OPUHA WATER LTD
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Quarterly Water Quality Report

January 2023 to March 2023

Key Findings

- Rain events and associated increased inflows resulted in elevated **turbidity** in Lake Opuha with turbidity values above 200 NTU recorded.
- A **cyanobacteria** health warning was issued for Lake Opuha in March 2023 due to scums of *Woronichinia naegeliana.* No cyanobacteria toxins have been detected.
- **Turbidity** within the Lake Opuha tributaries increased at various times. which did not correspond with rain events. A slip in the catchment of Station Creek caused increased turbidity within the creek.
- An artificial fresh released by Opuha Water Limited (OWL) into the Opuha River improved water clarity. **Black disc** (water clarity) readings increased following the fresh, with a decrease in **volatile suspended solids** (typically associated with algae). The artificial fresh removed **cyanobacteria** and **didymo** from the river rocks at various locations in the river, leading to better water clarity.
- Monitoring in the Kakahu River continued and showed **visual water clarity** decreasing downstream of the discharge and **suspended sediment concentration** increasing immediately downstream of the discharge.
- OWL is developing workplans with NIWA, the University of Canterbury, Cawthon Institute and environmental consultants to better understand water quality and sediment processes in Lake Opuha and its catchment, and in the Kakahu River.

Introduction to Opuha Water's Quarterly Water Quality Report

Water quality is monitored on a quarterly to monthly basis at Lake Opuha and several waterways throughout the Opuha Scheme and wider Opihi catchment. Opuha Water Ltd (OWL) has several water quality monitoring programs that focus on different areas of interest, such as Lake Opuha and its tributaries, the Upper Opihi River and its tributaries, the Opuha River and lower Opihi River, the Te Ana Wai River and the Kakahu River.

Water samples are collected and analysed for nitrogen, phosphorus, chlorophyll-a, iron, manganese, heavy metals, pesticides, *E. coli*, cyanobacteria, water clarity, dissolved oxygen, pH and conductivity. River surveys for benthic periphyton (material attached to the surface of rocks in the water) are also undertaken to better understand river health and to quantify the coverage of cyanobacteria and nuisance algae. The specific parameters analysed at each site depends on the objectives of the individual sampling programs.

OWL reviews the data on a monthly basis to identify any significant changes in water quality throughout the scheme and produces a quarterly report for shareholders and stakeholders.

The objective of this report is to highlight interesting data observed during the quarter for OWL's water quality monitoring programs, and to track short-term changes. A more in-depth investigation of the water quality data – such as trend analysis, statistical analysis and comparison to guidelines – will be undertaken in OWL's Annual Water Quality Report.

Additional information regarding sampling sites is given in *Appendix A – Sampling Locations.*

Lake Opuha

Continuous water quality monitoring occurs at Lake Opuha via sensors located on, or close to, the lake tower. Sensors measure dissolved oxygen, conductivity, turbidity and temperature close to the lake surface (5m below the surface) and at depth (close to the bottom of the lake). Water quality samples are also collected at the lake and sent to a laboratory for analysis. This type of sampling is undertaken for monitoring cyanobacteria, chlorophyll-a, total nitrogen and total phosphorus. The chlorophyll-a, total nitrogen and total phosphorus data is combined to produce a lake health metric called the Trophic Level Index (TLI).

The water quality parameters of interest for the 2023 January – March period are **turbidity** and **cyanobacteria.**

Turbidity is a water quality parameter that is easily measured and gives insight into the amount of suspended sediment in a waterway and the visual clarity of the water. Increased turbidity generally corresponds to decreased visual water clarity. Turbidity within Lake Opuha is typically below 5 NTU, unless there is a rain event within the catchment. Figure 1 illustrates the turbidity in Lake Opuha from 1 January 2023 to 31 March 2023 and shows that there have been five rain events that have resulted in turbidity within the lake increasing above 20 NTU.

Turbidity increases in the lake at the surface (—) and at depth (—) during rain events. The greatest increase in turbidity (decrease in water clarity) occurs at depth, most likely due to inflows travelling along the bottom of the lake and not mixing with the water at the top of the lake. The increased turbidity in the lake has implications for the supply of water to the Kakahu Irrigation Scheme as high turbidity water (low water clarity) flows from the lake into the Opuha River.

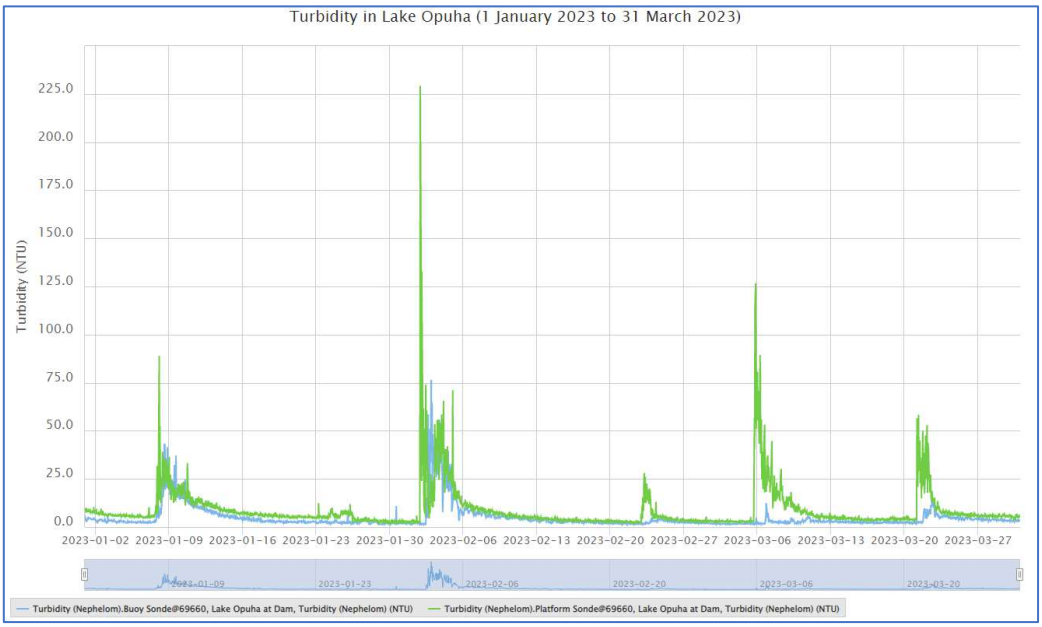


Figure 1: Turbidity in Lake Opuha at surface (—) and depth (—) from 1 January 2023 to 31 March 2023.

