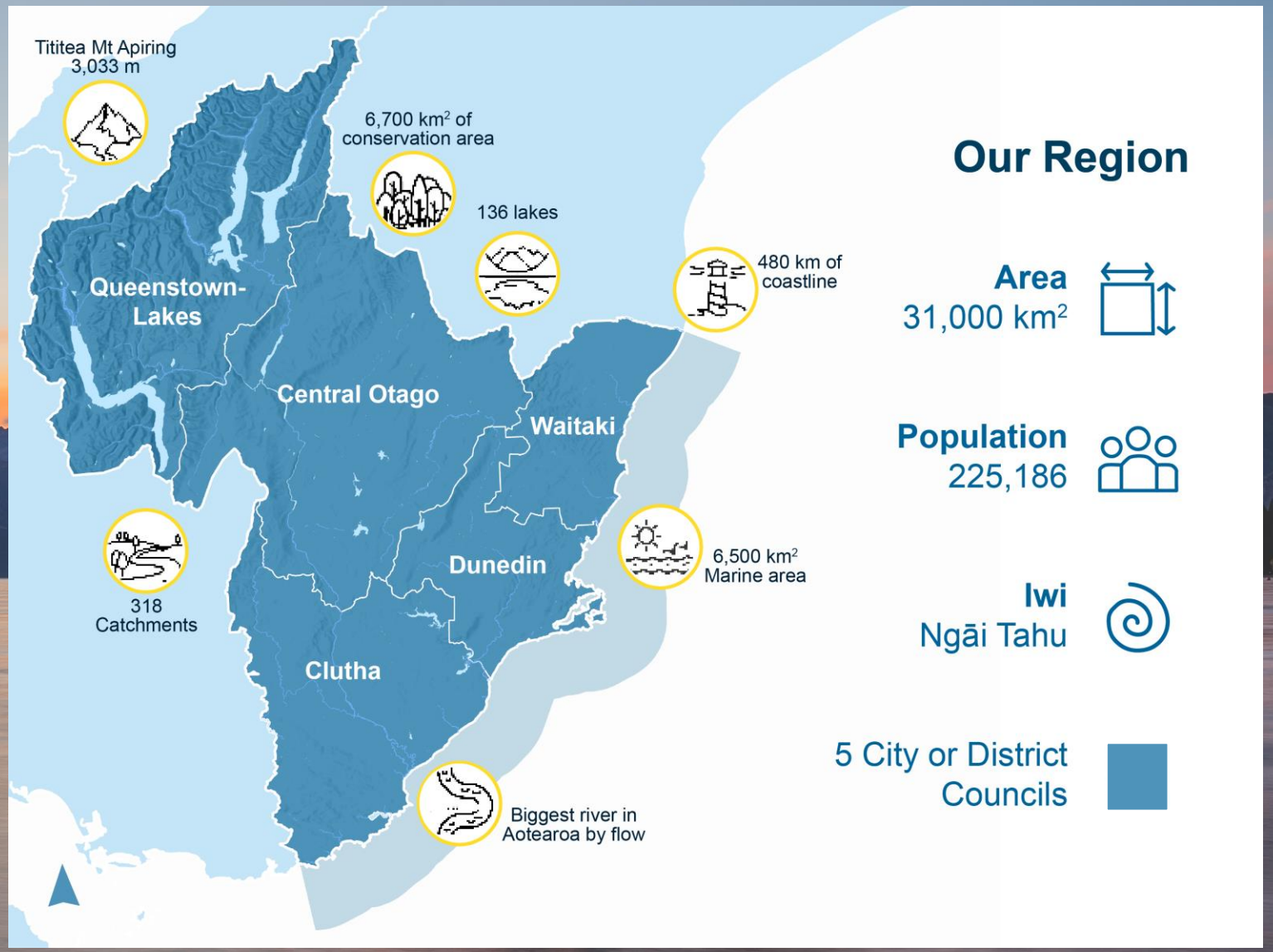

Otago
Regional
Council
Water Quality & Ecosystem Health
Otago 2018-2023


Tititea Mt Apiring
3,033 m
6,700 km² of
conservation area
136 lakes
480 km of
coastline
Queenstown-
Lakes
Central Otago
Waitaki
Dunedin
Clutha
318
Catchments
6,500 km²
Marine area
Biggest river in
Aotearoa by flow
Our Region
Area
31,000 km²
Population
225,186
Iwi
Ngāi Tahu
5 City or District
Councils

Upper Lowburn, Dunstan Rohe

# Our regional monitoring network

Water quality and ecosystem health are an integral component of environmental health and influence many uses and values of our waterways.

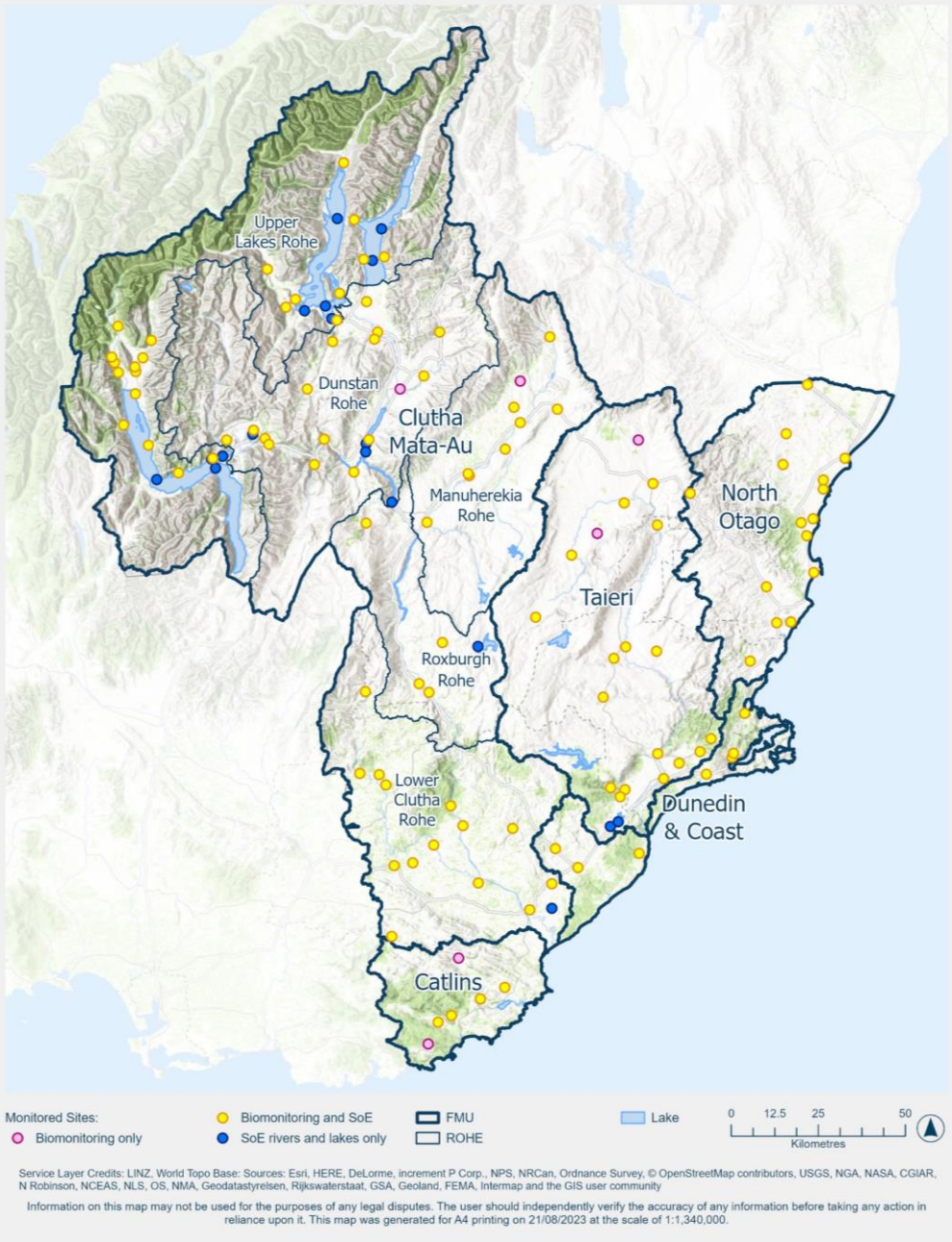
Otago Regional Council (ORC) operates a State of Environment (SoE) water quality monitoring network in lakes and rivers throughout the region. The information gathered through this programme is used to report on the state and trends of water quality and ecosystem health over time to inform environmental management and policy effectiveness.

The ORC currently monitors 106 river sites and 8 lakes. The sites are chosen to represent river types in the Otago region, based on the River Environment Classification (REC). See pages 12 and 23 for site names and numbers used in the following graphics.

This report gives an overview of state results for the monitoring period 1st July 2018- 30th June 2023 against water quality parameters or ecosystem health attributes defined by the National Objectives Framework (NOF) as described in the National Policy Statement – Freshwater Management 2020. Full technical reports, including trend analysis, can be found on our homepage, and data can be accessed via our environmental data portal.

## Otago Monitoring Sites

Biomonitoring and river/lake State of the Environment (SoE) sites



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# Performance Framework

Water quality parameters and ecosystem health attributes are assessed using a band framework.

This table provides generic descriptions.

Each parameter has its own specific table with underlying numeric banding.

National bottom lines do not exist for all attributes. Where they do, they are generally set between the “C Band” and “D Band”, with some exceptions.

Some water bodies naturally exceed national bottom lines and in these cases the relevant monitoring sites are identified and exempted.

Similarly, not all water bodies would achieve the A band even under natural conditions. For instance, even natural sites in Otago do not achieve the A band for the macro-invertebrate community index.

| National Objective Framework Band | Descriptive Summary |
|---|---|
| **A Band** | Water quality generally good, communities are healthy and resilient, similar to natural reference conditions. High conservation value systems. 99% species protection level. |
| **B Band** | Water quality and ecological communities are potentially slightly impacted. Limited potential for toxicity impacts. Occasional minor stress on sensitive organisms. |
| **C Band** | Water quality and ecological communities are potentially moderately impacted. Some toxicity impacts particularly on sensitive species. Moderate stress on a number of aquatic organisms. |
| **National Bottom Line** | National Bottom Lines are set out in the National Policy Statement as a threshold which should not be exceeded. |
| **D Band** | Water quality and ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state. Potential for acute toxicity impacts. Significant, persistent stress on a range of aquatic organisms. |

# Ngā karere mātua/Key findings

- Ammonia and Nitrate concentrations are in the A or B band for 104 of 106 sites in river and all lakes
- Dissolved reactive phosphorus concentrations in the A, B, and C band for 91 of 106 sampling sites
- *E.coli* is above the D band for at least one parameter at approximately half the monitored river sites and in the A band for 15 lake sites.
- Suspended sediment is above the national bottom line at 84 out of 106 sites.
- Of the 10 sites monitored for DO, one site briefly dropped below the national bottom line for the 1 – day minimum.
- All large lakes meet the A band for Chlorophyll-*a,* TN and TP.
- Periphyton measures are above the national bottom line for 29 of 36 river sites monitored.
- 29 of 36 river sites are close to natural reference conditions for ecosystem processes.
- 16 of 17 river monitoring sites are above the D band for Fish IBI.
- A total 28 of 35 river sites are above the national bottom line for macroinvertebrate health.

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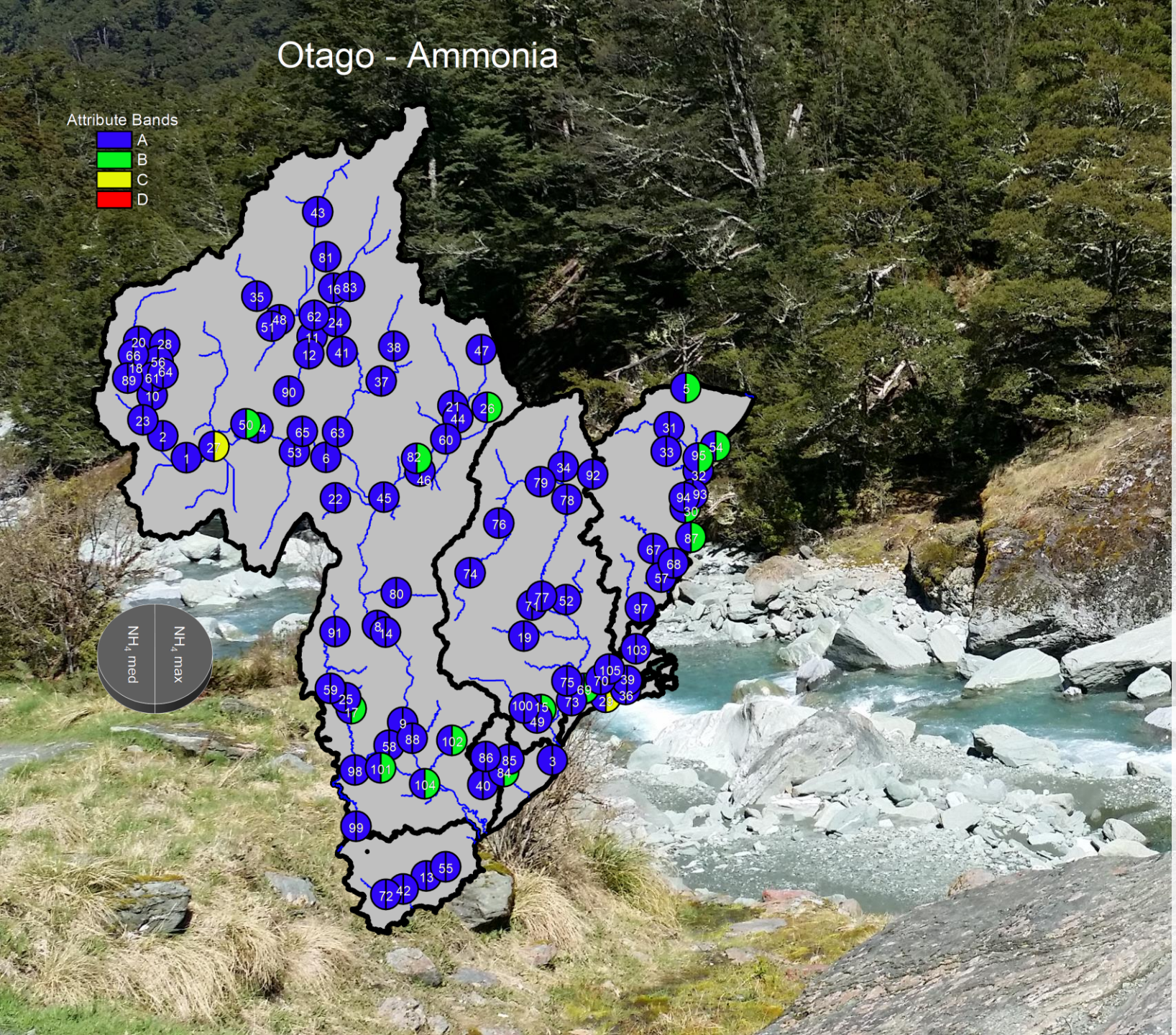
# Water Quality - Rivers




# Nitrate toxicity - Ammonia (Rivers)

High levels of ammoniacal nitrogen (NH4-N) in water can create conditions that make it difficult for aquatic insects or fish to survive. In Otago rivers, ammonia concentrations are generally low, achieving an A or B band. At these concentrations, ammonia is not expected to be harmful to most freshwater species and does not pose a risk for humans.

