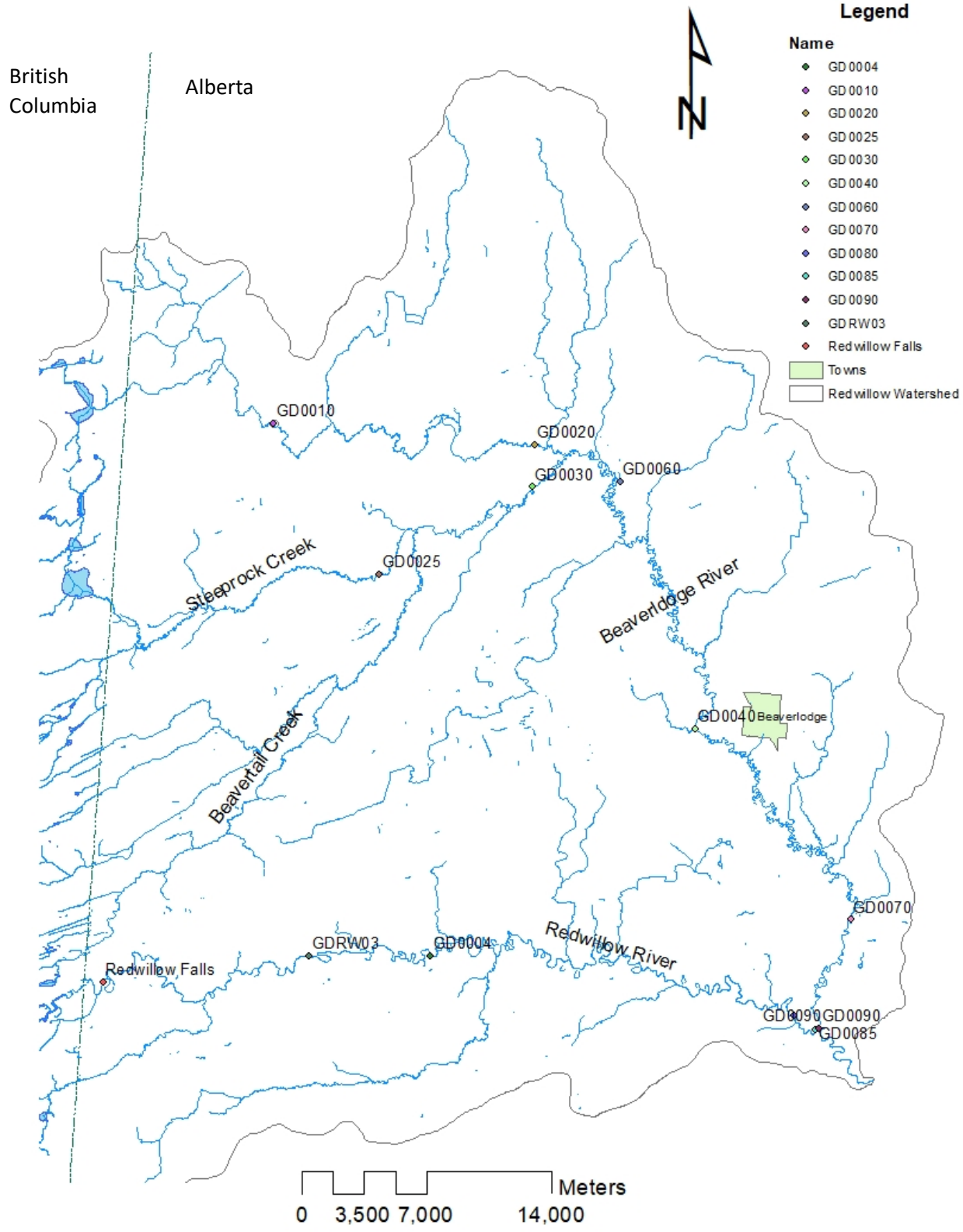


*Figure 6. Map of sites visited during the winter 2021 water quality sampling in the Redwillow Watershed.*

deployed below the ice. Sondes were deployed inside CPVC pipe to protect the sondes from physical damage due to flotsam or beavers. The sondes and CPVC pipe were secured to an anchor on the bank with aircraft cable.

A YSI ProSolo Digital Water Quality Meter (ysi.com/prosolo) was used to take point measurements when deploying and retrieving the datasondes as a method to verify the accuracy of the datasonde readings. Measurements were also taken where water was present but not of sufficient depth to deploy a datasonde. Calibration of the YSI ProSolo followed the manufacturer's specifications. Between deployments datasondes were transported in a warm vehicle and the YSI probe was also transported in a warm vehicle and calibrations were in the vehicle.

Weather data was accessed from Alberta Climate Information Service (https://acis.alberta.ca/acis/) for two weather stations: Beaverlodge within the Redwillow Watershed and Grande Prairie approximately 40 kilometres to the east. The data from the Grande Prairie station was used because there was not the same historical data for snowpack for the Beaverlodge station and this is next nearest station with this data.