OWL is currently working with NIWA, research scientists from the University of Canterbury and environmental consultants to develop a workplan to better understand the source of sediment coming into Lake Opuha, and also what happens to the sediment once it enters the lake (*i.e.,* Where does it deposit? How long does it take for sediment to settle? Is sediment remobilised within the lake during increased inflows?). It is anticipated that this work will give OWL a better understanding of sediment dynamics within the lake and what factors can be controlled to improve water clarity.

On 1 March 2023, a **cyanobacteria (blue-green algae)** health warning was issued by Community and Public Health for Lake Opuha, due to the presence of scums that were identified as *Woronichinia naegeliana* (https://www.lawa.org.nz/explore-data/canterbury-region/warnings-and-alerts/lake-opuha-cyanobacteria-warning/). Cyanobacteria scums were observed at Bennetts Recreation Reserve Boat Ramp, the Dam Boat Ramp

and along the dam wall. In response to the presence of these scums, sampling of the Opuha River was done to determine if cyanobacteria was being discharged into the Opuha River. Cyanobacteria levels in the Opuha River remained low throughout the warning period. Testing by Environment Canterbury (ECan) showed there were no cyanobacteria toxins in Lake Opuha.

The health warning for Lake Opuha was still in place at the start of May 2023. OWL will continue visual inspections and water monitoring in Lake Opuha and the Opuha River until the health warning is removed.

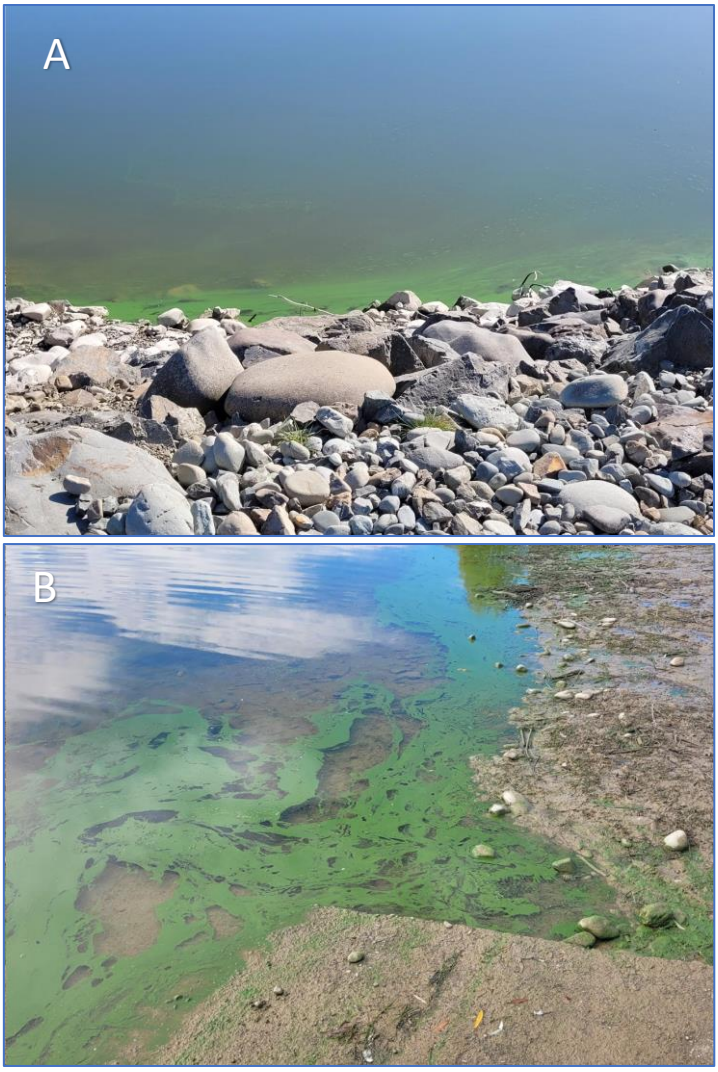


Figure 2: Cyanobacteria (blue-green algae) scums in Lake Opuha at A) along Dam Wall and B) Bennett's Recreation Reserve Boat Ramp.

During the coming months, OWL will meet with internationally recognised cyanobacteria researchers from the Cawthon Institute (https://www.cawthron.org.nz/) to determine how best to manage cyanobacteria in Lake Opuha. We will investigate options to minimize cyanobacteria health warnings in the lake (*i.e.,* What further monitoring, or studies could be done? Could the aeration system be operated to reduce cyanobacteria formation?).

Tributaries of Lake Opuha

Water Quality monitoring is undertaken in the North and South Opuha Rivers and Ribbonwood, Station, and Deep Creeks. Monitoring in the North and South Opuha Rivers commenced in 2019, whereas monitoring in Ribbonwood, Station and Deep Creeks started in February 2022. The water quality parameter of interest for the January – March 2023 period is **turbidity**.

During rain events in the catchment above Lake Opuha, the **turbidity** of the tributaries increases as sediment washes into rivers. However, there were occasions during the January – March 2023 period when turbidity of some of the tributaries increased but there was no corresponding rain event. It is possible this turbidity was caused by land-use activities or maintenance works within the river.

Figure 3 shows the turbidity in the South and North Opuha Rivers measured during January, February and March 2023. Sampling is done one day per month, so the results illustrate what occurred on that particular day. All turbidity values were reasonably low during the January – March period, except for the South Opuha River, which recorded a turbidity of 12.9 NTU in February. A turbidity sample collected approximately 6.5 km upstream of the South Opuha River sampling site returned a value of only 1.1 NTU, indicating that an activity is occurring between these two sampling points that is increasing turbidity within the river (this might either be a land-use input or maintenance works within the river).