River sites that are experiencing higher anthropogenic pressures via activities such as agricultural runoff, fertilizer application or effluent discharge generally have higher concentrations of $NH_4$-N.

The main sources of NNN and $NH_4$-N are fertilizers, wastewater, and animal waste. NNN and $NH_4$-N can come from diffuse sources, such as land runoff or point sources, like wastewater pipes.

| | Ammonia (toxicity) mg/l | | |
|---|---|---|---|
| | Description | numeric attribute state | |
| | | Annual median | Annual maximum |
| A | 99% species protection level: No observed effect on any species tested. | ≤0.03 | ≤0.05 |
| B | 95% species protection level: Starts impacting occasionally on the 5% most sensitive species. | >0.03 and ≤0.24 | >0.05 and ≤0.40 |
| | National bottom line | 0.24 | 0.4 |
| C | 80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species). | >0.24 and ≤1.3 | >0.4 and ≤2.2 |
| D | Starts approaching acute impact level (that is, risk of death) for sensitive species. | >1.3 | >2.2 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.

# Nitrate toxicity – Nitrite-Nitrate-Nitrogen (Rivers)

High levels of nitrate-nitrite-nitrogen (NNN) in water can create conditions that make it difficult for aquatic insects or fish to survive. In Otago rivers, concentrations are generally very good (< 0.03 mg/l for NNN), complying with the A band. At these concentrations, NNN is not expected to be harmful to most freshwater species and does not pose a risk for humans.

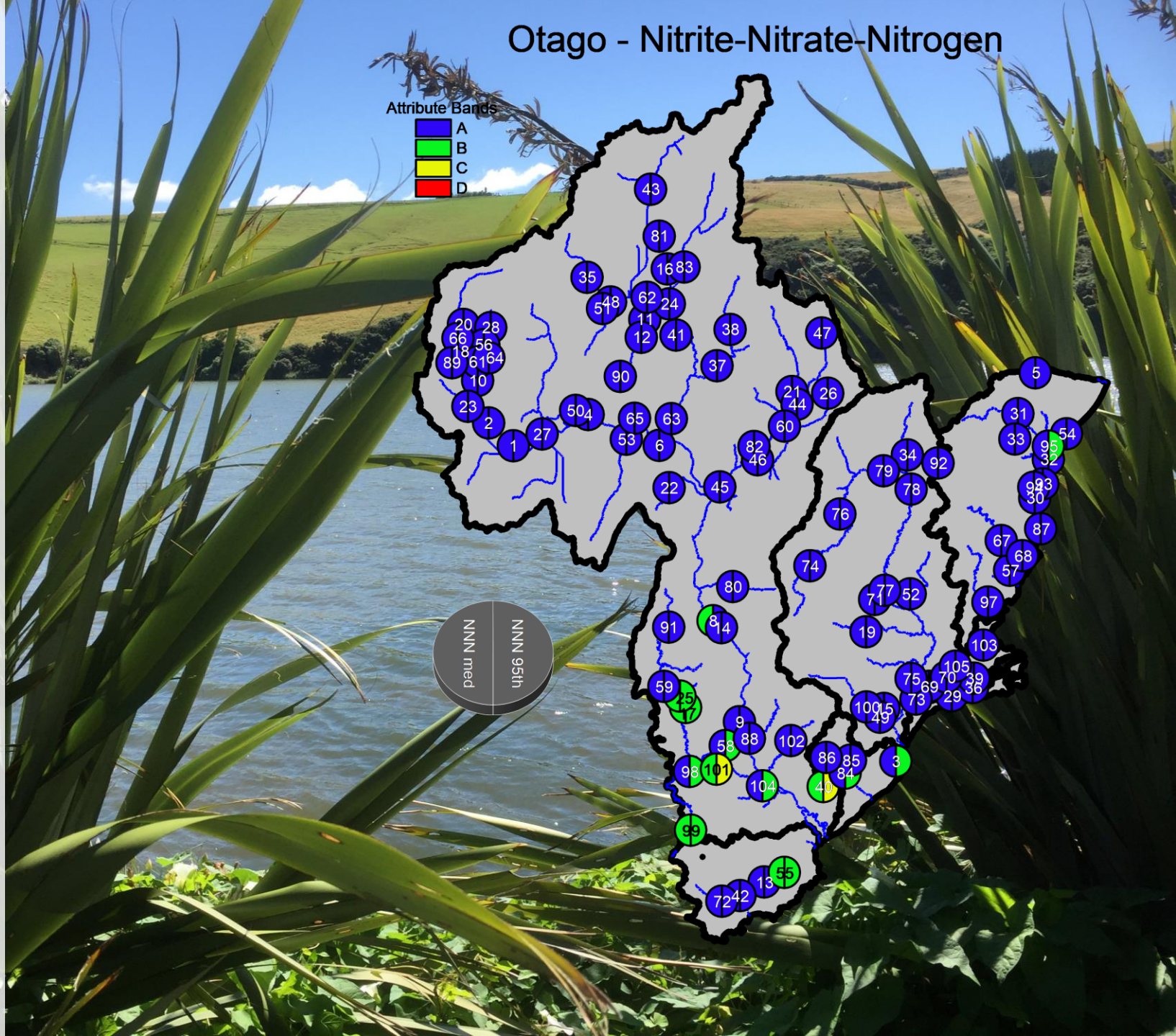
River sites that are experiencing higher anthropogenic pressures such as intensive farming or urban development generally have higher concentrations of NNN.

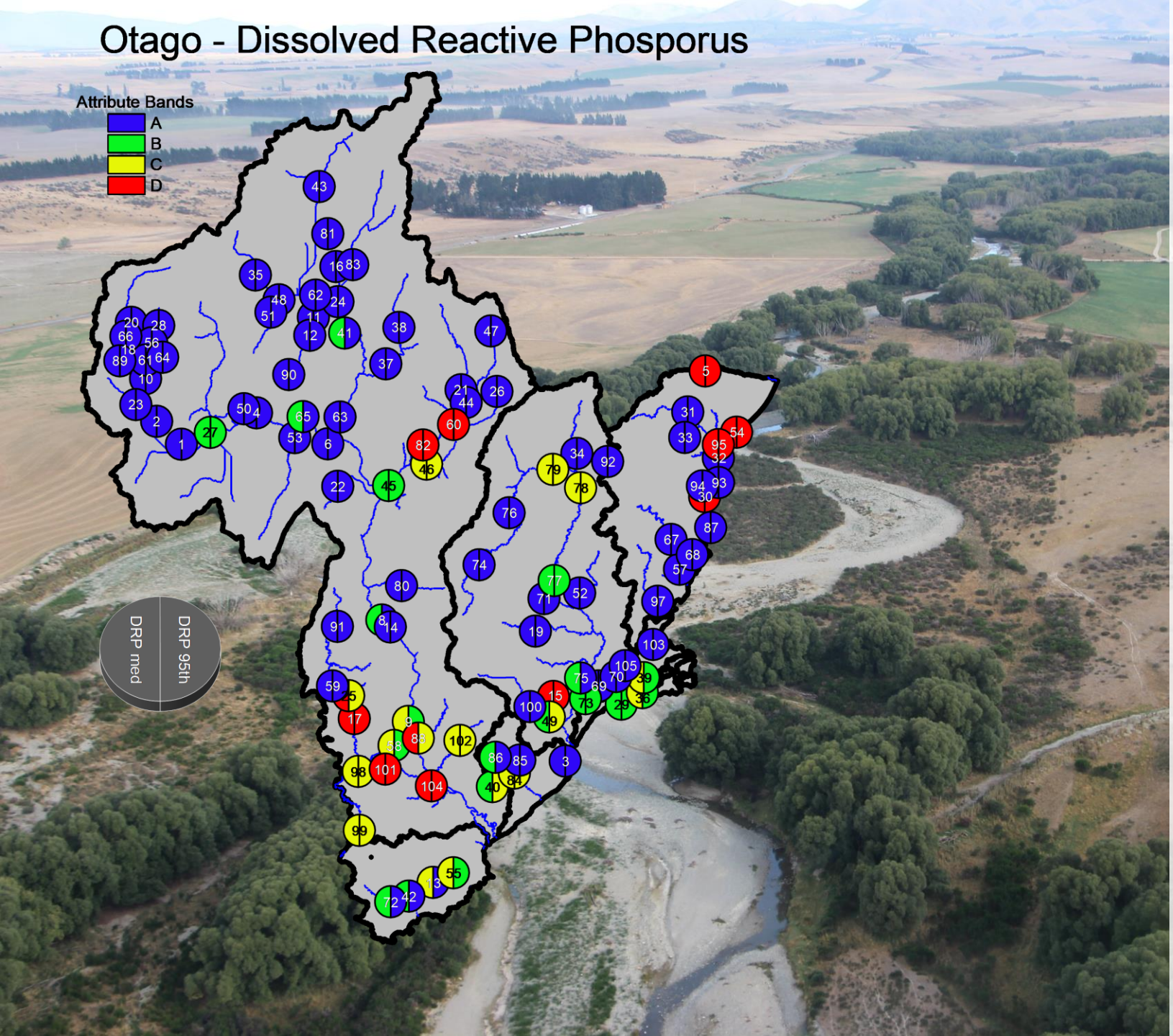
The main sources of NNN and NH4-N are fertilizers, wastewater, and animal waste. NNN and NH4-N can come from diffuse sources, such as land runoff or point sources, for example wastewater pipes.

Sites below the national bottomline for the 95th percentile for NNN are Lovells Creek (#40) and Wairuna Stream (#101; both Lower Clutha Rohe).

| | Nitrate (toxicity) mg/l | | |
|---|---|---|---|
| | Description | numeric attribute state | |
| | | Annual median | Annual 95th percentile |
| A | High conservation value system. Unlikely to be effects even on sensitive species. | ≤1.0 | ≤1.5 |
| B | Some growth effect on up to 5% of species. | >1.0 and ≤2.4 | >1.5 and ≤3.5 |
| | National bottom line | 2.4 | 3.5 |
| C | Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects. | >2.4 and ≤6.9 | >3.5 and ≤9.8 |
| D | Impacts on growth of multiple species, and starts approaching acute impact level (that is, risk of death) for sensitive species at higher concentrations (>20 mg/L). | >6.9 | >9.8 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.






# DRP(Rivers)

Dissolved reactive phosphorus is a form of phosphorus that is readily available for uptake by algal cells, allowing for fast algal growth if supply is sufficient. In the NPS-FM, the DRP attributes includes the impact of DRP on algal growth, invertebrates , fish and ecosystem processes. Therefore, bands are indicative of the health of several water quality components.

A total of 12 sites show DRP concentrations which fall in the D band. These sites are located in the Manuherekia Rohe and the Lower Clutha, Dunedin & Coast and North Otago FMU's. This measure has no national bottom line. However, the D-band indicates substantial DRP elevation above natural reference conditions.

| | Dissolved reactive phosphorous (mg/L) | | |
|---|---|---|---|
| | **Description** | **numeric attribute state** | |
| | | median | 95th percentile |
| A | Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to dissolved reactive phosphorus (DRP) enrichment are expected. | ≤ 0.006 | ≤ 0.021 |
| B | Ecological communities are slightly impacted by minor DRP elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates. | > 0.006 and ≤0.010 | > 0.021 and ≤0.030 |
| C | Ecological communities are impacted by moderate DRP elevation above natural reference conditions. If other conditions also favour eutrophication, DRP enrichment may cause increased algal and plant growth, loss of sensitive macro-invertebrate and fish taxa, and high rates of respiration and decay. | > 0.010 and ≤ 0.018 | > 0.030 and ≤ 0.054 |
| D | Ecological communities impacted by substantial DRP elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DRP enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia are lost. | >0.018 | >0.054 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.

# *E. coli* (Rivers)

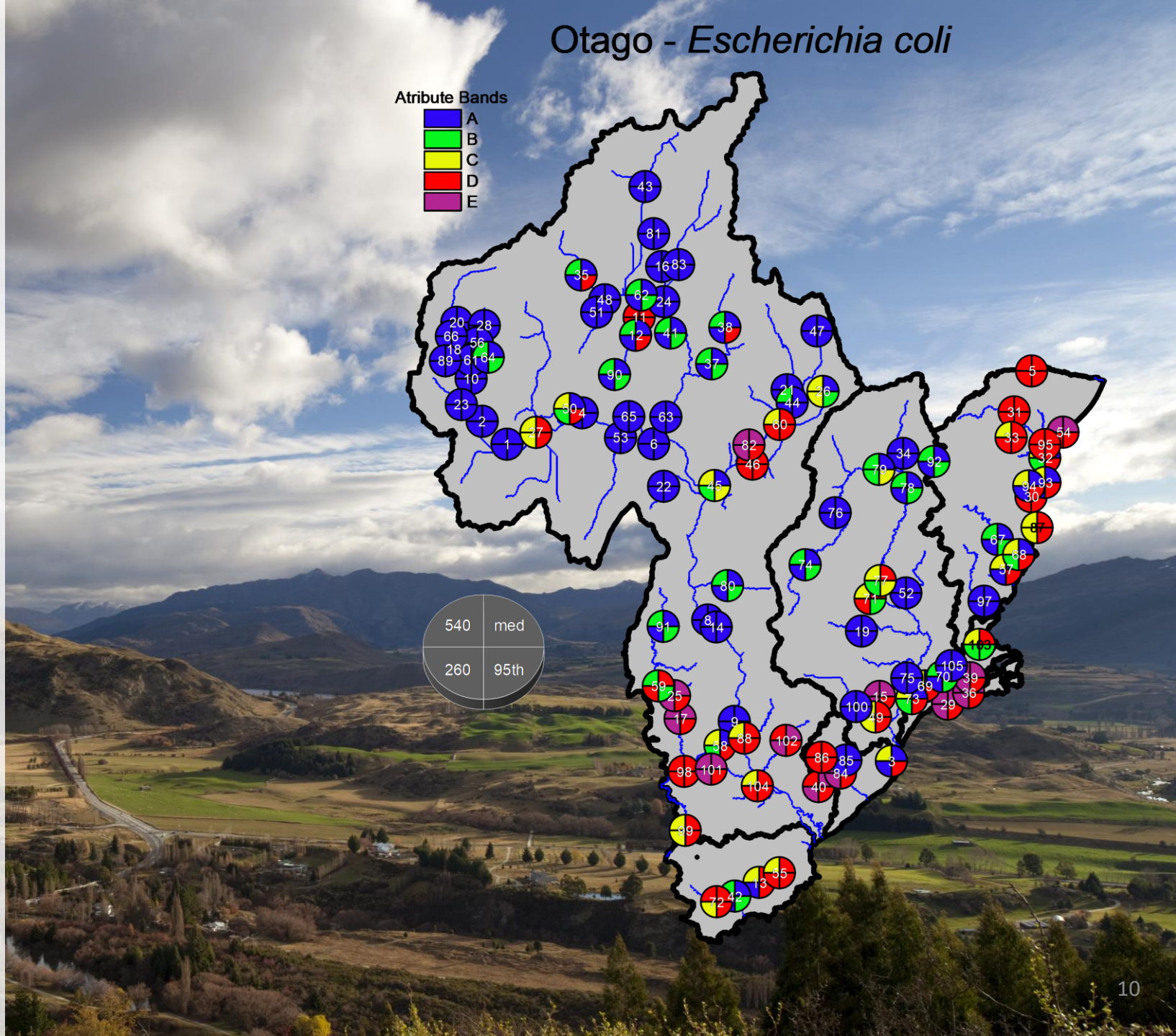
The bacterium *Escherichia coli* (*E. coli*) is naturally present in animal faeces and in freshwater and can reach high concentrations by the addition of wastewater or runoff from agricultural pastures to streams. High densities of *E. coli* indicate that the water has been contaminated with faecal matter and may therefore contain pathogens (such as cryptosporidium) that can cause illness.