## Results and Discussion:

Overall, dissolved oxygen concentrations (mg/L) were recorded above 6.5 mg/L (Figures 7 -11 & Table 2), which is determined to be suitable for cold water fish later life stages by The Canadian Council of Ministers of the Environment guidelines. Only a single measurement below 6.5 mg/L was recorded (Figure 8 & Table 2). This is also the dissolved oxygen threshold recommended for fish welfare by the Northern River Basin Study (Chambers, 1996) for under ice conditions and the Alberta Chronic guideline for protection of aquatic life (Government of Alberta, 1997). Davies et al. 2019 noticed significant responses in adfluvial Arctic Grayling populations to dissolved oxygen concentration below 4.0 mg/L (Davis et al., 2019), lending support to a dissolved oxygen guideline of 6.5 mg/L for fluvial Arctic Grayling to support robust populations.

Differences between the Aqua TROLL Sonde Rugged Dissolved Oxygen value and the YSI ProSolo dissolved oxygen were within 1.7 mg/L of each other except at GD0010 (Figure 12). At GD0010 large differences of 5.04 and 5.18 mg/L were observed at deployment and retrieval, respectively. A paired T-test of all 5 sites where both the Aqua TROLL Sonde and the YSI ProSolo probe were used (both deployment and retrieval) yielded a p-value of 0.098. Employing a significance level of 0.05, it can be assumed that the accuracy of the devices is similar enough to accept their measurements. Nevertheless, the discrepancy is concerning and occurred at the deployment site with the lowest dissolved oxygen levels.

GD0010 was the farthest upstream location in the watershed and subject to lower flows than sites farther downstream and oxygen levels declined by 2.45 mg/L over the 10-day deployment (Figure 7). Interestingly, this site was also the most degraded in terms of riparian zone health and land use (riparian zone was not fenced and both cow tracks and manure were present on the ice at the time of sampling) and has been previously identified as being an area of lower water quality (McGurk, Michael; Froese, M; Quach, M; Seward, 2009). If the declining dissolved oxygen levels continued, it is possible that by late winter dissolved oxygen would have fallen below 6.5 mg/L. The greatest discrepancy between the device measurements occurred during early winter and colder temperatures, which could have contributed to the discrepancies.