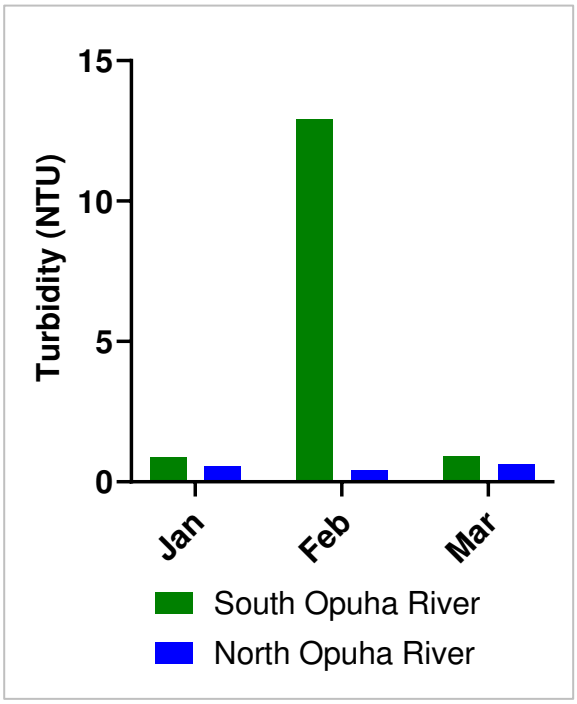


Figure 3: Turbidity in the South Opuha River and North Opuha River for January, February, and March 2023.

Figure 4 shows the turbidity in Ribbonwood, Station and Deep Creeks measured for January and March 2023. No sampling was done in February. All turbidity values were reasonably low except for Station Creek, which recorded turbidity values of 117 NTU and 44 NTU for January and March respectively. Station Creek has also looked considerably dirtier than other creeks in the area at various times during the past three months. OWL was notified by ECan that there had been a slip in the Station Creek catchment. Work was done by ECan to clear the slip, however it is likely that increased sediment concentrations within the creek will continue for some time. OWL will continue to monitor the tributaries of Lake Opuha and will discuss turbidity levels within these tributaries in the next quarterly report.

Due to the increase in turbidity in the tributaries of Lake Opuha during rain events, and outside of rain events, OWL is considering installing turbidity sensors in the South and North Opuha Rivers, and Ribbonwood and, Station Creeks; and flow sensors in Ribbonwood and Station Creeks. This would allow estimates of the sediment load

flowing into Lake Opuha and identification of where in the catchment the largest loads of sediment are coming from.

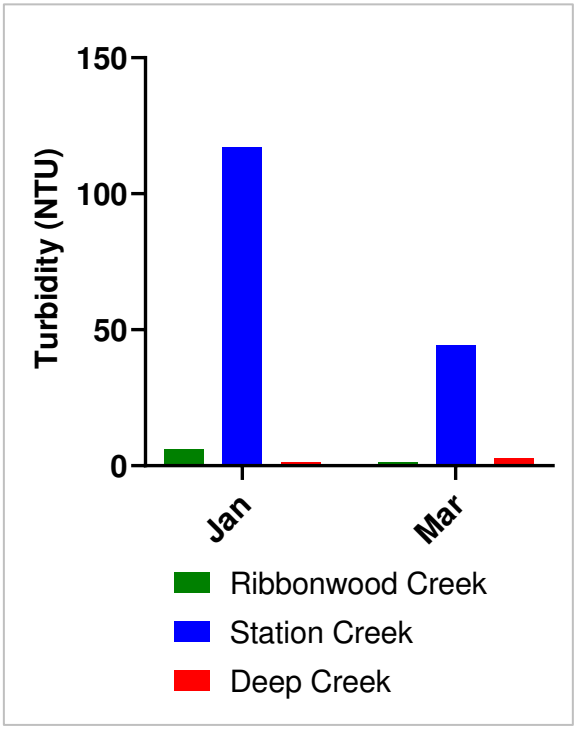


Figure 4: Turbidity in Ribbonwood, Station, and Deep Creeks for January and March 2023.

Upper Opihi River and Tributaries

Monthly water quality monitoring is carried out in the Upper Opihi River and its tributaries. This sampling program started in January 2022 to better understand the water quality in the tributaries and their contribution to the Upper Opihi River. The major tributaries monitored include: Three Springs Culvert, and Wellshot , Hall, Glenfield, Allandale, Strathconan and Coal Streams.

Sampling from January 2023 to March 2023 showed no major anomalies, with data typical of previous months.

Opuha and Lower Opihi Rivers

Monthly water quality monitoring is done in the Opuha River (Downstream Weir, Gorge and Skipton Bridge) and the Lower Opihi River (Raincliff and Pleasant Point). Water quality parameters of interest for January – March 2023 are **black disc (water clarity)**, **total suspended solids**, **volatile suspended solids** and **periphyton**. Data for the Opuha River (downstream of the Downstream Weir, Gorge and Skipton Bridge) will be presented in this section.

In February 2023, OWL released an artificial fresh into the Opuha River to remove nuisance algae from rocks and, potentially, improve water clarity. In the weeks prior to the artificial fresh, algae floating in the water column was observed, which impacted visual water clarity. Removal of nuisance algae from rocks within the Opuha River reduces toxic cyanobacteria, potentially improving the ecological communities of the river and increasing visual clarity, which benefits the Kakahu Irrigation Scheme. The maximum flow at the Downstream Weir during the artificial fresh was ~60cumecs.

Sampling prior to the artificial fresh was done on 22 February 2023. The fresh was released on the evening of 22 February 2023, and sampling after the fresh occurred on 3 March 2023.