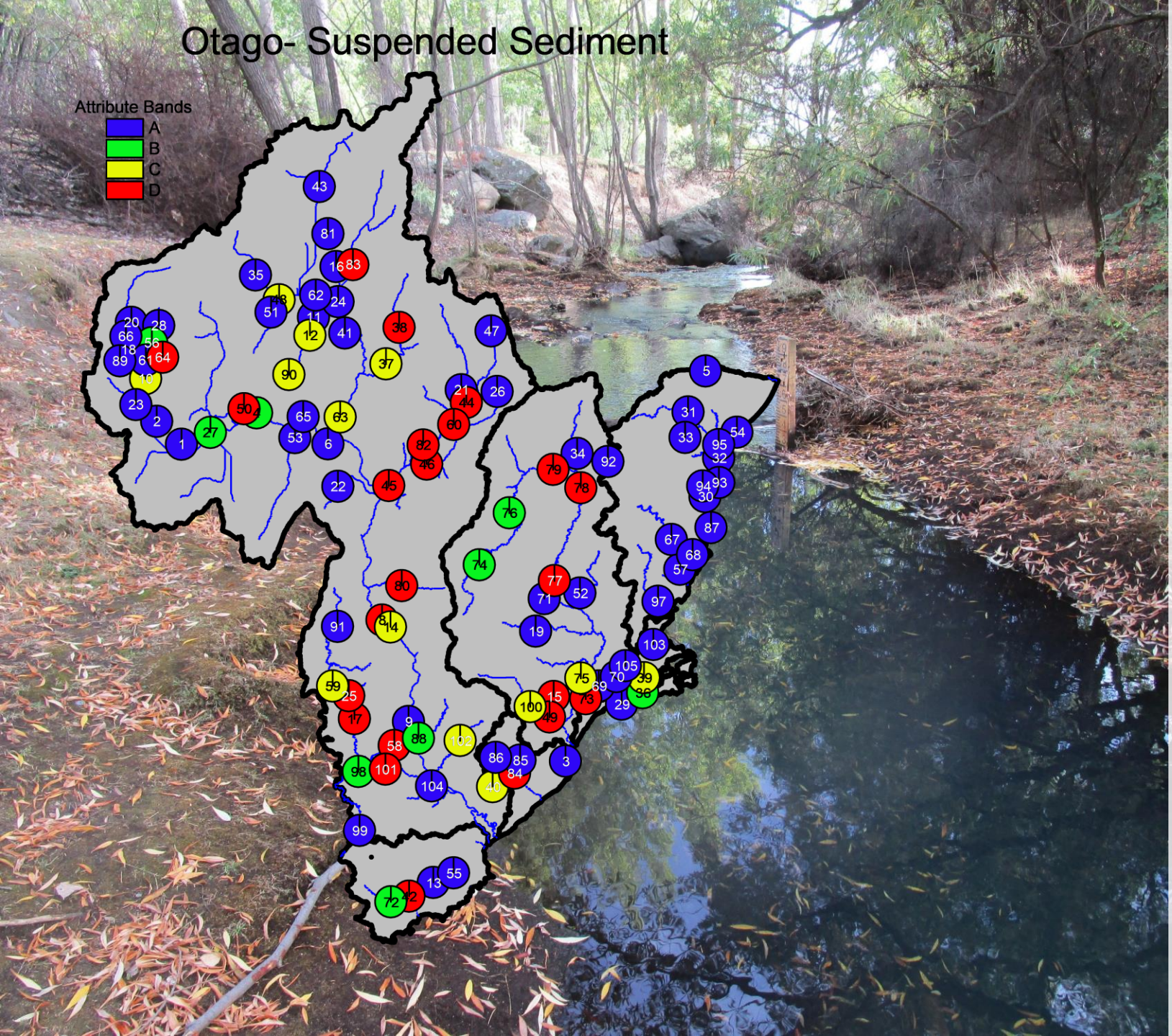
The NPS-FM uses four different metrics to inform the current state of *E. coli* in rivers and lakes: median, 95th percentile, 260 MPN (Most Probable Number)/100mL exceedance, and 540 MPN/100mL exceedance.

Sites that are below the D band for at least one *E. coli* measure are located in Dunedin & Coast and North Otago FMU's and the Lower Clutha Rohe.

| | Escherichia Coli | E.Coli/100ml | | | |
|---|---|---|---|---|---|
| | Description | Numeric attribute state | | | |
| | Description of risk of Campylobacter infection (based on E. coli indicator) | % exceedances over 540/100 mL | % exceedances over 260/100 mL | Median concentration /100 mL | 95th percentile of E. coli/100 mL |
| A | For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 1%. | <5% | <20% | ≤130 | ≤540 |
| B | For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 2%. | 5-10% | 20-30% | ≤130 | ≤1000 |
| C | For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is >3%. | 10-20% | 20-34% | ≤130 | ≤1200 |
| D | 20-30% of the time the estimated risk is ≥50 in 1,000 (>5% risk). The predicted average infection risk is >3%. | 20-30% | >34% | ≤130 | >1200 |
| E | For more than 30% of the time the estimated risk is ≥50 in 1,000 (>5% risk). The predicted average infection risk is >7%. | >30% | >50% | >260 | >1200 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.






# Suspended Sediment (Rivers)

Elevated concentrations of suspended fine sediment negatively influence benthic environments, fish community composition. Suspended fine sediment is naturally present in all rivers due to the presence of organic substances and the weathering of rocks. Rather than monitoring visual clarity, ORC is monitoring turbidity which is independent of ambient light conditions and can be robustly converted to visual clarity.

The two major rivers in Otago, the Clutha and Taieri, are influenced by natural sources of suspended fine sediment. High loads of glacial flour are present in the Clutha, creating its unique turquoise colour, while natural tannin staining is responsible for the brown colour of the Taieri and some rivers in the Catlins FMU.

Suspended sediment is above the national bottom line at 84 out of 106 sites.

| | Suspended fine sediment | visual clarity (m) | | | |
|---|---|---|---|---|---|
| | Description | Numeric attribute state by suspended sediment class | | | |
| | | 1 | 2 | 3 | 4 |
| A | Minimal impact of suspended sediment on instream biota. Ecological communities are similar to those observed in natural reference conditions. | ≥1.78 | ≥0.93 | ≥2.95 | ≥1.38 |
| B | Low to moderate impact of suspended sediment on instream biota. Abundance of sensitive fish species may be reduced. | <1.78 and ≥1.55 | <0.93 and ≥0.76 | <2.95 and ≥2.57 | <1.38 and ≥1.17 |
| C | Moderate to high impact of suspended sediment on instream biota. Sensitive fish species may be lost. | <1.55 and ≥1.34 | <0.76 and ≥0.61 | <2.57 and ≥2.22 | <1.17 and ≥0.98 |
| | National bottom line | 1.34 | 0.61 | 2.22 | 0.98 |
| D | High impact of suspended sediment on instream biota. Ecological communities are significantly altered and sensitive fish and macroinvertebrate species are lost or at high risk of being lost. | <1.34 | <0.61 | <2.22 | <0.98 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.

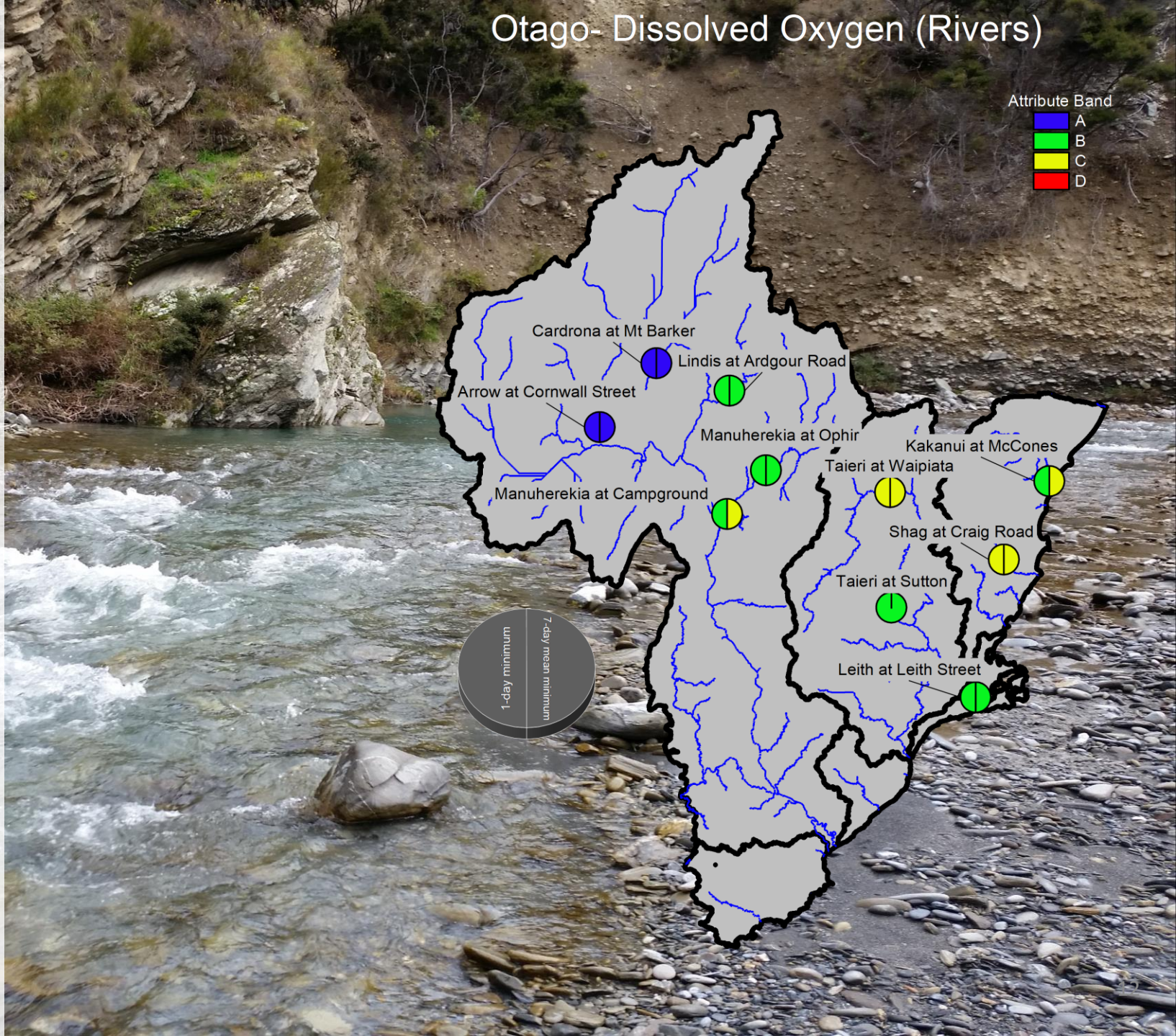
# Dissolved Oxygen (Rivers)

Dissolved Oxygen (DO) is a measure of the amount of oxygen that is contained in water. Many organisms, including fish and macroinvertebrates breath oxygen (via their gills) and bacteria consume oxygen when decomposing organic matter. Fast flowing streams or alpine streams tend to hold high concentrations of DO while slow flowing or stagnant waters tend to be low in DO because biomass decomposition processes consume oxygen. If oxygen concentrations in water fall below 5 mg/L organisms become stressed and DO concentrations <2 mg/L can lead to the death of organisms.

All sites monitored achieve attribute bands above the national bottom line. Readers interest in the technical information behind calculations of bands can find more information following to the link on the last page of this report.

| | Dissolved Oxygen (ecosystem health) Rivers | | |
|---|---|---|---|
| | **Description** | **mg/L (milligrams per litre)** | |
| | | **numeric attribute state** | |
| | | 7-day mean minimum (summer period: 1 November to 30th April) | 1-day minimum (summer period: 1 November to 30th April) |
| A | No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near-pristine) sites. | ≥8.0 | ≥7.5 |
| B | Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species. | ≥7.0 and <8.0 | ≥5.0 and <7.5 |
| C | Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each day. Risk of sensitive fish and macroinvertebrate species being lost. | ≥5.0 and <7.0 | ≥4.0 and <5.0 |
| | National bottom line | 5 | 4 |
| D | Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity. | <5.0 | <4.0 |

The Environmental data portal shows an additional five sites to those presented here, these sites were not analysed due to insufficnet data for reporting.