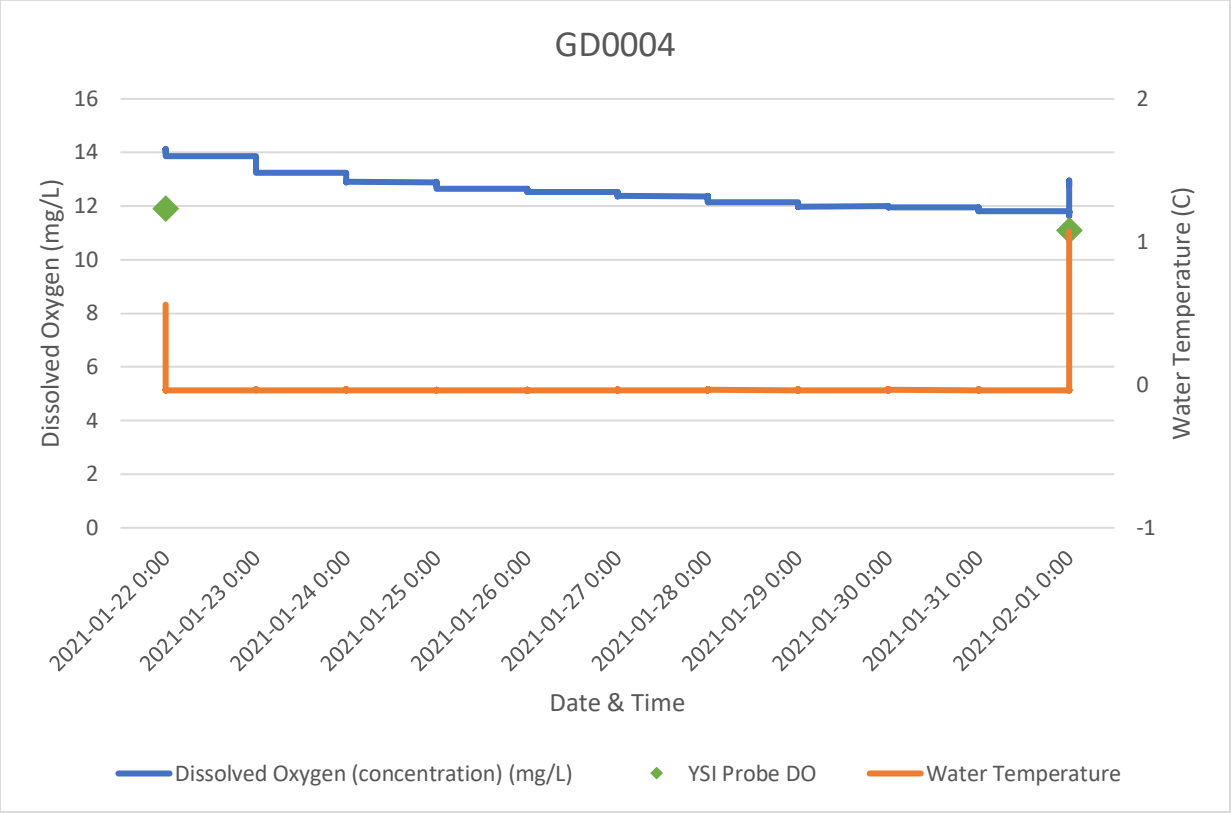


*Figure 7. Dissolved oxygen and water temperature measurements on the Redwillow River at GD0004*

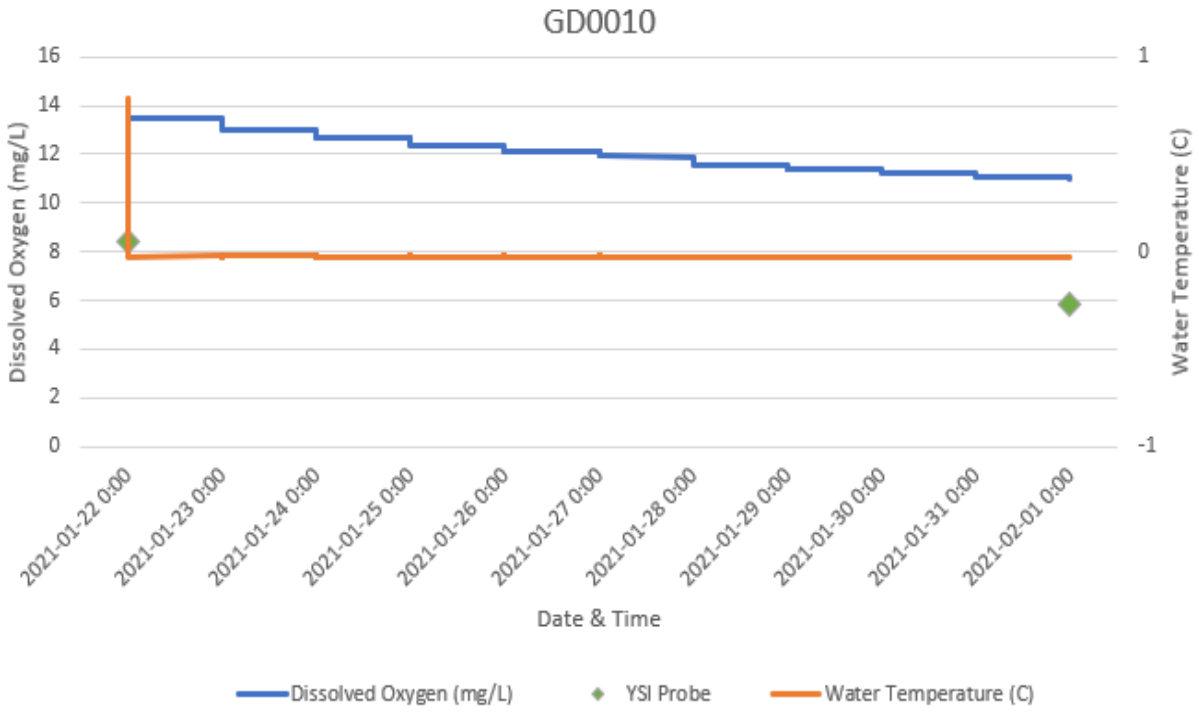


*Figure 8. Dissolved oxygen and water temperature measurements on the Beaverlodge River at GD0010*