Figure 5 compares data at the Opuha River sampling locations (Downstream Weir, Gorge and Skipton Bridge) before and after the fresh. **Black disc** is a measure of visual water clarity; the greater the black disc measurement the better the water clarity. The black disc values in the Opuha River increased on average by 0.76 m after the fresh, with the biggest increase occurring at the Gorge, from 1.17 m to 2.10 m (Figure 5 – A). **Total suspended solids** were

similar for the Downstream Weir and Skipton Bridge before and after the fresh, but there was an appreciable decrease in total suspended solids at the Gorge site from 3.8 g/m^3 to 6.3 g/m^3 (Figure 5 – B). **Volatile suspended solids** is an estimate of the suspended solids in a water that are organic-based, which would include algae in the water column. After the fresh, the volatile suspended solids decreased at all sites to less than the detection limit of 0.5 g/m^3 (*i.e.,* not measurable by the lab), with the biggest decrease observed at the Gorge from 1.70 g/m^3 to <0.5 g/m^3 (Figure 5 – C).

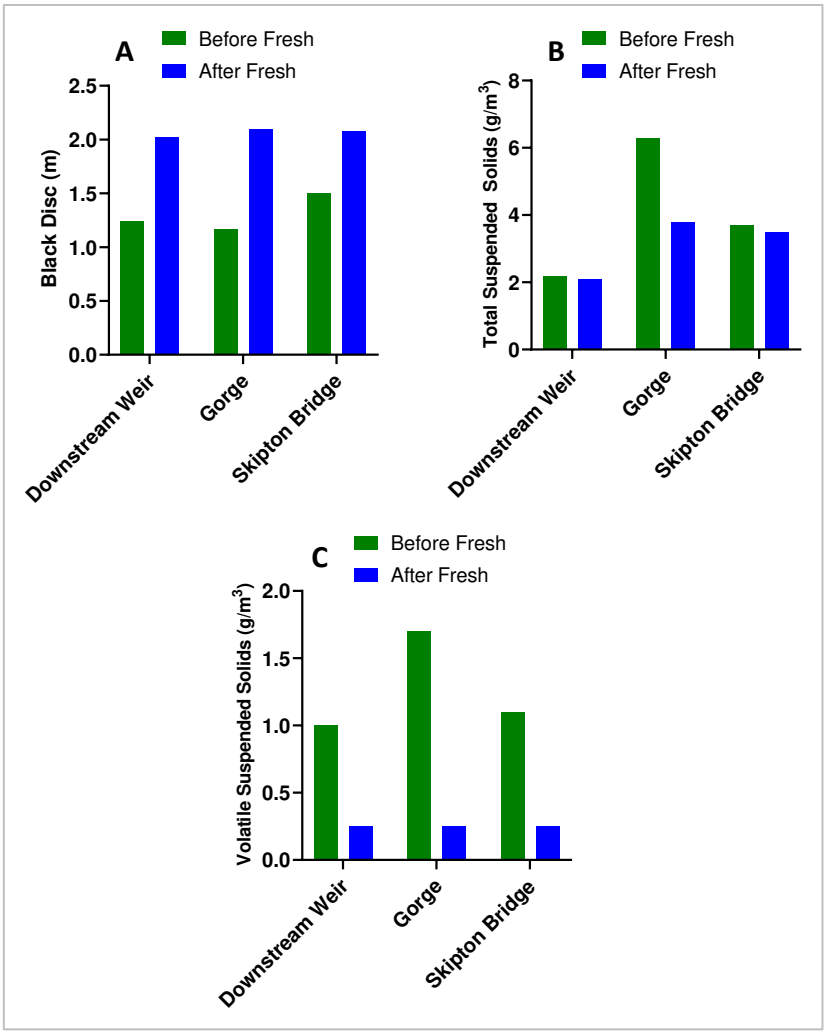


Figure 5: Data for A) black disc, B) total suspended solids and C) volatile suspended solids, before and after the fresh in the Opuha River.

As intended, the artificial fresh also had an impact on **periphyton** within the Opuha River. Periphyton is material that is attached/growing on the surface of rocks in a river and includes filamentous algae, benthic cyanobacteria and didymo. The amount of periphyton within in an area is estimated by looking through an underwater viewer and estimating the percentage coverage of periphyton. There was a small decrease in filamentous algae at the Downstream Weir and Skipton Bridge following the fresh, however there was a small increase in filamentous algae at the Gorge (Figure 6 – A). Cyanobacteria decreased from 19% coverage to 5% coverage at the Gorge, however there was a small increase at the Downstream Weir and Skipton Bridge (Figure 6 – B). A decrease in didymo was observed at all locations with the biggest decrease in didymo occurring at the Downstream Weir from 23% to 8% (Figure 6 – C).

The artificial fresh resulted in an increase in visual water clarity at all sampling locations in the Opuha River. The volatile suspended solids at all sampling locations decreased to less than the laboratory detection limit of 0.5 mg/m^3, indicating that the artificial fresh removed the build-up of nuisance algae and material from the rocks of the Opuha River. This improves visual water clarity, as this material can no longer be remobilised into the water column. This assessment is further supported by the periphyton results, which show that the artificial fresh removed cyanobacteria from the Gorge and didymo from all sampling locations.