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# Sampling site numbers and names seen in figures pages 6 to 14

| # | Site | # | Site | # | Site | # | Site |
|---|---|---|---|---|---|---|---|
| 1 | 12 Mile Creek at Glenorchy Queenstown Road | 28 | Invincible Creek at Rees Valley Road | 54 | Oamaru Creek at SH1 | 80 | Teviot at Bridge Huts Road |
| 2 | 25 Mile Creek at Glenorchy Queenstown Road | 29 | Kaikorai Stream at Brighton Road | 55 | Owaka at Katea Road | 81 | The Neck Creek at Meads Road |
| 3 | Akatore Creek at Akatore Creek Road | 30 | Kakaho Creek at SH1 | 56 | Ox Burn at Rees Valley Road | 82 | Thomsons Creek at SH85 |
| 4 | Arrow at Morven Ferry Road | 31 | Kakanui at Clifton Falls Bridge | 57 | Pleasant at Patterson Road Ford | 83 | Timaru at Peter Muir Bridge |
| 5 | Awamoko at SH83 | 32 | Kakanui at McCones | 58 | Pomahaka at Burkes Ford | 84 | Tokomairiro at Blackbridge |
| 6 | Bannockburn at Lake Dunstan | 33 | Kauru at Ewings | 59 | Pomahaka at Glenken | 85 | Tokomairiro at Lisnatunny |
| 8 | Benger burn at SH8 | 34 | Kye Burn at SH85 Bridge | 60 | Poolburn at Cob Cottage | 86 | Tokomairiro at West Branch Bridge |
| 9 | Blackcleugh Burn at Rongahere Road | 35 | Leaping Burn at Wanaka Mt Aspiring Road | 61 | Precipice Creek at Glenorchy Paradise Road | 87 | Trotters Creek at Mathesons |
| 10 | Buckler Burn at Glenorchy Queenstown Road | 36 | Leith at Dundas Street Bridge | 62 | Quartz Creek at Maungawera Valley Road | 88 | Tuapeka River |
| 11 | Bullock Creek at Dunmore Street Footbridge | 37 | Lindis at Ardgour Road | 63 | Quartz Reef Creek at SH8 | 89 | Turner Creek at Kinloch Road |
| 12 | Cardrona at Mt Barker | 38 | Lindis at Lindis Peak | 64 | Rees at Glenorchy Paradise Road Bridge | 90 | Upper Cardrona at Tuohys Gully Road |
| 13 | Catlins at Houipapa | 39 | Lindsays Creek at North Road Bridge | 65 | Roaring Meg at SH6 | 91 | Upper Pomahaka at Aitchison Runs Road |
| 14 | Clutha at Millers Flat | 40 | Lovells Creek at Station Road | 66 | Scott Creek at Routeburn Road | 92 | Upper Shag at SH85 Culvert |
| 15 | Contour Channel | 41 | Luggate Creek at SH6 Bridge | 67 | Shag at Craig Road | 93 | Waianakarua at Browns |
| 16 | Craig Burn at SH6 | 42 | Maclennan at Kahuiku School Road | 68 | Shag at Goodwood Pump | 94 | Waianakarua at South Branch SH1 |
| 17 | Crookston Burn at Kelso Road | 43 | Makarora at Makarora | 69 | Silverstream at Taieri Depot | 95 | Waiareka Creek at Taipo Road |
| 18 | Dart at The Hillocks | 44 | Manuherikia at Blackstone | 70 | Silverstream at Three Mile Hill Road | 97 | Waikouaiti at Confluence |
| 19 | Deep Stream at SH87 | 45 | Manuherikia at Galloway | 71 | Sutton Stream at SH87 | 98 | Waipahi at Cairns Peak |
| 20 | Dundas Creek at Mill Flat | 46 | Manuherikia at Ophir | 72 | Tahakopa at Tahakopa | 99 | Waipahi at Waipahi |
| 21 | Dunstan Creek at Beattie Road | 47 | Manuherikia downstream of Fork | 73 | Taieri at Allanton Bridge | 100 | Waipori at Waipori Falls Reserve |
| 22 | Fraser at Old Man Range | 48 | Matukituki at West Wanaka | 74 | Taieri at Linnburn Runs Road | 101 | Wairuna at Millar Road |
| 23 | Greenstone at Greenstone Station Road | 49 | Meggat Burn at Berwick Road | 75 | Taieri at Outram | 102 | Waitahuna at Tweeds Bridge |
| 24 | Hawea at Camphill Bridge | 50 | Mill Creek at Fish Trap | 76 | Taieri at Stonehenge | 103 | Waitati at Mt Cargill Road |
| 25 | Heriot Burn at Park Hill Road | 51 | Motatapu at Wanaka Mt Aspiring Road | 77 | Taieri at Sutton | 104 | Waiwera at Maws Farm |
| 26 | Hills Creek at SH85 | 52 | Nenthorn at Mt Stoker | 78 | Taieri at Tiroiti | 105 | Whare Creek at Whare Flat Road |
| 27 | Horn Creek at Queenstown Bay | 53 | Nevis at Wentworth Station | 79 | Taieri at Waipiata | | |


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# Water Quality - Lakes

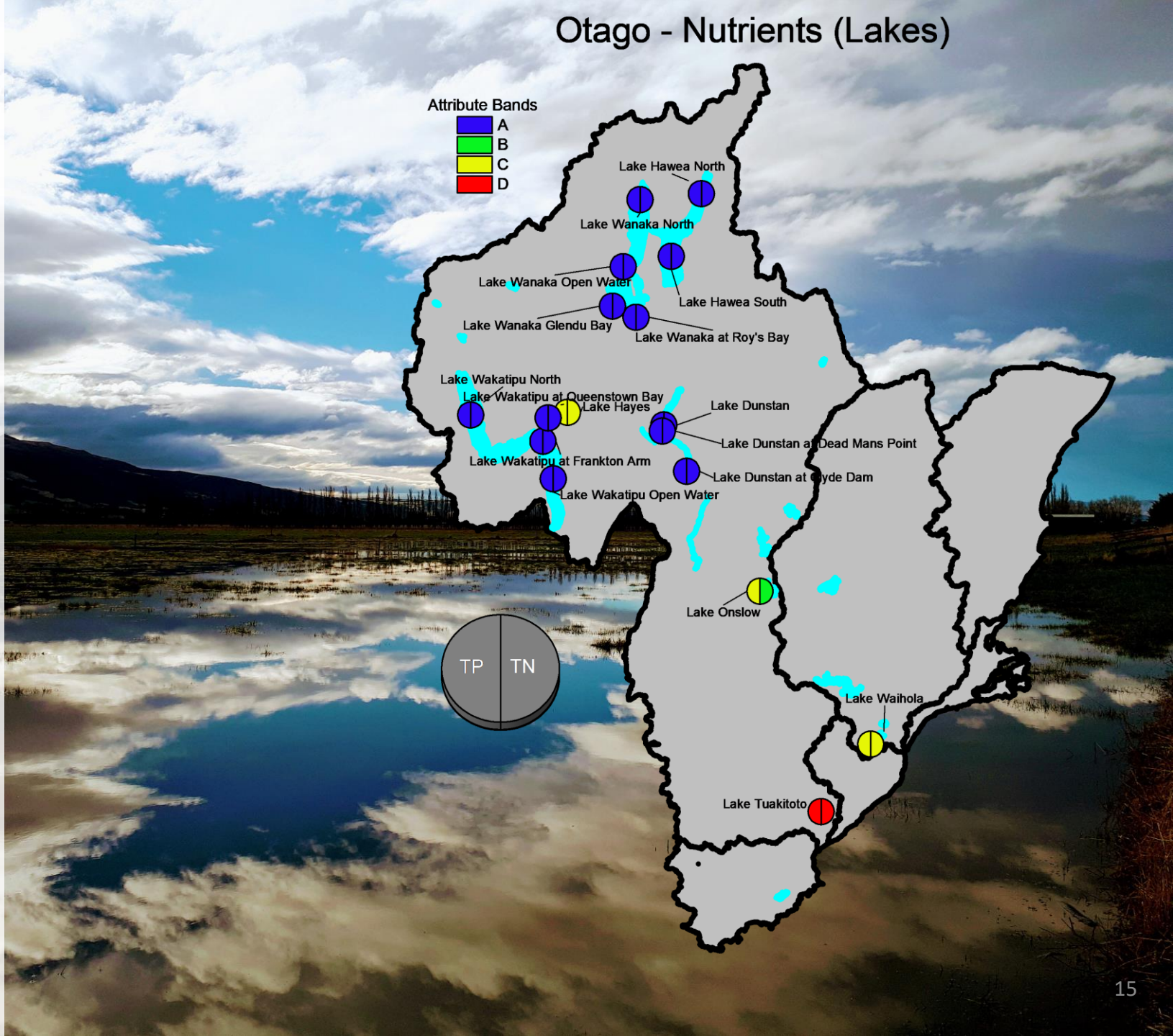
# Nutrients - Total Nitrogen & Total Phosphorus (Lakes)

The growth of algae, forming the basis of food-webs in lakes, is controlled by the amount and availability of nutrients. The major nutrients algae need for growth are nitrogen (N) and phosphorous (P). The concentrations of these nutrients in freshwater often give an indication of the possible magnitude of algal growth.

Lakes in the Upper Lakes Rohe (Lake Wakatipu, Lake Wānaka, and Lake Hāwea) and Lake Dunstan (Dunstan Rohe) achieve the A band for TN and TP, however rapid urban development is a threat to lake water quality. Lakes in other parts of Otago show a poorer current state, i.e., Lake Hayes achieves the C band for TN and TP.

Lake Waihola and Lake Tuakitoto are both shallow wetlands with mainly agricultural activity in their catchments. Shallow lakes commonly have high sediment re-suspension due to wind activity which enriches lake nutrient concentrations.

NPSFM tables for TN and TP are given on the next page.



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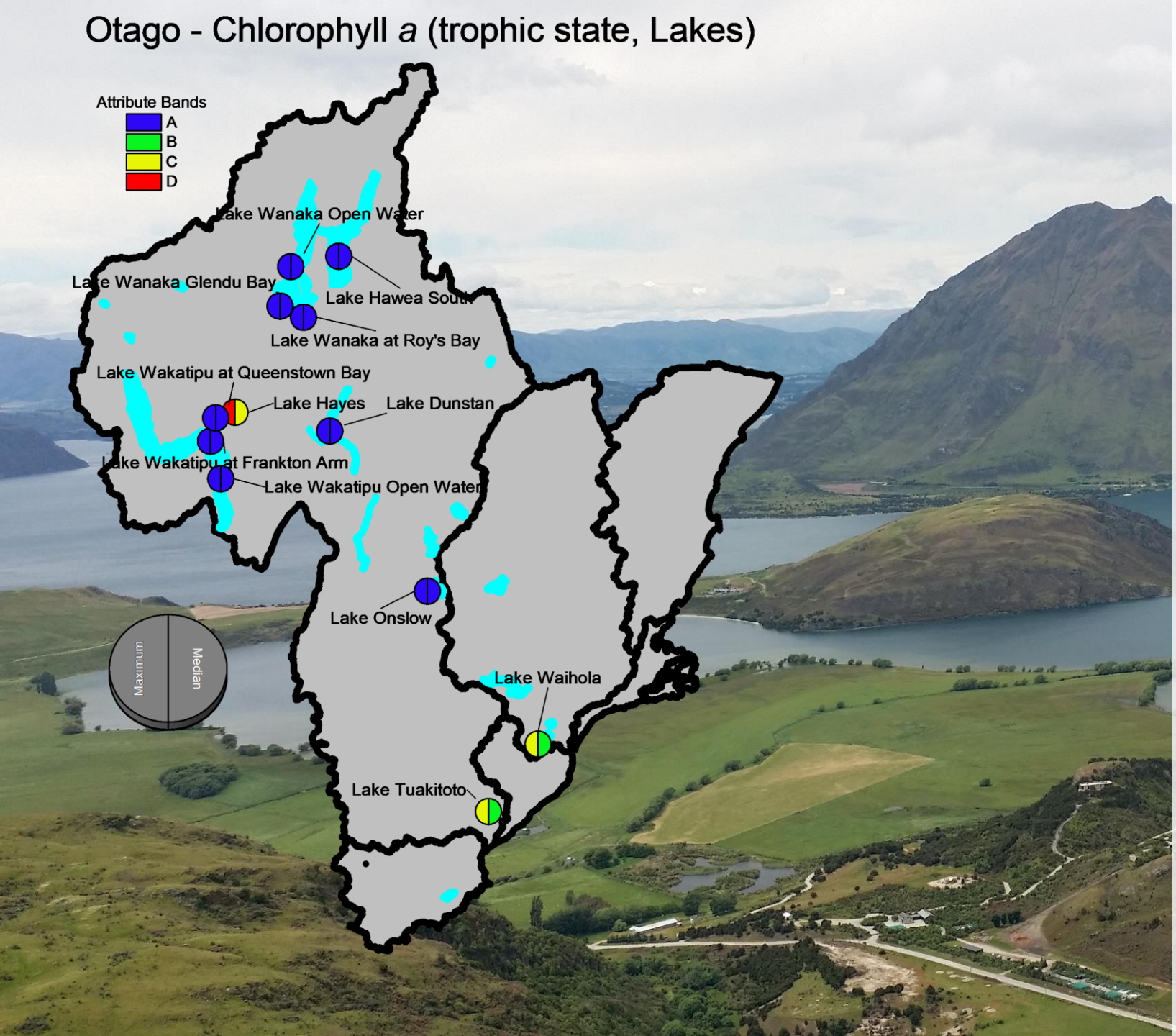
# NPS-FM tables for TN and TP as shown on page 14

| | Total Nitrogen (trophic state) Lakes mg/m$^3$ | | |
|---|---|---|---|
| | **Description** | **numeric attribute state** | |
| | | Annual median | Annual median |
| | | Seasonally stratified and brackish | Polymictic |
| A | Lake ecological communities are healthy and resilient, similar to natural reference conditions. | ≤160 | ≤300 |
| B | Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions. | >160 and ≤350 | >300 and ≤500 |
| C | Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. | >350 and ≤750 | >500 and ≤800 |
| | National bottom line | 750 | 800 |
| D | Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes. | >750 | >800 |

| | Total phosphorous (trophic state) Lakes mg/m$^3$ | |
|---|---|---|
| | **Description** | **numeric attribute state** |
| | | Annual median |
| A | Lake ecological communities are healthy and resilient, similar to natural reference conditions. | ≤10 |
| B | Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrient levels that are elevated above natural reference conditions. | >10 and ≤20 |
| C | Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. | >20 and ≤50 |
| | National bottom line | 50 |
| D | Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes. | >50 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.




# Phytoplankton (Lakes)

Phytoplankton or algal growth depends on the availability of nutrients and other physicochemical factors such as temperature, wave action, light intensity, and pH. The best proxy for phytoplankton growth is the measurement of chlorophyll *a* (Chl-*a*), which is indicative of photosynthetically active cells. Therefore, higher Chl-*a* concentrations are equivalent to increased phytoplankton growth. The NPS-FM uses Chl-*a* as an indicator of phytoplankton in lakes.

Most monitored lakes achieve the A band for Chl-*a*. Lake Waihola and Lake Tuakitoto achieve the B band for annual median Chl-a and the C band for annual maximum Chl-*a*. Lake Hayes falls below the national bottom line for annual median Chl-a and shows the C band for annual maximum Chl-a.

| | Phytoplankton (trophic state) Lakes | | |
|---|---|---|---|
| | Description | Chlorophyll-*a* mg/m$^3$ | |
| | | Annual median | Annual maximum |
| A | Lake ecological communities are healthy and resilient, similar to natural reference conditions. | ≤2 | ≤10 |
| B | Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions. | >2 and ≤5 | >10 and ≤25 |
| C | Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. Reduced water clarity is likely to affect habitat available for native macrophytes. | >5 and ≤12 | >25 and ≤60 |
| | National bottom line | 12 | 60 |
| D | Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes. | >12 | >60 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.