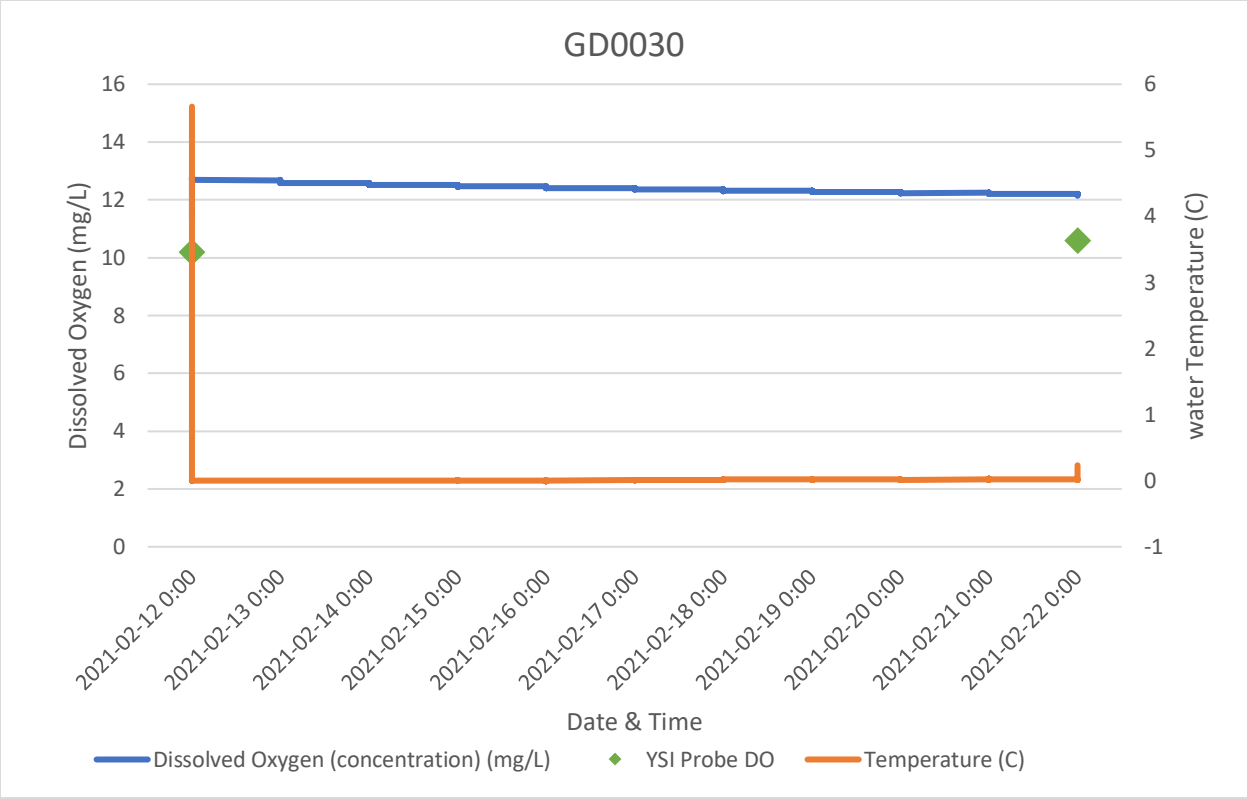


*Figure 9. Dissolved oxygen and water temperature measurements on Beavertail Creek at GD0030*

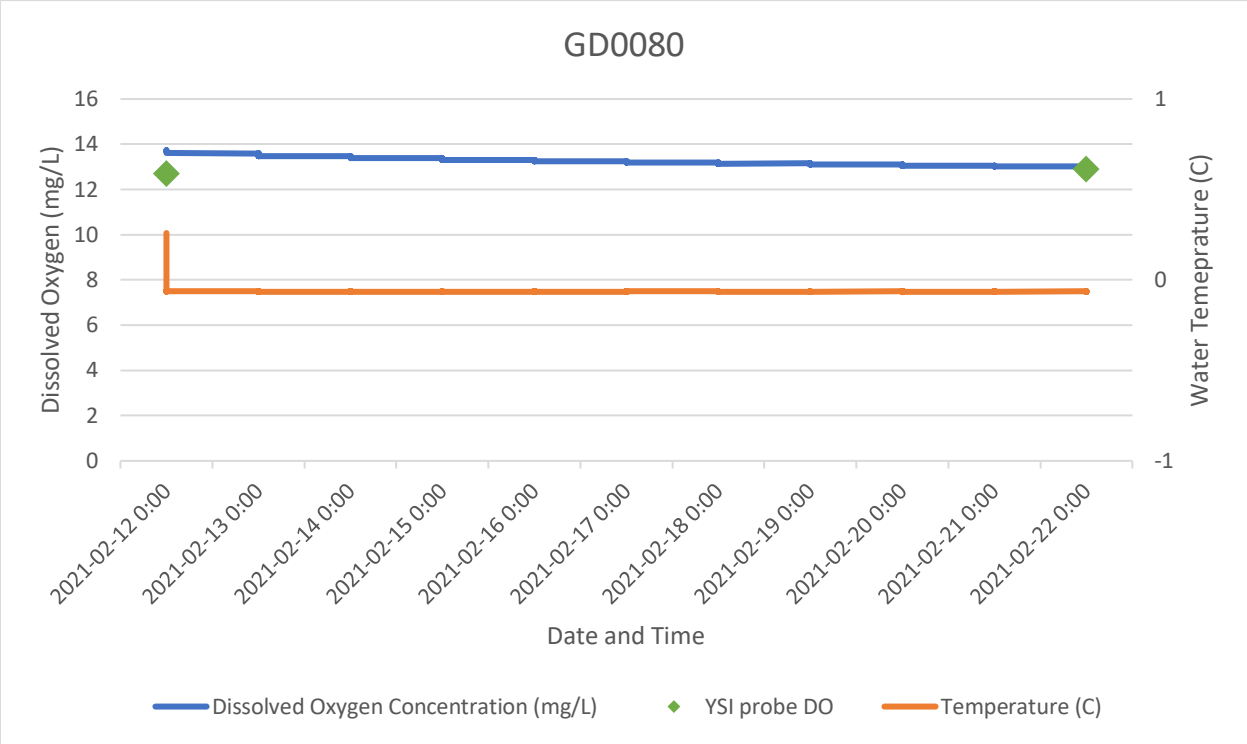


*Figure 10. Dissolved oxygen and water temperature measurements on the Redwillow River at GD0080*