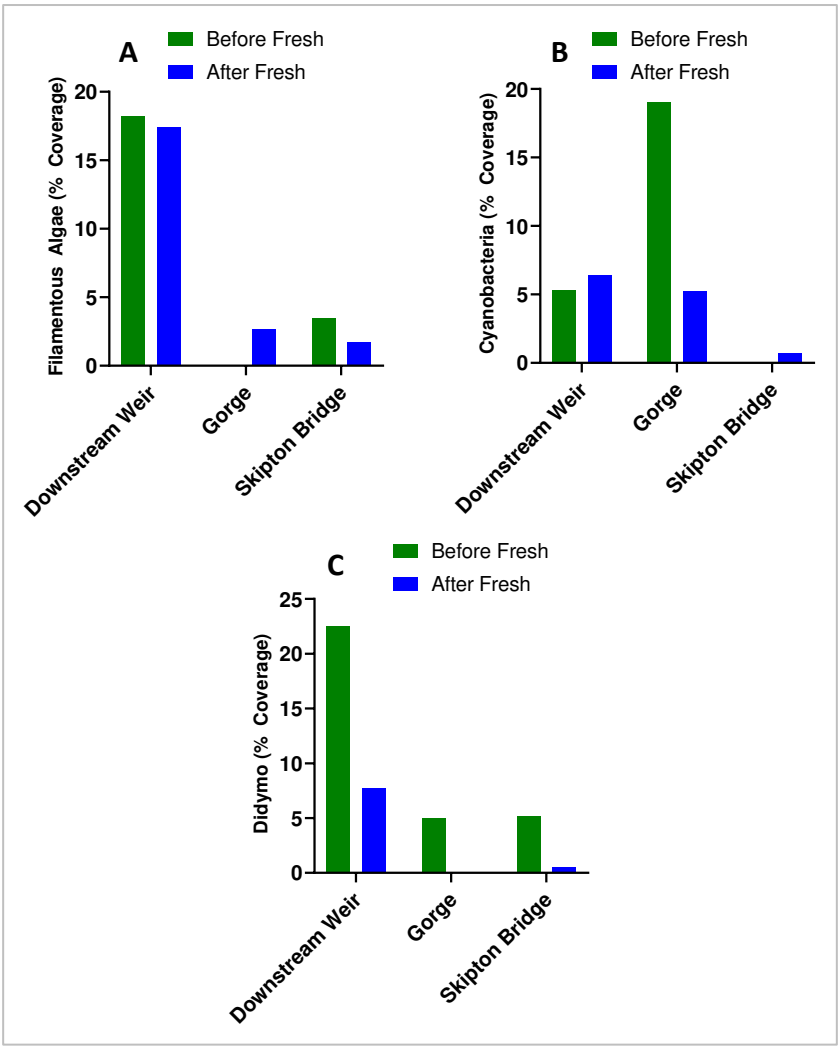


Figure 6: Measurements in the Opuha River before and after fresh for A) filamentous algae, B) cyanobacteria and C) didymo.

Te Ana Wai River

Water Quality monitoring in the Te Ana Wai River started in 2019 and is done at three locations: Albury, Cave and Chisholm Road. ECan undertakes monitoring at a fourth location – Te Ngawai Road Bridge.

Sampling from January 2023 to March 2023 showed no major anomalies with data typical of previous months.

Kakahu River

Monthly water quality monitoring is carried out at multiple locations in the Kakahu River. In January, February and March 2023, an additional sampling location was included in the Kakahu River at the Gorge (Smillie's Property). This report will look at **black disc** (water clarity) and **suspended sediment concentration** data from January to March 2023 at six locations in the Kakahu River. The sampling locations are (from upstream to downstream): Mulvihill Flow Recorder, 30 m Upstream of Discharge, 100 m Downstream of Discharge, Gorge (Smillie's Property), Morrison's Bridge and Winchester Hanging Rock Road Bridge).

All black disc and suspended sediment concentration data for January, February and March 2023 is shown in Figure 7. Note that the detection limit for suspended sediment concentration is 2 g/m^3 and values that are less than the detection limit are indicated as red bars in Figure 7. This means that a suspended sediment concentration value that is <2 g/m^3 can essentially be anywhere between 0 g/m^3 and 1.99 g/m^3.

January 2023 sampling occurred when the pipeline was discharging 850 L/s of Opuha River water into the Kakahu River, which was flowing at 220 L/s. The black disc data shows a decrease in water clarity between the sampling locations upstream and downstream of the discharge. All downstream sampling locations recorded black disc

values around 2 m (range: 2.03 m to 2.23 m), whereas the black disc values upstream of the discharge were 2.45 m (Mulvihill Flow Recorder) and 3.11 m (30 m Upstream of Discharge). The suspended sediment concentration data for January 2023 shows that the highest concentration was recorded 100 m downstream of the discharge (4 g/m^3) whereas all other locations were either at or less than the detection limit of 2 g/m^3.

February 2023 sampling occurred when the pipeline was discharging 1,050 L/s of Opuha River water into the Kakahu River, which was flowing at 50 L/s. The black disc values upstream of the discharge for the Mulvihill Flow Recorder and 30 m Upstream of Discharge sampling locations were 3.21 m and 3.75 m, respectively. The black disc value at the 100 m downstream of discharge sampling location was 1.33 m and steadily increased further downstream: Gorge (1.56 m), Morrison's Bridge (1.93 m) and Winchester Hanging Rock Road Bridge (2.31 m). The suspended sediment concentration data for February 2023 shows that the highest concentration was recorded 100 m downstream of the discharge (5 g/m^3), whereas all other locations recorded values from < 2 g/m^3 to 3 g/m^3.

March 2023 sampling occurred when the pipeline was not discharging water into the Kakahu River; the Kakahu River was flowing at 130 L/s. The black disc values upstream of the discharge point for the Mulvihill Flow Recorder and 30 m upstream of discharge sampling locations were 4.75 m and 5.15 m, respectively. The black disc values at the 100 m downstream of discharge (4.90 m) and Gorge sampling locations (4.75) were similar to the upstream sampling locations, however there was a measurable decrease in black disc for the Morrison's Bridge (3.55 m) and Winchester Hanging Rock Rd Bridge (3.35 m) sampling locations. The suspended sediment concentration data for March 2023 shows that all samples were less than the detection limit of 2 g/m^3.

Collectively, the Kakahu River results from January, February and March 2023 show the following:

- Monitoring over the three months indicates that the discharge has added suspended sediment to the Kakahu River. However, the impact that this sediment, and sediment from other sources within the Kakahu catchment, have on the ecological communities within the river remains unclear.