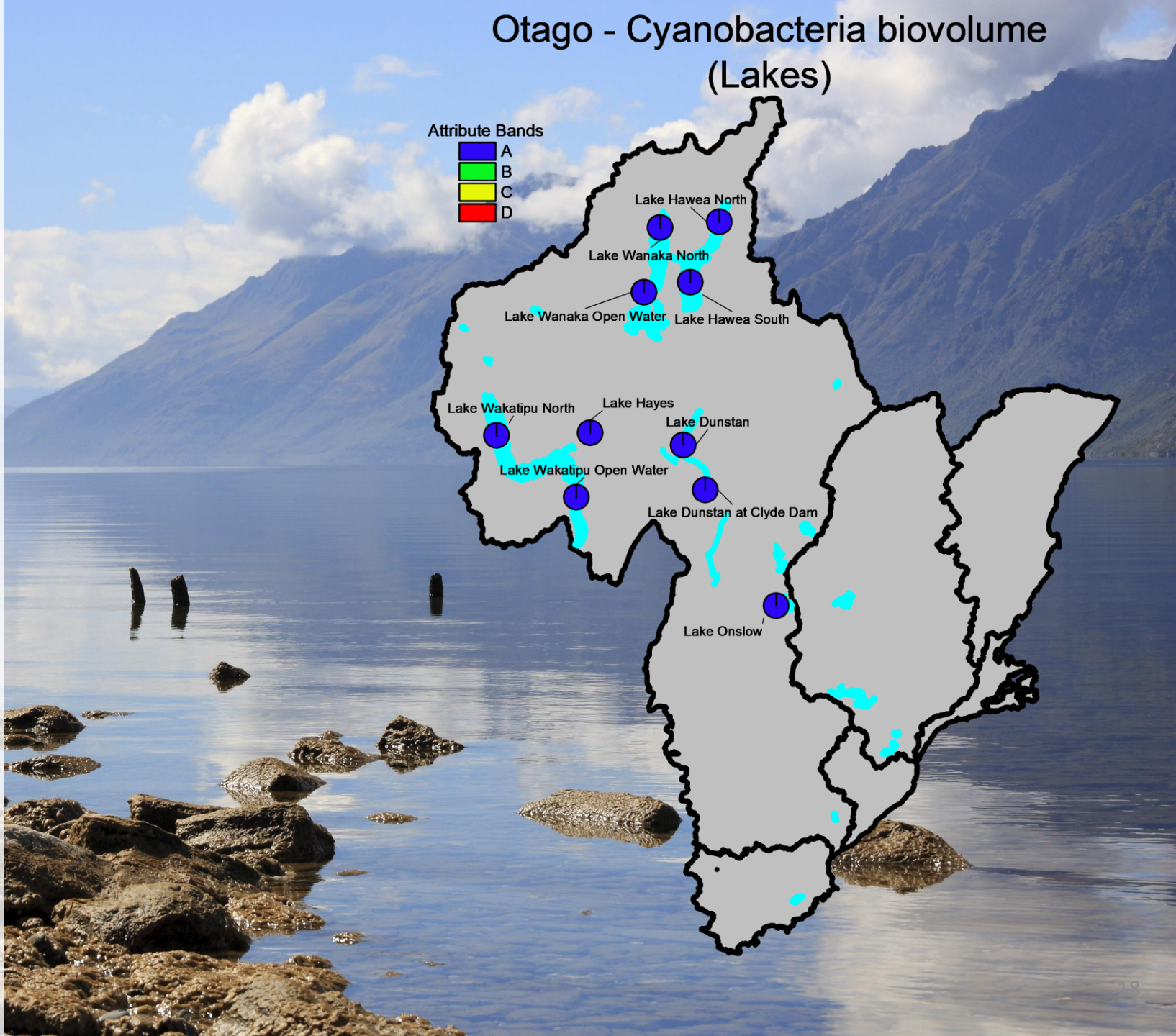
# Planktonic Cyanobacteria (Lakes)

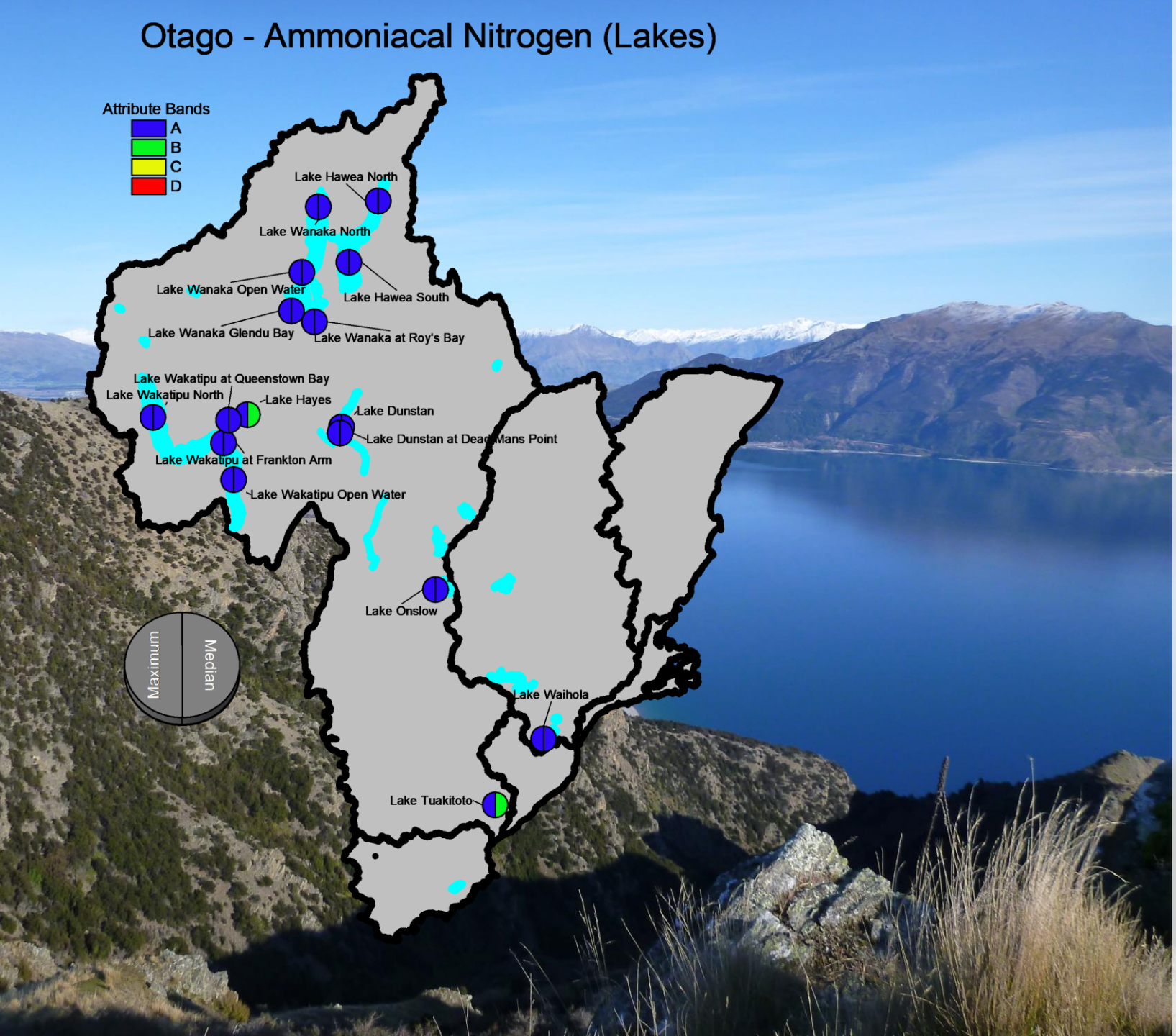
Cyanobacteria are a fast growing, highly competitive group of algae that can harvest energy via photosynthesis and are often able to access nutrient pools that are locked to other algae taxa. In addition, some species can produce toxins that interfere with the growth of other algae species. Due to this combination of traits, and when conditions are right, cyanobacteria can quickly form blooms on the surface of lakes. If these blooms reach a certain size (measured in biovolume) and contain toxin producing species, the toxins they release can be harmful to other aquatic life and terrestrial vertebrates if they use the water for drinking or recreational activities.

The NPS-FM has varying attribute states for the 80th percentile of cyanobacteria biovolume (mm3/L). All monitored lakes that have enough datapoints for band calculation achieve the A band. Lakes Tuakitoto and Waihola are monitored but don't have a data record that is long enough to calculate bands yet.

| | Cyanobacteria Lakes $mm^3/L$ | |
|---|---|---|
| | **Description** | **numeric attribute state** |
| | | 80th percentile |
| A | Risk exposure from cyanobacteria is no different to that in natural conditions (from any contact with freshwater). | ≤0.5 mm3/L biovolume equivalent for the combined total of all cyanobacteria |
| B | Low risk of health effects from exposure to cyanobacteria (from any contact with freshwater). | >0.5 and ≤1.0 mm3/L biovolume equivalent for the combined total of all cyanobacteria |
| C | Moderate risk of health effects from exposure to cyanobacteria (from any contact with freshwater). | >1.0 and ≤1.8 mm3/L biovolume equivalent of potentially toxic cyanobacteria OR >1.0 and ≤10 mm3/L total biovolume of all cyanobacteria |
| | National bottom line | 1.8 mm3/L biovolume equivalent of potentially toxic cyanobacteria OR 10 mm3/L total biovolume of all cyanobacteria |
| D | High health risks (for example, respiratory, irritation and allergy symptoms) exist from exposure to cyanobacteria (from any contact with freshwater). | >1.8 mm3/L biovolume equivalent of potentially toxic cyanobacteria OR >10 mm3/L total biovolume of all cyanobacteria |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.






# Nitrate toxicity - Ammonia (Lakes)

High levels of ammoniacal nitrogen (NH4-N) in water can create conditions that make it difficult for aquatic insects or fish to survive. The main sources of NNN and $NH_4$-N are fertilizers, wastewater, and animal waste. NNN and $NH_4$-N can come from diffuse sources, such as land runoff or point sources, for example, wastewater pipes.

All monitored lakes achieve the A or B band for ammonia.

| | Ammonia (toxicity) mg/l | | |
|---|---|---|---|
| | **Description** | **numeric attribute state** | |
| | | Annual median | Annual maximum |
| A | 99% species protection level: No observed effect on any species tested. | ≤0.03 | ≤0.05 |
| B | 95% species protection level: Starts impacting occasionally on the 5% most sensitive species. | >0.03 and ≤0.24 | >0.05 and ≤0.40 |
| | National bottom line | 0.24 | 0.4 |
| C | 80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species). | >0.24 and ≤1.3 | >0.4 and ≤2.2 |
| D | Starts approaching acute impact level (that is, risk of death) for sensitive species. | >1.3 | >2.2 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.

# *E. coli* (Lakes)

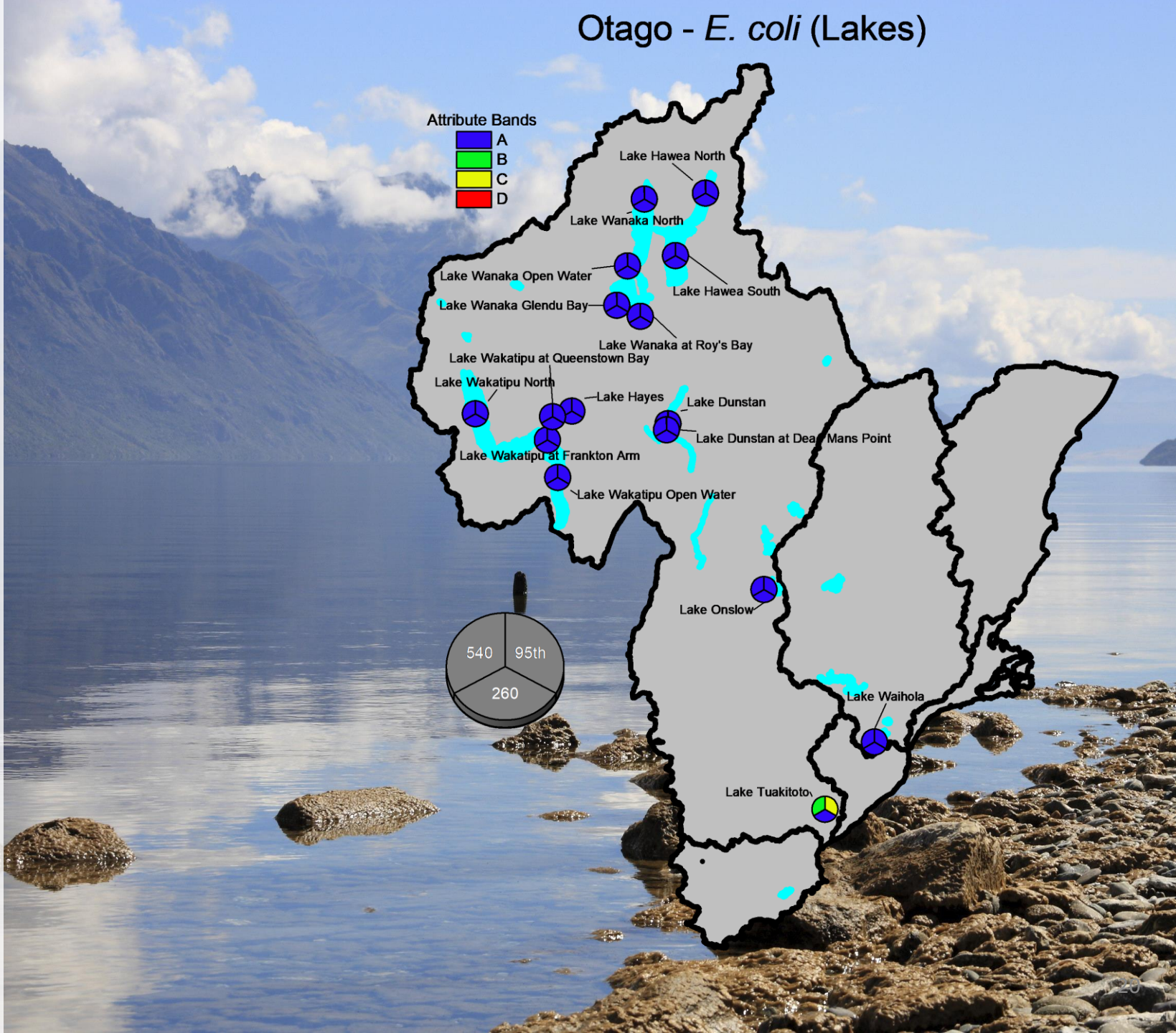
The bacterium *Escherichia coli* (*E. coli*) is naturally present in animal faeces and freshwater and can reach high concentrations due to wastewater or runoff from agricultural pastures to streams. High densities of *E. coli* indicate the presence of other bacteria and the risk of infection with several diseases, such as gastroenteritis, if the waterbody is used for recreational activities.