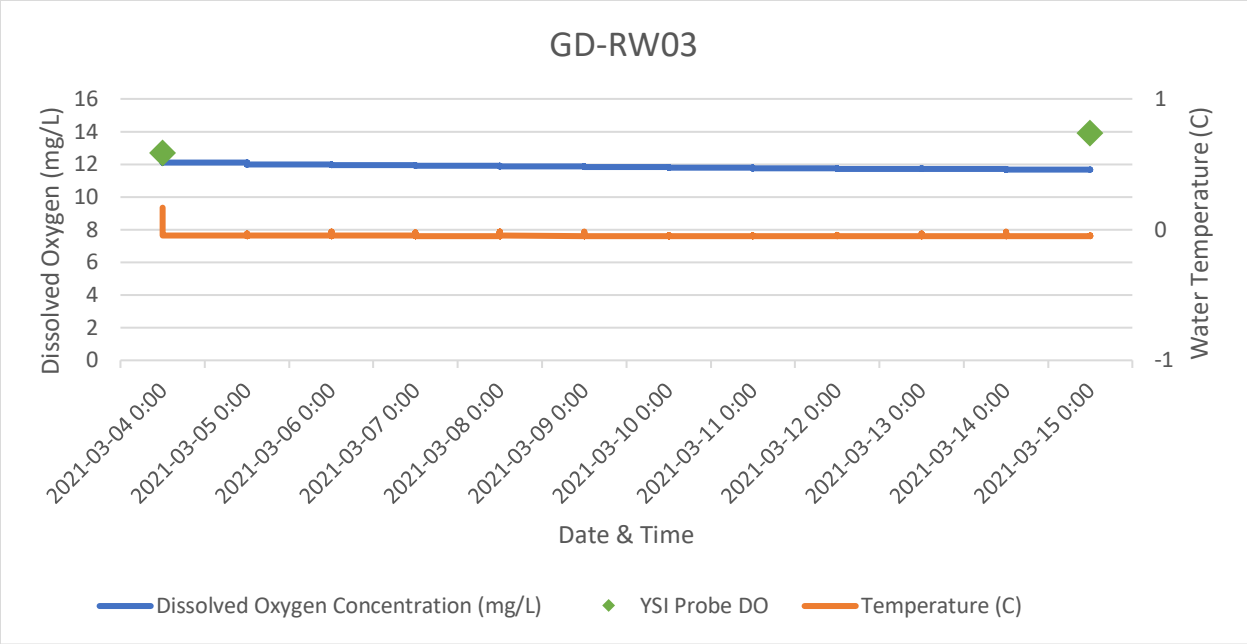


*Figure 11. Dissolved oxygen and water temperature measurements on the Redwillow River at GDRW03*