- There is a decrease in the suspended sediment concentration downstream of the 100 m downstream location, which corresponded with an increase in visual clarity in February, but did not in January (all downstream locations had similar black disc readings in January).
- The decrease in suspended sediment concentration between the 100 m downstream location and other downstream locations *might* indicate that sediment is being deposited in the Kakahu River, but it could also mean that the suspended sediment is being diluted by a surface water inflow or a groundwater inflow. Furthermore, there are likely to be areas throughout the Kakahu River that will be adding and removing sediment from the water column; it is, therefore, difficult to attribute any one source to sediment deposition.
- The black disc results for the two upstream locations (upstream of the discharge point) varied from 8% to 21%, indicating that there are other factors within the Kakahu River and catchment that affect the black disc readings, not just the discharge.
- The March black disc results (no discharge occurring) show a significant decrease between the Gorge (4.75 m) and Morrison's Bridge (3.55 m), indicating something is happening between these two sites contributing to a decrease in visual water clarity.

OWL is planning some work in collaboration with NIWA to understand the sediment sources within the Kakahu River. This might help identify other sediment sources within the Kakahu catchment, in addition to the discharge, that are contributing to the sediment load within the river. Sediment sources might include riverbank erosion, various farming activities, and forestry.

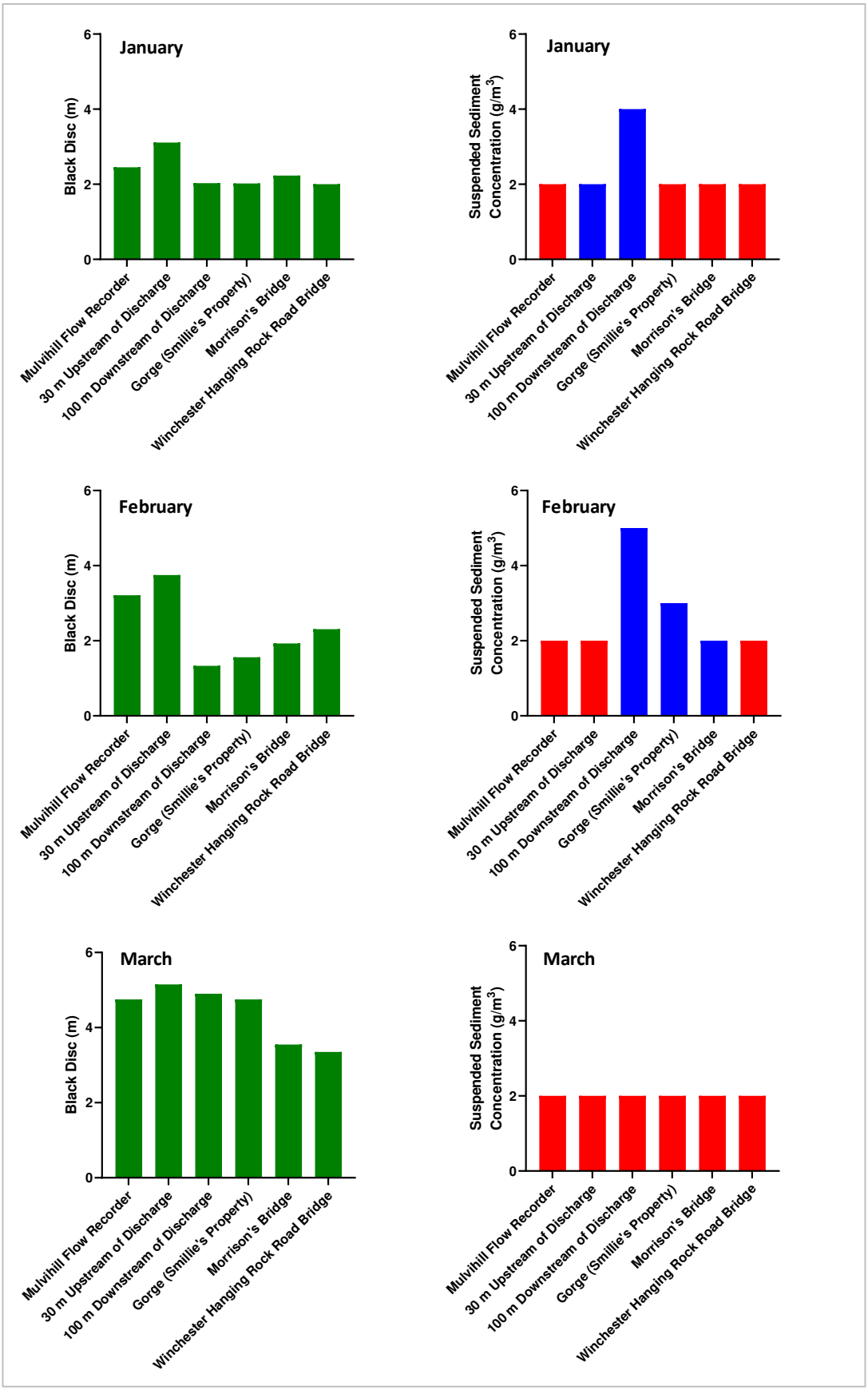
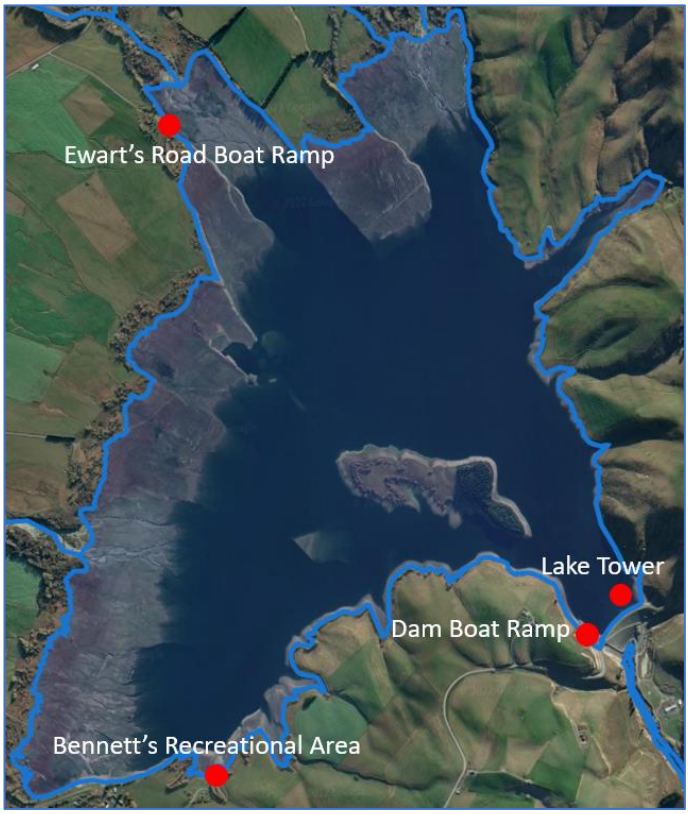