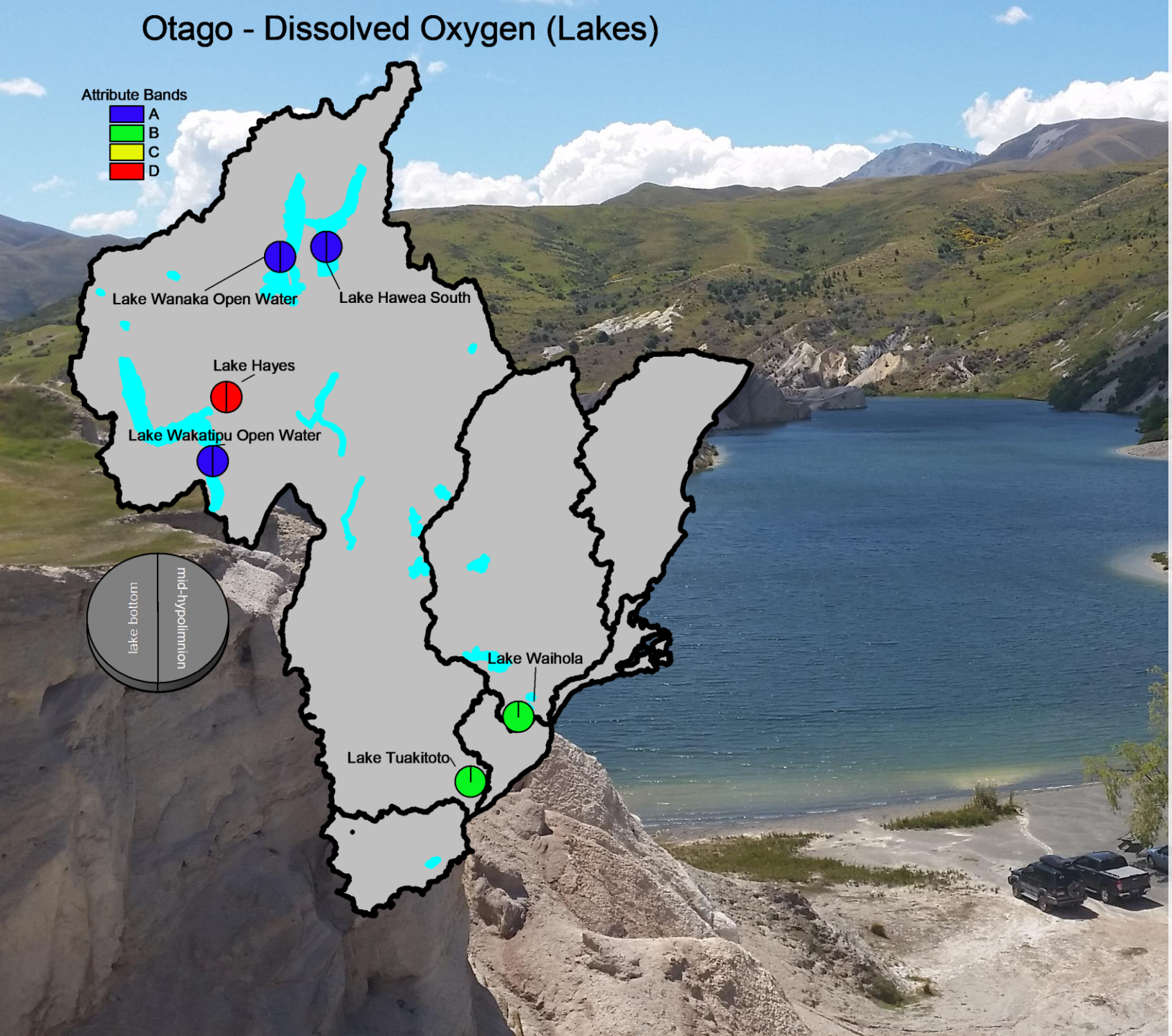
The NPS-FM uses four different metrics to determine the current state of *E. coli* in rivers and lakes: median, 95th percentile, 260 MPN (Most Probable Number)/100mL exceedance, and 540 MPN/100mL exceedance.

All sites achieve median concentrations <130cfu/100ml.

| | Escherichia Coli | E.Coli/100ml | | | |
|---|---|---|---|---|---|
| | Description | Numeric attribute state | | | |
| | Description of risk of Campylobacter infection (based on E. coli indicator) | % exceedances over 540/100 mL | % exceedances over 260/100 mL | Median concentration /100 mL | 95th percentile of E. coli/100 mL |
| A | For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 1%. | <5% | <20% | ≤130 | ≤540 |
| B | For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 2%. | 5-10% | 20-30% | ≤130 | ≤1000 |
| C | For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is >3%. | 10-20% | 20-34% | ≤130 | ≤1200 |
| D | 20-30% of the time the estimated risk is ≥50 in 1,000 (>5% risk). The predicted average infection risk is >3%. | 20-30% | >34% | ≤130 | >1200 |
| E | For more than 30% of the time the estimated risk is ≥50 in 1,000 (>5% risk). The predicted average infection risk is >7%. | >30% | >50% | >260 | >1200 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.






# Dissolved Oxygen (DO) (Lakes)

The concentration of dissolved oxygen in water provides information about the oxygen content dissolved in water. While the water molecule consist of 2 hydrogen and one oxygen atom (some cool facts about $H_2O$ here), this oxygen can't be used by aquatic life. Atmospheric oxygen mixed into the water column is what aquatic organisms need to breathe. Therefore, when less mixing occurs (for example in summer when lakes thermally stratify) oxygen becomes consumed in a lake and the concentration of DO drops. If the concentration falls below a certain threshold, species that need oxygen to live (such as fish) won't survive. For most species, this threshold is around 4 to 5 mg/L which is reflected in the NPS-FM bottom line of 4 mg/L for mid-hypolimnetic DO.

| | Lake-bottom dissolved oxygen (mg/L) | |
|---|---|---|
| | Description | |
| | | Annual minimum |
| A | No risk from lake-bottom dissolved oxygen of biogeochemical conditions causing nutrient release from sediments. | ≥7.5 |
| B | Minimal risk from lake-bottom dissolved oxygen of biogeochemical conditions causing nutrient release from sediments. | ≥2.0 and < 7.5 |
| C | Risk from lake-bottom dissolved oxygen of biogeochemical conditions causing nutrient release from sediments. | ≥0.5 and < 2.0 |
| | **Natonal Bottomline** | 0.5 |
| D | Likelihood from lake-bottom dissolved oxygen of biogeochemical conditions resulting in nutrient release from sediments. | <0.5 |

| | Mid-hypolimnetic dissolved oxygen (mg/L) | |
|---|---|---|
| | Description | |
| | | Annual minimum |
| A | No stress caused to any fish species by low dissolved oxygen. | ≥7.5 |
| B | Minor stress on sensitive fish seeking thermal refuge in the hypolimnion. Minor risk of reduced abundance of sensitive fish and macro-invertebrate species. | ≥5.0 and < 7.5 |
| C | Moderate stress on sensitive fish seeking thermal refuge in the hypolimnion. Risk of sensitive fish species being lost. | ≥4 and < 5 |
| | **Natonal Bottomline** | 4 |
| D | Significant stress on a range of fish species seeking thermal refuge in the hypolimnion. Likelihood of local extinctions of fish species and loss of ecological integrity. | <4.0 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 55.

# Submerged plants (Lakes)

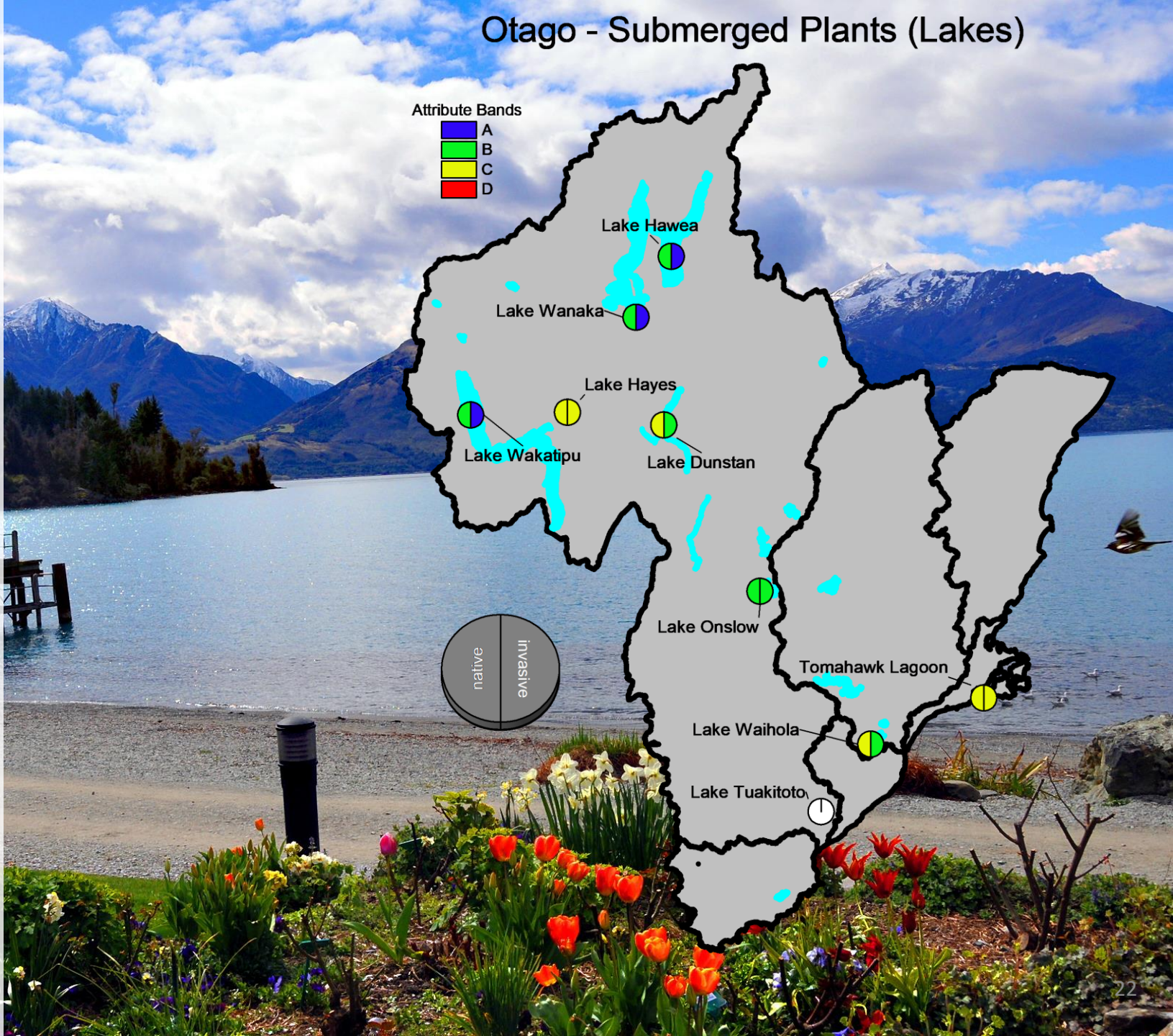
Submerged plants (macrophytes) are plant species that grow naturally in lakes. Their growth depends on the availability of light and nutrients. Therefore, if a lake become more eutrophic, macrophyte growth might increase and diminish habitat variability. In addition, invasive macrophytes can outcompete native species under certain conditions and can therefore become abundant. This has potentially negative effects on habitat variability and the aquatic food chain. Of the lakes assessed for submerged plants, Lake Tuakitoto was found unvegetated and is therefore displayed in white.

The NPS-FM gives independent attribute bands for invasive and native submerged plants.

| | Submerged Plants (native) Aquatic health | |
|---|---|---|
| | **Description** | **numeric attribute state** |
| | | % of maximum potential score |
| A | No invasive plants present in the lake. Native plant communities remain intact. | 0% |
| B | Invasive plants having only a minor impact on native vegetation. Invasive plants will be patchy in nature co-existing with native vegetation. Often major weed species not present or in early stages of invasion. | >1 and ≤25% |
| C | Invasive plants having a moderate to high impact on native vegetation. Native plant communities likely displaced by invasive weed beds particularly in the 2 – 8 m depth range. | >25 and ≤90% |
| | National bottom line | 90% |
| D | Tall dense weed beds exclude native vegetation and dominate entire depth range of plant growth. The species concerned are likely hornwort and Egeria. | >90% |

| | Submerged Plants (native) Aquatic health | |
|---|---|---|
| | **Description** | **numeric attribute state** |
| | | % of maximum potential score |
| A | Excellent ecological condition. Native submerged plant communities are almost completely intact. | >75% |
| B | High ecological condition. Native submerged plant communities are largely intact. | >50 and ≤75% |
| C | Moderate ecological condition. Native submerged plant communities are moderately impacted. | ≥20 and ≤50% |
| | National bottom line | 20% |
| D | Poor ecological condition. Native submerged plant communities are largely degraded or absent. | <20% |

Attribute bands calculated following LakeSPI investigation in March 2020. Lake SPI is assessed every 3 years with the next one done in March 2024.