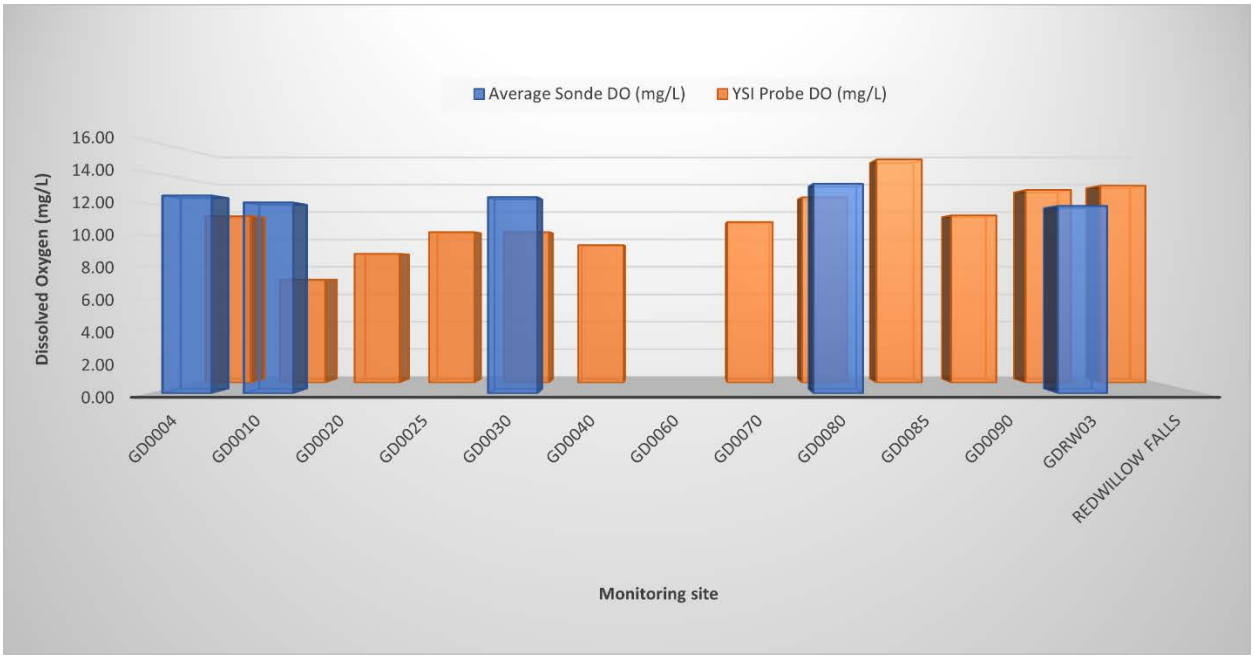


*Figure 12. Aqua Troll sonde and YSI probe dissolved oxygen values measured at Redwillow Watershed winter monitoring sites.*

A broad range of water and ice conditions were encountered. Water depth, measured from substrate to top of water in the auger hole, ranged from 717 cm just below Redwillow Falls to 0 cm at GD0060. GD0060 is the only location where no water quality parameters could be recorded since the Beaverlodge River was frozen to the substrate at this location. Ice depth ranged from 16 cm at a riffle on the Redwillow River (GD0080) to 127 cm on the Beaverlodge River just upstream of the confluence with the Redwillow River (GD0090). A potential limiting factor for winter fish habitat in the Redwillow Watershed is habitat fragmentation due to low under water ice levels (Figure 13). Sondes were not

deployed when there was less than 15 cm of water below the ice due to concerns about the sondes being frozen into the ice and damaged. One site (GD0060) had no water under the ice and at the other sites where sondes could not be deployed, it is conceivable that there were barriers to fish passage due to insufficient water depth. Stranding of fish in stream reaches could lead to anoxia in late winter and subsequent fish mortality. These low water levels reduce the available winter fish habitat in the Redwillow Watershed.

The 11 low snowpack (defined as < 20 cm) cold (defined as < -20 C) days in the 2020-2021 winter is distinctive (Figure 13). Data retrieved from the Alberta Climate Information Service (https://acis.alberta.ca/acis/) for the Grande Prairie weather station from January 1, 1912, until December 31, 2020, documented just 3 years with 10 or more such days. The average number of low snowpack cold days from 1912 – 2020 was 1.8. Further monitoring is required to understand the relationship between snowpack, temperature and potential fish habitat fragmentation due to ice thickness.

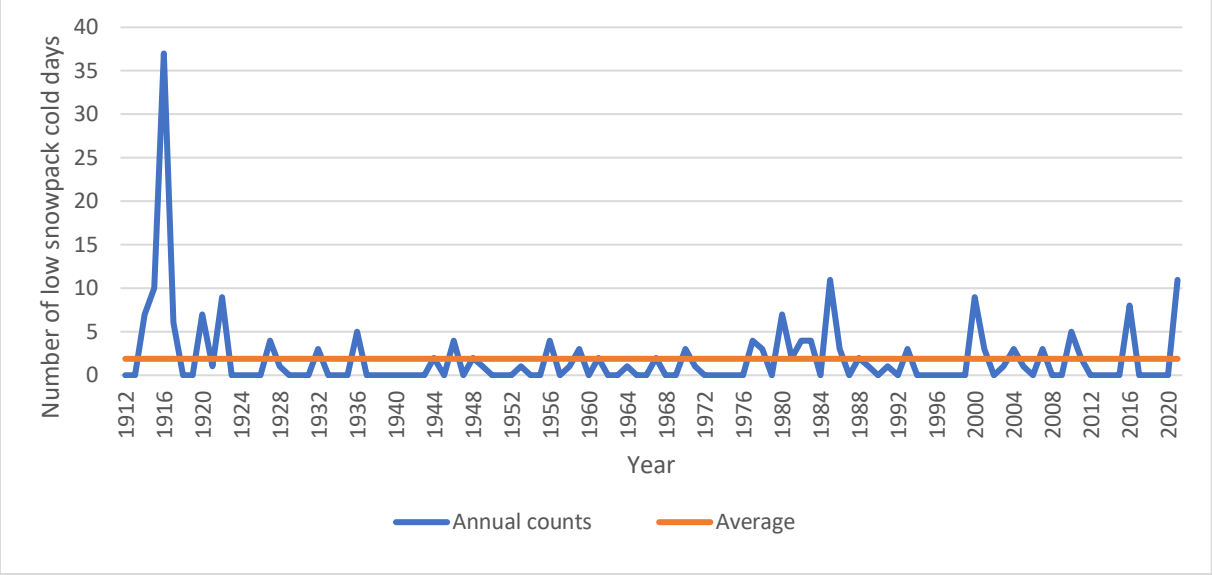


*Figure 13. Plot of number of low snowpack cold days per year. Low snowpack is defined as less than 20 cm and cold as air temperatures below -20 C.*

Water pH was consistently neutral (minimum 6.35, maximum 8.45, mean 6.98) across the watershed (Table 2). This aligns with previous work that has shown the streams waters to be neutral to slightly basic (McGurk, Michael; Froese, M; Quach, M; Seward, 2009).