Figure 7: Black Disc and Suspended Sediment Concentration for Kakahu River for January 2023. Red bars for Suspended Sediment Concentration indicate a value that is less than the laboratory detection limit and should be interpreted as a value <2 g/m³.

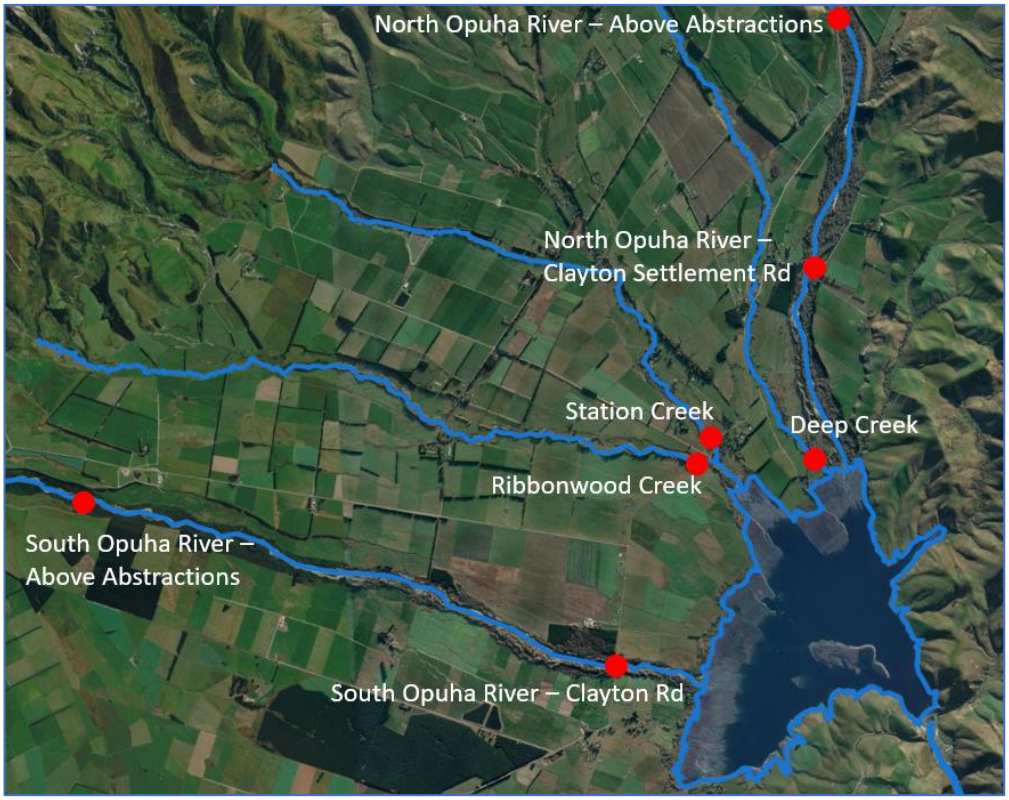
Any questions or feedback regarding the Quarterly Water Quality Report can be directed to Jared Panther (jared@opuha.co.nz; 021 223 7465) or Julia Crossman (julia@opuha.co.nz; 021 535 174).