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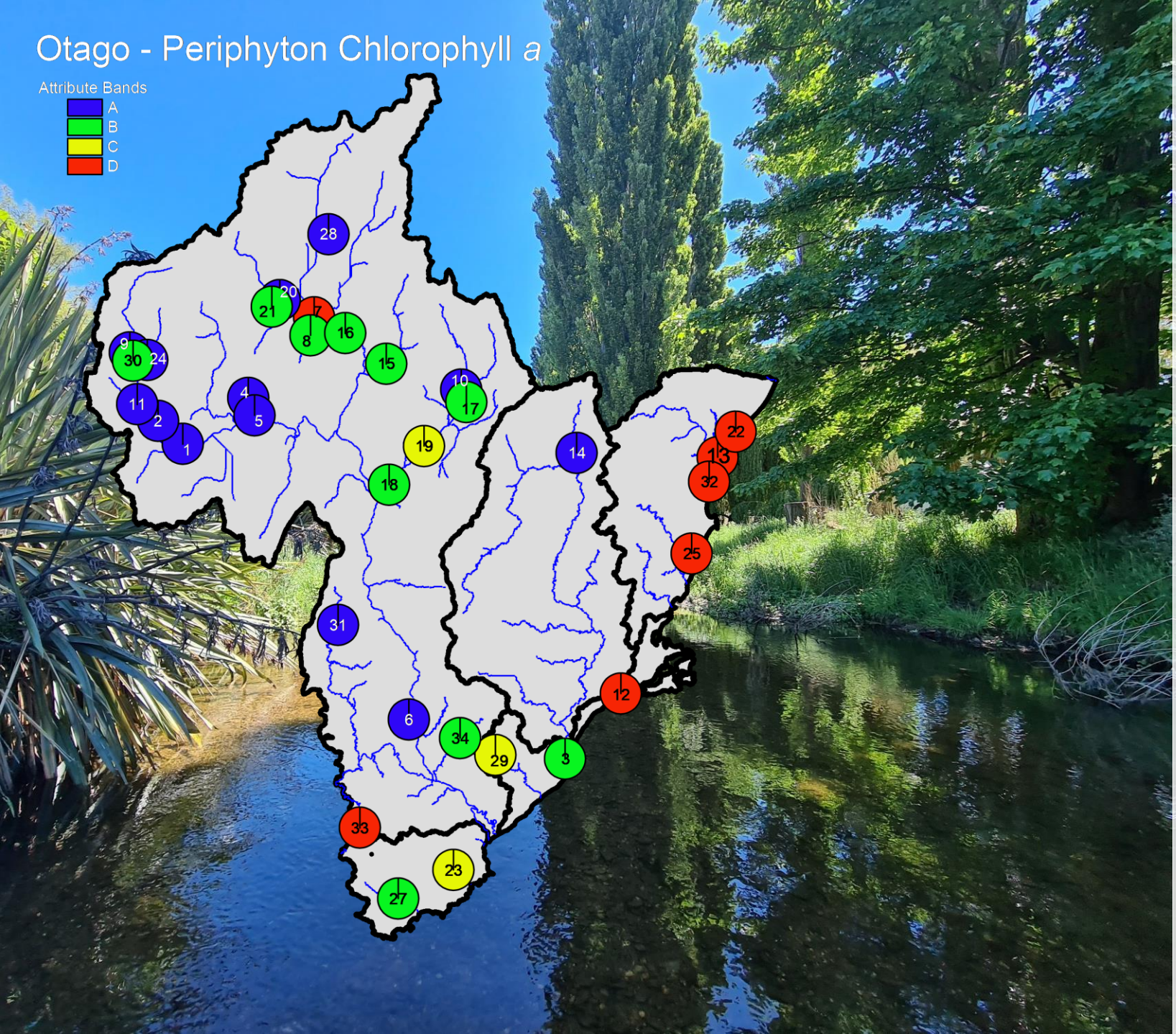
# Ecosystem Health

Torrentfish (*Cheimarrichthys fosteri*)




# Periphyton (Rivers)

Instream algal growth is commonly assessed via measurements of chlorophyll-*a* (Chl-*a*) as all types of algae contain Chl-*a* and this metric therefore reflects the total amount of live algae biomass in a sample. The NPS-FM 2020 specifies attributes for trophic state based on periphyton (algae) biomass in rivers.

Periphyton sampling was undertaken with one composite sample collected from each site. Samples were collected using the method described by the Ministry for the Environment. The total Chl-*a* was calculated using a standard formula and scaled to the number of milligrams of Chl-*a* per $m^2$ of the stream bed.

A total of seven sites fail the national bottom line for periphyton Chl-*a*. Of these sites, four are located in the North Otago FMU, one in the Lower Clutha Rohe, one in the Dunstan Rohe and one in the Dunedin & Coast FMU. References to site numbers given on page 23.

| | Periphyton (trophic state) Rivers | | |
|---|---|---|---|
| | **Description** | **Chlorophyll-*a* $mg/m^3$** | |
| | | **numeric attribute state** | |
| | | default class | productive class |
| A | Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat. | ≤50 | ≤50 |
| B | Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat. | >50 and ≤120 | >50 and ≤120 |
| C | Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or moderate alteration of the natural flow regime or habitat. | >120 and ≤200 | >120 and ≤200 |
| | National bottom line | 200 | 200 |
| D | Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat. | >200 | >200 |

Attribute bands are calculated for the period 1st July 2020 to 30th June 2023 for all sites with a minimum sample number of 32.

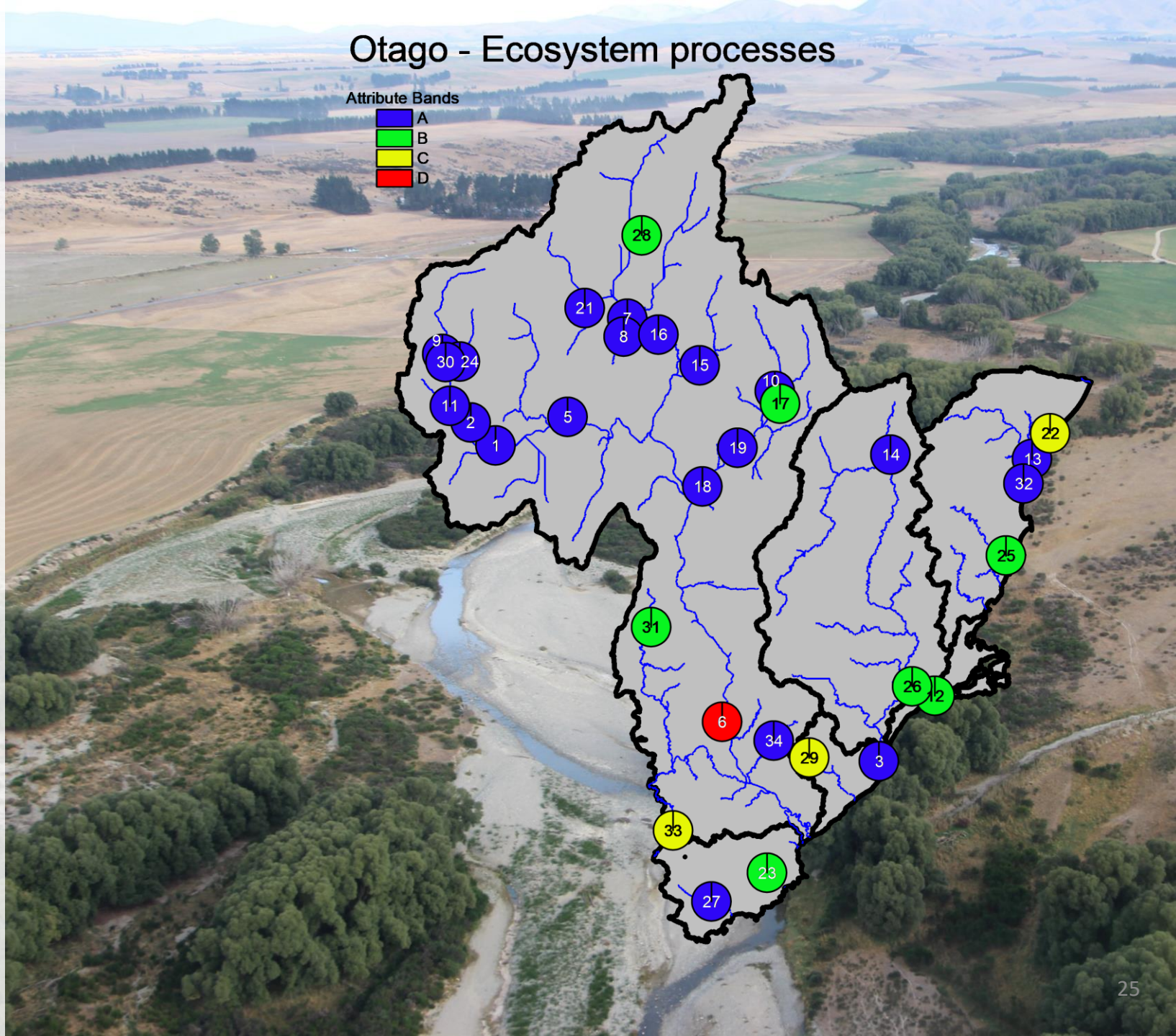
# Ecosystem Processes (Rivers)

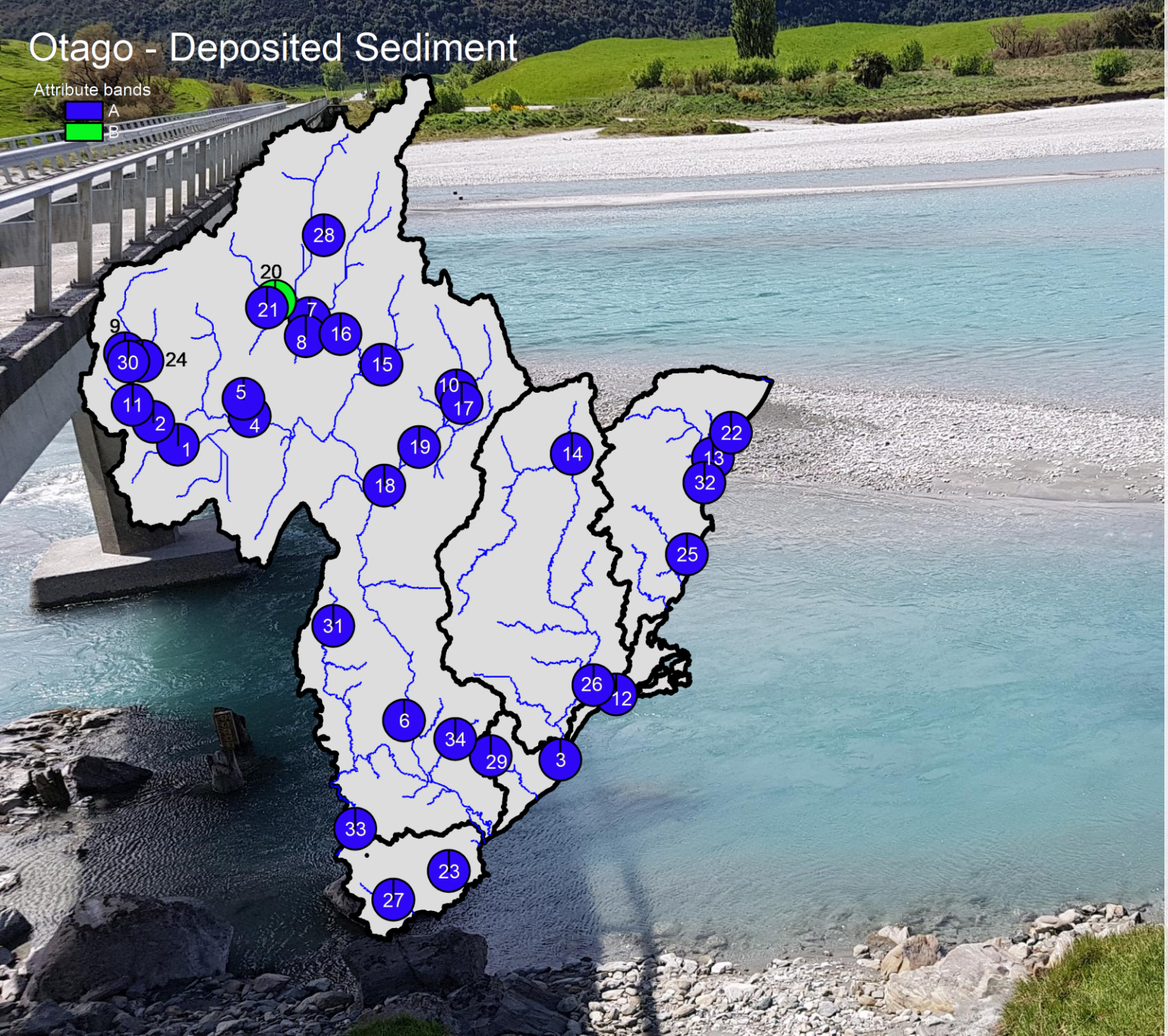
The NPS-FM shows ecosystem metabolism as measured by continuous dissolved oxygen. While the metabolism programme is being implemented in Otago, ecosystem processes are also being assessed via cotton strip asseys (CSA), which provide an estimate of organic matter processing. Cawthron developed interim attribute bands for ORC to use with CSA, these attribute bands are used here and given in the table below. Reference sites (i.e., near pristine sites) are used to validate CSA results and attribute states are assigned on the difference to natural conditions. References to site numbers given on page 23.

Of the sites monitored, the Blackcleugh Burn fails to comply with the C band showing river ecological processes that are unhealthy and significantly impacted by nutrient levels above natural reference conditions.

| | Percent cotton tensile strength loss per degree day (%CTSL dd-1 ) | |
|---|---|---|
| | **Description** | **Numeric attribute state** |
| A | River ecological processes are healthy and resilient, like natural reference conditions. | ≤0.12 |
| B | River ecological processes are slightly impacted by nutrient levels that are elevated above natural reference conditions and/or by altered flows/habitat due to land use impacts | >0.12 and ≤0.24 |
| C | River ecological processes are moderately impacted by nutrient levels that are elevated above natural reference conditions and/or by altered flows/habitat due to land use impacts. | >0.24 and ≤0.37 |
| D | River ecological processes are unhealthy and significantly impacted by nutrient levels that are elevated above natural reference conditions and/or by altered flows/habitat due to land use impacts. | >0.37 |

Attribute bands are calculated for the period 1st July 2022 to 30th June 2023 with cotton strips deployed for a minimum 14 days at each site.






# Deposited sediment (Rivers)

Excess sediment directly affects the health of a waterway, decreasing its mauri or life-supporting capacity. Deposited fine sediment occurs naturally in the beds of rivers and streams. It usually enters a stream because of terrestrial weathering processes or bank erosion and in-stream fluvial processes. Because sediment is naturally transported longitudinally through a river network, its state at any given point will be influenced by climate, geology, topography, and current velocity. Human activities can affect this natural sediment cycle by accelerating sediment delivery to streams and increasing the quantity of smaller particle sizes. The effect of excess in-stream sedimentation is recognised as a major impact of changing land use on river health. References to site numbers given on page 23.

All monitoring sites achieve the A or B band for deposited sediments. The B band shown for the Matukituki is likely due to glacial flour being deposited.