## Future Direction:

Subsequent years of monitoring are required to develop a better understanding of winter fish habitat through out a range of environmental conditions. It is recommended that more datasondes are secured to enable longer, concurrent deployment in order to provide a completer and more synoptic picture of winter dissolved oxygen levels across the watershed. Future monitoring should examine habitat fragmentation due to low water levels as there is evidence for meso-scale habitat selection in Arctic Grayling induced by oxygen levels (Davis et al., 2020). Habitat

use occurs at different scales. Meso-scale habitat selection can be defined as selection of habitat at temporal and geographic scale that is finer than seasonal migrations and coarser than diel water column position. This could be occurring in the Redwillow Watershed in Arctic Grayling if fish are selecting stream reaches for overwintering based on available dissolved oxygen. The potential habitat fragmentation due to lack of under ice water or dissolved oxygen would be driver of fish location within the watershed and a determinant of available habitat. To better understand this more data on winter water quality greater spatial and temporal resolution is needed. In particular, the relationship between ice thickness and temperature and snowpack needs to be better understood.

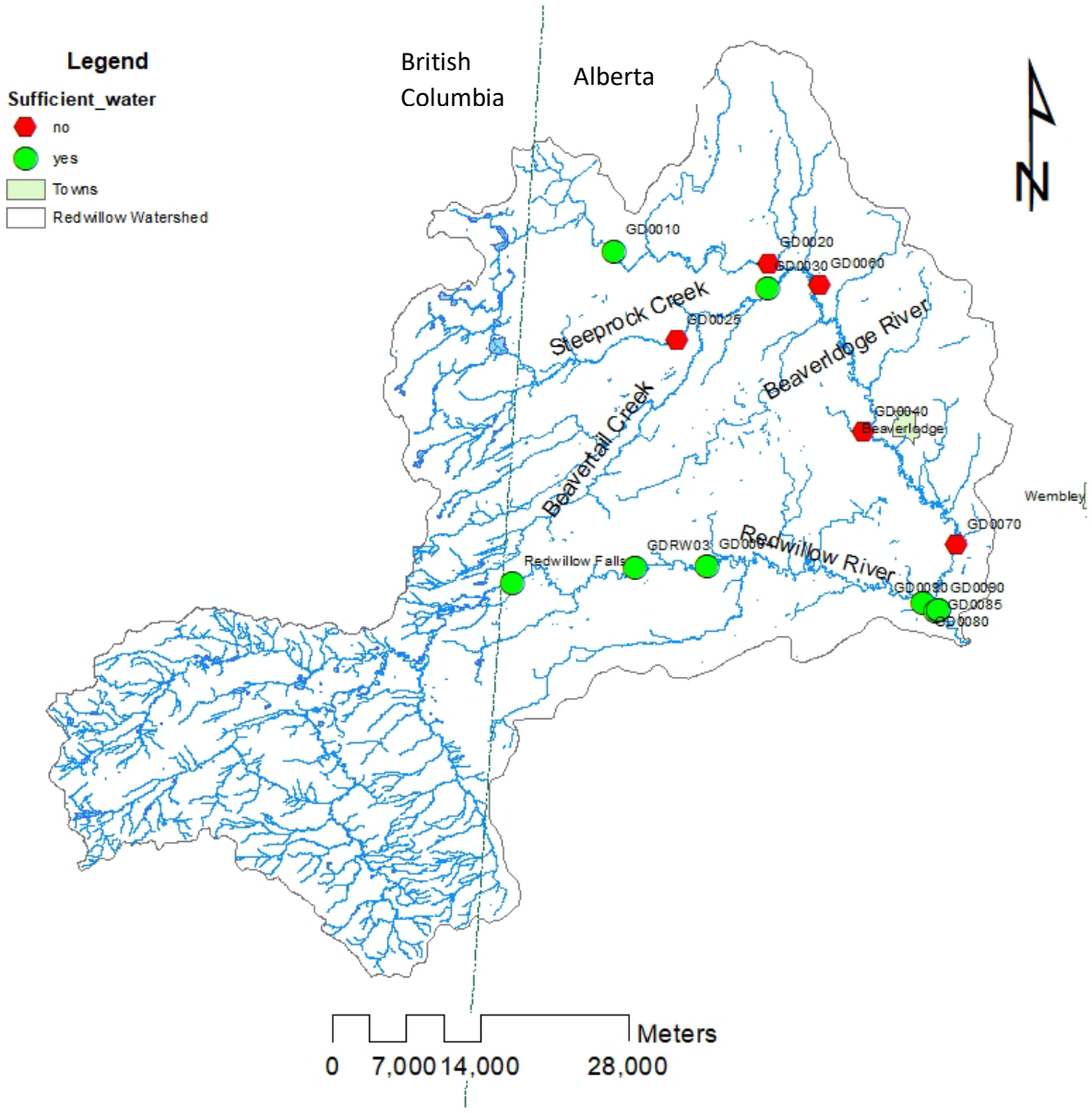


*Figure 14. Map showing Redwillow Watershed winter water quality sampling sites and whether there was sufficient water under the ice to deploy sondes.*

*Table 2. Summary statistics for all sites visited during Redwillow Watershed winter 2021 water quality monitoring.*

| | GD0004 | GD0010 | GD0020 | GD0025 | GD0030 | GD0040 | GD0060 | GD0070 | GD0080 | GD0085 | GD0090 | GD0090 | GDRW03 | Redwillow Falls |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DO (mg/L) | | | | | | | | | | | | | | |
| Mean | 12.51 | 12.07 | | | 12.40 | | | | 13.25 | | | | 11.84 | |
| Minimum | 11.63 | 10.98 | | | 11.31 | | | | 12.99 | | | | 11.67 | |
| Maximum | 14.13 | 13.67 | | | 12.80 | | | | 13.74 | | | | 12.17 | |