Appendix A – Sampling Locations

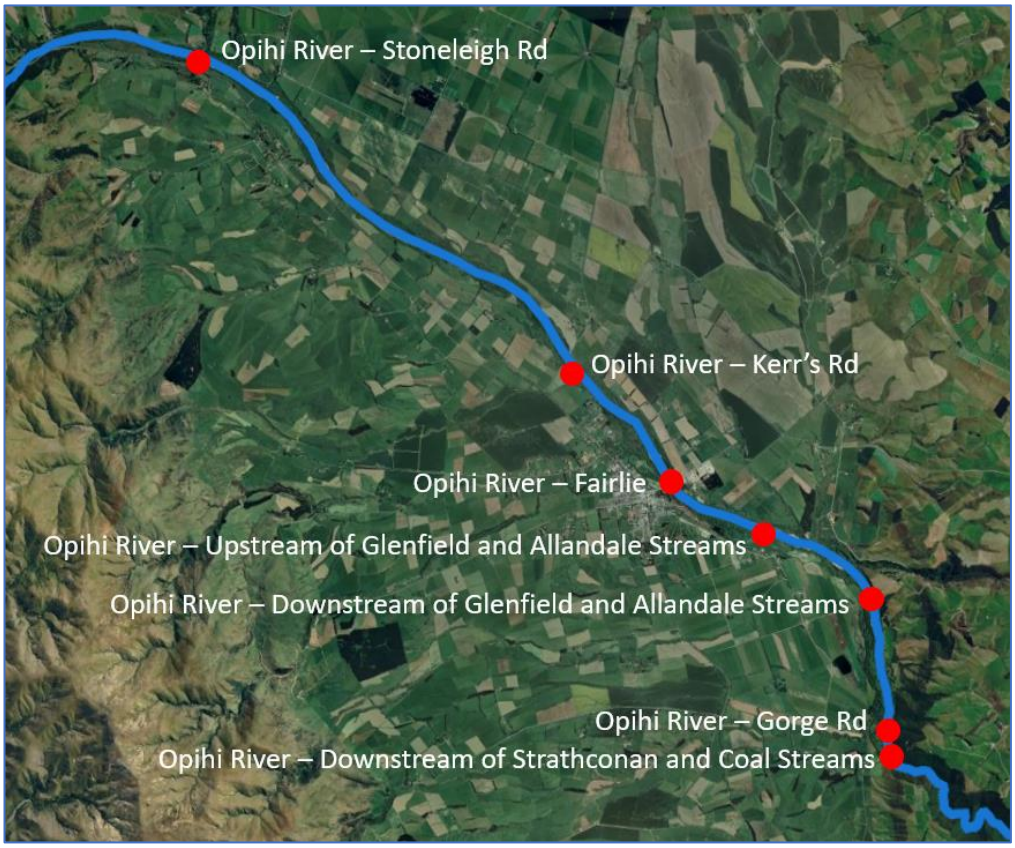
Lake Opuha Sampling Locations



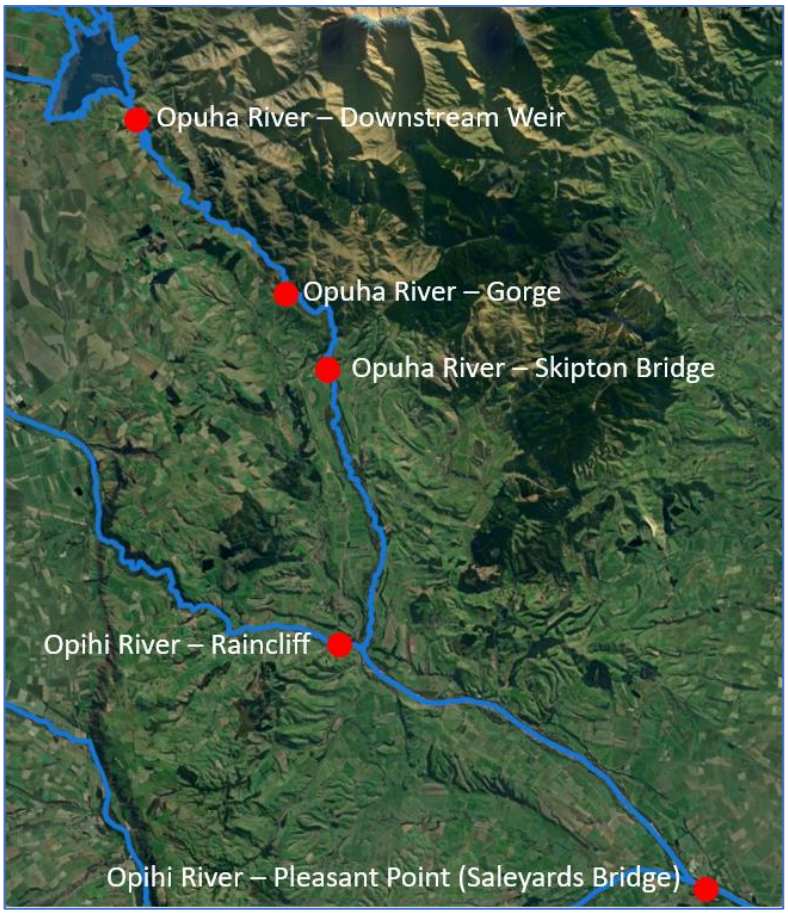
Tributaries of Lake Opuha Sampling Locations



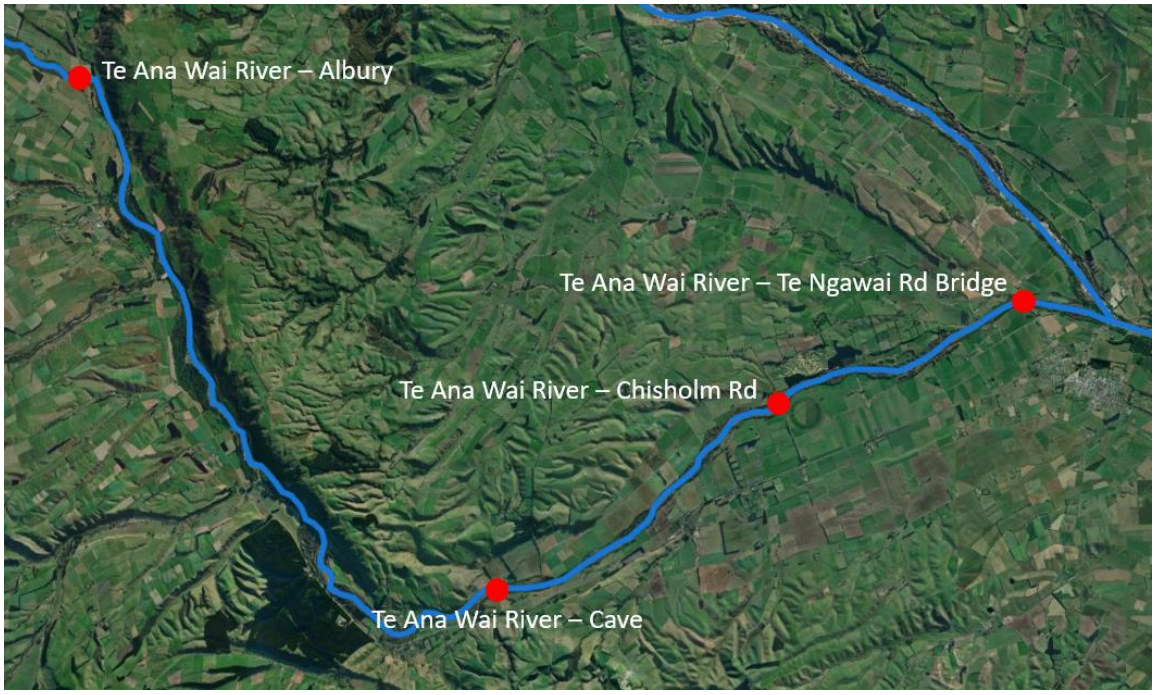
Upper Opihi River Sampling Locations



Opuha River and Lower Opihi River Sampling Locations



Te Ana Wai River Sampling Locations



Kakahu River Sampling Locations