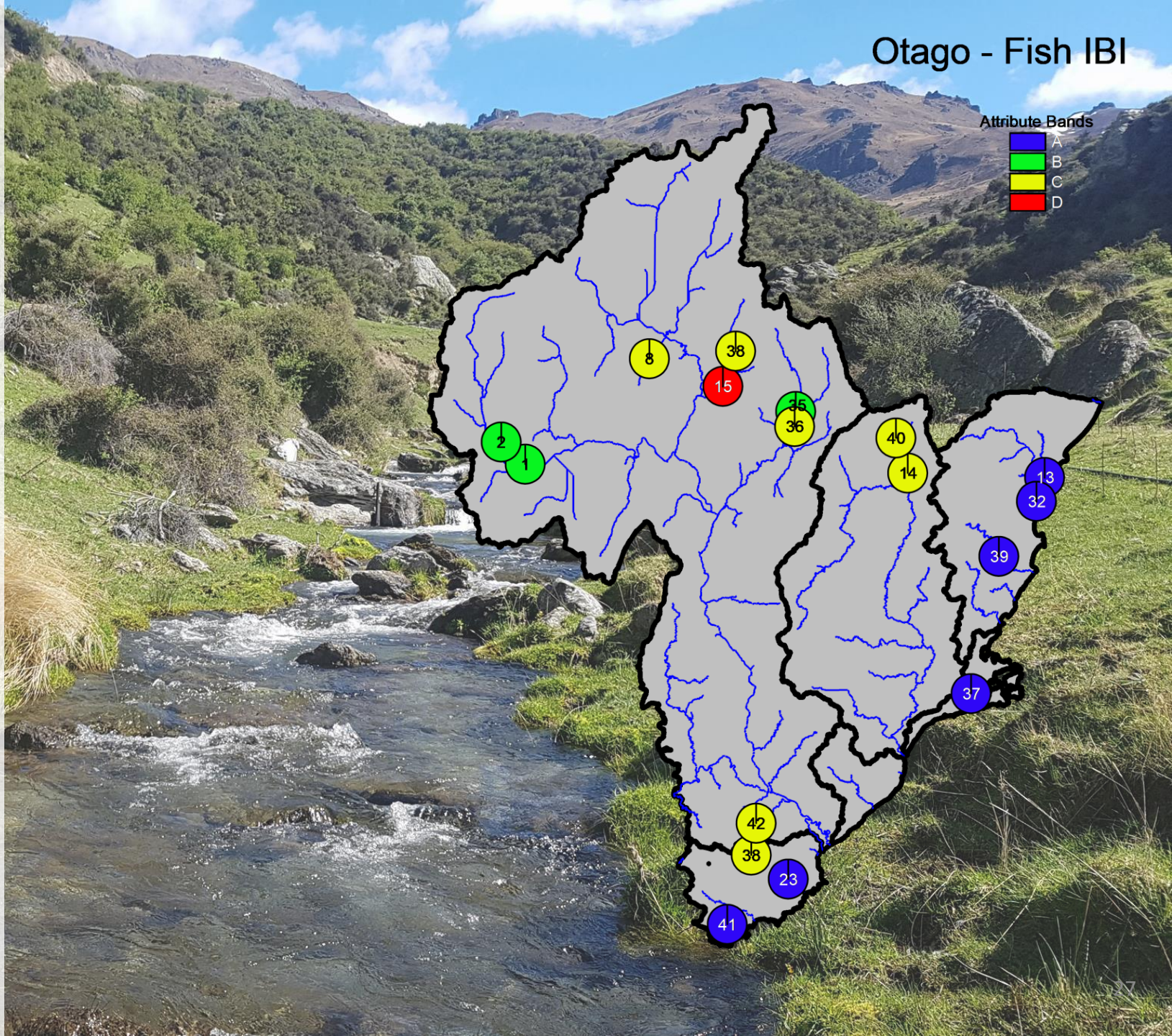
| | | % fine sediment cover | | | |
|---|---|---|---|---|---|
| | Description | Numeric attribute state by deposited sediment class | | | |
| | | 1 | 2 | 3 | 4 |
| A | Minimal impact of deposited fine sediment on instream biota. Ecological communities are similar to those observed in natural reference conditions. | ≤7 | ≤10 | ≤9 | ≤13 |
| B | Low to moderate impact of deposited fine sediment on instream biota. Abundance of sensitive macroinvertebrate species may be reduced | >7 and ≤14 | >10 and ≤19 | >9 and ≤18 | >13 and ≤19 |
| C | Moderate to high impact of deposited fine sediment on instream biota. Sensitive macroinvertebrate species may be lost. | >14 and ≤21 | >19 and ≤29 | >18 and ≤27 | >19 and ≤27 |
| | National bottom line | 21 | 29 | 27 | 27 |
| D | High impact of deposited fine sediment on instream biota. Ecological communities are significantly altered and sensitive fish and macroinvertebrate species are lost or at high risk of being lost. | >21 | >29 | >27 | >27 |

# Fish IBI(Rivers)

New Zealand's freshwater environments support more than 50 known native fish species. There is a high degree of endemism, with 92 per cent of New Zealand's named native fish species found nowhere else in the world. New Zealand's native freshwater fish species have several unusual characteristics: most are small, benthic, largely nocturnal, and more than half are diadromous (saline tolerant), moving between the sea and freshwater habitats during their lifecycle. Freshwater fish are an important component of freshwater ecosystems and a valued resource for Māori and recreational fishers. References to site numbers given on page 23.

The fish index of biotic integrity (IBI) measures the condition of fish communities at a particular site. Healthy ecosystems depend on and are characterized by a healthy and diverse fish population. Streams further from the coast show lower bands for Fish IBI than compared to streams closer to the coast. This is due to diadromous fish migrating between freshwater and the ocean, but also because human activities, such as stream bed alterations, can prevent the upstream migration of fish, lowering species diversity with distance from the coast.

| | Fish Index of Biotic Integrity (F-IBI) | |
|---|---|---|
| | Description | |
| A | High integrity of fish community. Habitat and migratory access have minimal degradation | ≥34 |
| B | Moderate integrity of fish community. Habitat and/or migratory access are reduced and show some signs of stress. | <34 and ≥28 |
| C | Low integrity of fish community. Habitat and/or migratory access is considerably impairing and stressing the community | <28 and ≥18 |
| D | Severe loss of fish community integrity. There is substantial loss of habitat and/or migratory access, causing a high level of stress on the community. | <18 |



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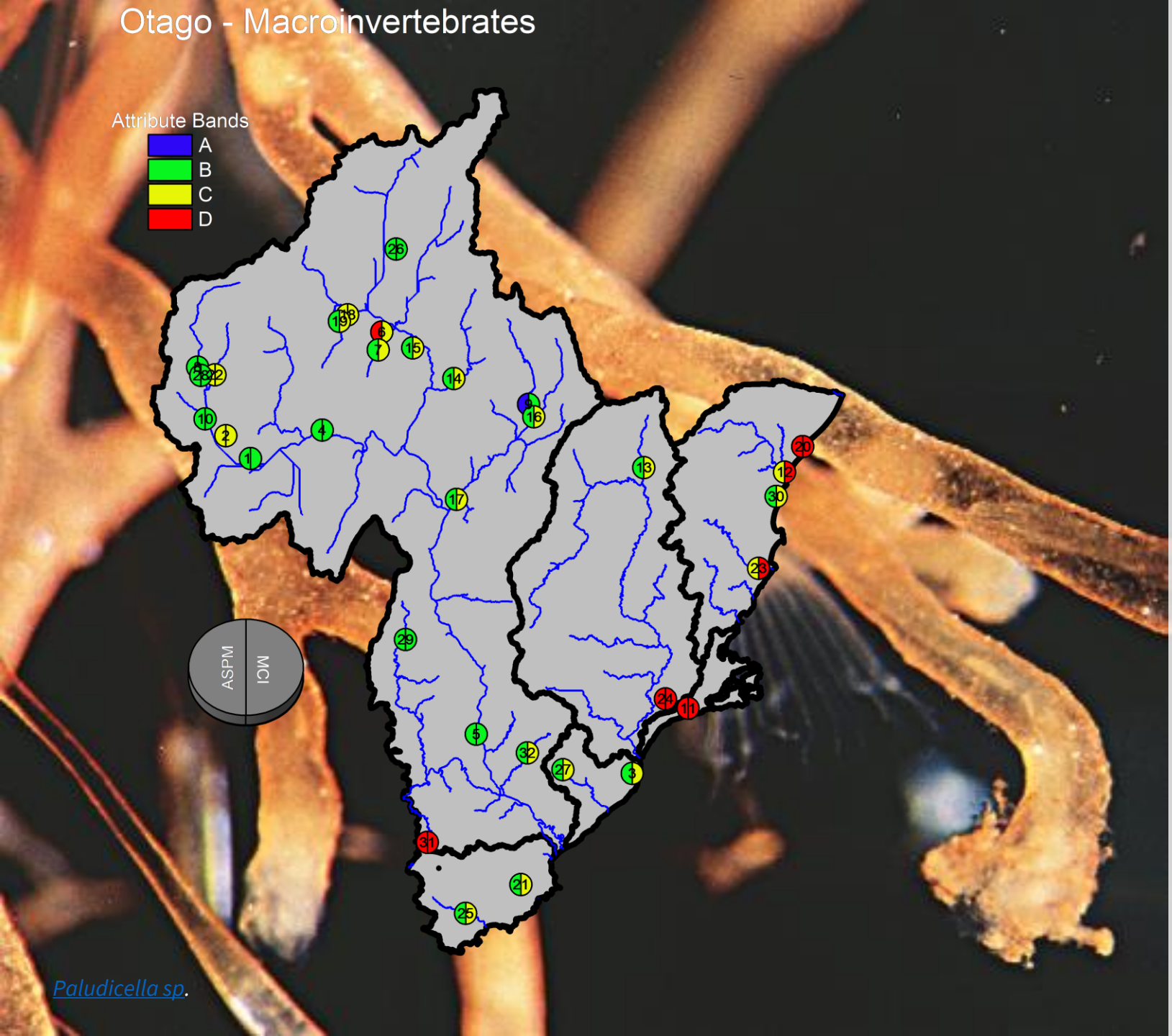
# Sampling site numbers and names seen in figures pages 23 to 26

| # | Site | # | Site |
|---|---|---|---|
| 1 | 12 Mile Creek at Glenorchy Queenstown Road | 22 | Oamaru Creek at SH1 |
| 2 | 25 Mile Creek at Glenorchy Queenstown Road | 23 | Owaka at Katea Road |
| 3 | Akatore Creek at Akatore Creek Road | 24 | Precipice Creek at Glenorchy Paradise Road |
| 4 | Arrow at Morven Ferry Road | 25 | Shag at Goodwood Pump |
| 5 | Arrow River at Arrow Gorge Track | 26 | Silverstream at Taieri Depot |
| 6 | Blackcleugh Burn at Rongahere Road | 27 | Tahakopa at Tahakopa |
| 7 | Bullock Creek at Dunmore Street Footbridge | 28 | The Neck Creek at Meads Road |
| 8 | Cardrona at Mt Barker | 29 | Tokomairiro at West Branch Bridge |
| 9 | Dart at The Hillocks | 30 | Turner Creek at Kinloch Road |
| 10 | Dunstan Creek at Beattie Road | 31 | Upper Pomahaka at Aitchison Runs Road |
| 11 | Greenstone at Greenstone Station Road | 32 | Waianakarua at Browns |
| 12 | Kaikorai Stream at Brighton Road | 33 | Waipahi at Waipahi |
| 13 | Kakanui at McCones | 34 | Waitahuna at Tweeds Bridge |
| 14 | Kye Burn at SH85 Bridge | 35 | Dunstan at St Bathans Loop Rd |
| 15 | Lindis at Ardgour Road | 36 | Dunstan U/S Confluence |
| 16 | Luggate Creek at SH6 Bridge | 37 | Leith at Dundas Street |
| 17 | Manuherikia at Blackstone Hill | 38 | Owaka at Purekireki |
| 18 | Manuherikia at Galloway | 39 | Shag at Craig Road |
| 19 | Manuherikia at Ophir | 40 | Spec Gully at Danseys Pass Road |
| 20 | Matukituki at West Wanaka Station | 41 | Tautuku D/S McLean Falls |
| 21 | Motatapu at Wanaka Mt Aspiring Road | 42 | Waiwera at Hillfoot Road |




*Paludicella sp*.

# Macroinvertebrates (Rivers)

Macroinvertebrates are animals that lack a backbone and are large enough to see with the naked eye. Examples of macroinvertebrate species in Otago include freshwater crayfish (Kōura) and mayfly larvae. Macroinvertebrates can be used as water quality indicators because different species have different pollution and nutrient tolerances. References to site numbers given on next page.

The Macroinvertebrate Community Index (MCI) is based on the tolerance or sensitivity of species to organic pollution and nutrient enrichment. Higher MCI scores indicate better stream conditions. Average Score Per Metric (ASPM): The ASPM index aggregates three other metrics that are averaged to indicate stream health. The component metrics are the MCI, the richness of Ephemeroptera, Plecoptera and Trichoptera (EPT taxa) and %EPT abundance.

NPS-FM numeric attribute states are applied here. ORC has undertaken work determining interim Otago specific attribute states for MCI in the Otago Region. Although the bottom line remains at 90MCI, it appears the A/B/C bands are naturally lower in Otago than the NPS-FM describes. Further sampling has been undertaken at 'reference' sites to validate model predictions.

| | **Macroinvertebrate Average Score Per Metric (ASPM)** | |
|---|---|---|
| | Description | ASPM |
| A | Macroinvertebrate communities have high ecological integrity, similar to that expected in reference conditions. | >0.6 |
| B | Macroinvertebrate communities have mild-to-moderate loss of ecological integrity. | >0.6 and <0.4 |
| C | Macroinvertebrate communities have moderate-to severe loss of ecological integrity. | >0.4 and <0.3 |
| | National bottom line | **0.3** |
| D | Macroinvertebrate communities have severe loss of ecological integrity. | <0.3 |
| | | |
| | **Macroinvertebrate Community Index (MCI) score** | |
| | Description | MCI |
| A | Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat. | ≥130 |
| B | Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat | ≥110 and <130 |
| C | Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or moderate alteration of the natural flow regime or habitat. | ≥90 and <110 |
| | National bottom line | **90** |
| D | Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat | <90 |

Attribute bands are calculated for the period 1st July 2018 to 30th June 2023 for all sites with a minimum sample number of 5.

Otago Regional Council

# Sampling site numbers and names seen in figure on page 28

| # | Site | # | Site |
|---|---|---|---|
| 1 | 12 Mile Creek at Glenorchy Queenstown Road | 17 | Manuherikia at Galloway |
| 2 | 25 Mile Creek at Glenorchy Queenstown Road | 18 | Matukituki at West Wānaka Station |
| 3 | Akatore Creek at Akatore Creek Road | 19 | Motatapu at Wānaka Mt Aspiring Road |
| 4 | Arrow at Morven Ferry Road | 20 | Oamaru Creek at SH1 |
| 5 | Blackcleugh Burn at Rongahere Road | 21 | Owaka at Katea Road |
| 6 | Bullock Creek at Dunmore Street Footbridge | 22 | Precipice Creek at Glenorchy Paradise Road |
| 7 | Cardrona at Mt Barker | 23 | Shag at Goodwood Pump |
| 8 | Dart at The Hillocks | 24 | Silverstream at Taieri Depot |
| 9 | Dunstan Creek at Beattie Road | 25 | Tahakopa at Tahakopa |
| 10 | Greenstone at Greenstone Station Road | 26 | The Neck Creek at Meads Road |
| 11 | Kaikorai Stream at Brighton Road | 27 | Tokomairiro at West Branch Bridge |
| 12 | Kakanui at McCones | 28 | Turner Creek at Kinloch Road |
| 13 | Kye Burn at SH85 Bridge | 29 | Upper Pomahaka at Aitchison Runs Road |
| 14 | Lindis at Ardgour Road | 30 | Waianakarua at Browns |
| 15 | Luggate Creek at SH6 Bridge | 31 | Waipahi at Waipahi |
| 16 | Manuherikia at Blackstone Hill | 32 | Waitahuna at Tweeds Bridge |

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All technical information, including band calculation, sample statistics and discussion of data, can be found here: orc-river-lake-groundwater-state-and-trends-2017-2022.pdf

| | | |
|---|---|---|
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| Jason Augspurger | Reviewer 3 | 12/04/2024 |

All photos used in this report were sourced from the ORC Daminion library.