| YSI Probe | | | | | | | | | | | | | | |
| Average | 11.50 | 7.10 | 8.90 | 10.40 | 10.40 | 9.50 | | 11.10 | 12.80 | 15.40 | 9.90 | 13.20 | 13.30 | 13.60 |
| Minimum | 11.10 | 5.80 | | | 10.20 | | | | 12.70 | | | | 12.70 | |
| Maximum | 11.90 | 8.40 | | | 10.60 | | | | 12.90 | | | | 13.90 | |
| Temp (C) | | | | | | | | | | | | | | |
| Mean | -0.03 | -0.02 | 0.00 | 0.20 | 0.02 | 0.20 | | 0.10 | -0.06 | -0.10 | 0.00 | -0.10 | -0.04 | 0.00 |
| Minimum | -0.04 | -0.03 | | | -0.01 | | | | -0.07 | | | | -0.05 | |
| Maximum | 1.07 | 0.78 | | | 5.66 | | | | 1.39 | | | | 0.17 | |
| pH | | | | | | | | | | | | | | |
| Mean | 7.44 | 7.03 | | | 7.32 | | | | 6.40 | | | | 6.73 | |
| Minimum | 7.21 | 6.80 | | | 6.83 | | | | 6.35 | | | | 6.68 | |
| Maximum | 8.45 | 7.97 | | | 8.77 | | | | 6.49 | | | | 6.93 | |
| Water (cm) | | | | | | | | | | | | | | |
| Snow depth | 11.0 | 10.2 | 2.0 | 1.0 | 12.7 | 3.0 | 4.0 | 16.5 | 19.7 | 5.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| Water depth below ice | 70 | 148 | 20 | 7 | 74 | 25 | 0 | 11 | 29 | 39 | 32 | 23 | 22 | 690 |
| Ice thickness | 40 | 32 | 62 | 39 | 41 | 69 | 32 | 79 | 16 | 53 | 109 | 127 | 48 | 32 |
| Coordinates (Decimal Degrees) | | | | | | | | | | | | | | |
| Latitude | 55.0791 | 55.34024 | 55.338 | 55.268232 | 55.317 | 55.201 | 55.323 | 55.111 | 55.061029 | 55.05426 | 55.055 | 55.055 | 55.075 | 55.054 |
| Longitude | -119.7 | -119.8716 | -119.6 | -119769191 | -119.6 | -119.5 | -119.6 | -119.3 | -119.3811 | -119.361 | -119.4 | -119.4 | -119.8 | -120 |
| Date | | | | | | | | | | | | | | |
| In | 22/1/2021 | 22/1/2021 | 1/2/2021 | 1/2/2021 | 12/2/2021 | 1/2/2021 | 1/2/2021 | | 12/2/2021 | 15/3/2021 | 22/2/2021 | 15/3/2021 | 4/3/2021 | 4/3/2021 |
| Out | 1/2/2021 | 1/2/2021 | | | 22/2/2021 | | | | 22/2/2021 | | | | 15/3/2021 | |

No datasondes were deployed at GD0020, GD0025, GD0040, GD0060, GD0060 or GD0070 due to lack of water. No sondes were deployed at GD0090 due to ice thickness, but 2 point samples were collected, and no datasonde was deployed at Redwillow Falls due to concerns about loss of equipment.

## Acknowledgements

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