Chatham Islands

Surface Water Summary
2021-22

Our people, our Islands, our future

chatham islands council

Environment Canterbury Science Summary:
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Key messages

- Rainfall records indicate 2021/22 had average to above average rainfall. This higher rainfall should make inroads to correcting the water deficit of the preceding two years of drought. Maintaining consistent rainfall monitoring sites particularly at Waitangi and the Airport are necessary for maintaining long term trends and management of community water supply resilience.

- Flow regimes of the major river systems are now well understood and characterised for both low flow and flood conditions. Flow monitoring of the rivers could be rationalised to monitoring priority rivers such as Te Awainanga and Nairn Rivers that provide significant resources and management issues.

- Poor and degrading water quality of waters across the island are likely caused primarily by climate patterns (preceding drought) although changing farming emphasis to heavier livestock (sheep to cattle) appear to strongly interact with climate particularly where organic (peat) soils are poor at supporting heavier animals and contribute to erosion, pugging, compaction and casualty animal effects.

- Reduction in state or degrading trends had reduced at some sites but were particularly notable at key sites. Blind Jims Creek is no longer degrading but still exhibited both poor water quality, impacted riparian habitats and an accompanying poor water quality in the Te Whanga receiving environment. Mangape Creek has stabilised but in the lower reaches of the Nairn River it discharges to are showing effects of anoxic water, increasing nutrient concentrations and high microbiological concentrations. These catchments show conspicuous effects and a high water quality risk profile and deserve attention to identify any at-risk contaminant sources and more scrutiny of riparian and river management.

- The degrading water quality of Lake Rangitai is highly likely to be a result of the previous greatly reducing area of this lake as it is highly abstracted from for stock water and domestic water use for the township of Kaingaroa. These water resources were largely being mined under sustained drought conditions, and as the lake becomes relatively small and shallow the water quality degrades and becomes less suitable for its uses. Despite a higher rainfall period the lake water quality has not appreciably improved. More careful or strategic management of this water resource is warranted.

- Te Whanga lagoon is a highly visible and important taonga or community asset. The very likely increasing trends in nitrogen, phosphorus and DOC in the lagoon are therefore of some notable concern. Scrutiny of these water quality results and trends for freshwaters in and flowing into Te Whanga lagoon should not be ignored.

- Closer attention to monitoring the limited domestic and potable water resources of the island are warranted including scoping monitoring of the groundwater resources and assessing the capacity of potential potable water resources.

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1 Introduction

Chatham Islands Council (CIC) is a unitary authority, acting as both a regional and a local council set up under its own act of parliament. Environment Canterbury (ECan) has been contracted since 2005 to provide advice and services to help CIC meet their Regional Council obligations including freshwater management. The water quality monitoring of the islands has been reported regularly via annual summary reports (2007, 2005-2010, 2014, 2015, 2016, 2018, 2021). These are available on the CIC website (https://cic.govt.nz/services/environmental-data/water-quality-data/). Another study undertaken with concurrent gauging's showed the correlations between flow rate for smaller streams (Ritson, 2010). Recently, Pattle Delamore Partners (PDP 2020), was engaged to undertake a review and report of the environmental monitoring on Chatham Island, including both water quality and historical qualitative and quantitative hydrological data (https://cic.govt.nz/services/environmental-data/water-quality-data/) and climate records. Since then, a further report has provided an update for the hydrological year 2020/21 (Meredith *et al.,* 2023). This current report provides a further update of surface water monitoring (both water quality, quantity, and rainfall) state and trends for the main Chatham Island for the 2021-2022 year. Other islands such as the permanently occupied Pitt Island has not been monitored in this programme. A commentary is provided on the likely influences of any trends or changes in water quality and quantity state identified.

The Chatham Islands form an archipelago of 10 islands with an approximate 60 km radius, these islands were formed from a volcanic upthrust causing the catchment geology to consist of volcanic basalt, unconsolidated sand, limestone, and schist. This is overlain with peat, sand, mudstone, and silt (GNS, 2014). Up to 60% of the main island, Chatham Island, is covered in peat or peat derived soils, ranging in thickness from half a metre to over 10 metres deep (Figure 1-1).

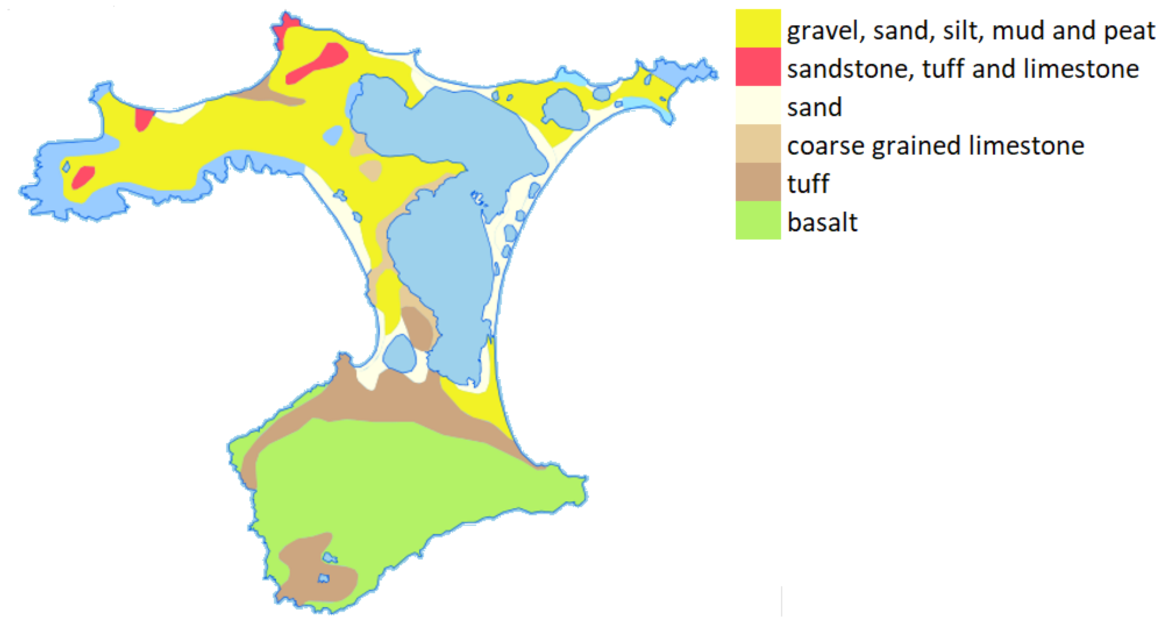

Figure 1-1: A map of Chatham Island with an overlay of the land type from the GNS - geological map of New Zealand 1:250k (GNS, 2014)

Many of the watercourses on Chatham Island drain peat basins, are highly peat stained and often have consolidated or mobile peat bed materials. The peatlands can buffer extreme weather patterns and rainfall events by acting like a sponge (rapidly absorbing and more slowly releasing water). This peat nature dominates both the resulting flow regime and water quality of the streams and rivers. These waterways are therefore a dominant and conspicuous part of the Chatham Islands environment. However, they currently provide very little contribution to developed and used water resources. These waters are not generally of suitable potable or domestic use standard, do not provide for high recreational or amenity uses, and are currently not developed for any industrial uses. They are utilised as an opportunistic livestock drinking water resource (stock water) and support the natural aquatic ecology of the island including supporting gathered foods and resources (mahinga kai) including eels (tuna). There are no introduced sports fish or pest fish species in island waterways. There is very little, if any, water use (water allocation for abstraction) pressure on these resources, little scope for major engineering developments (damming, diversion or channelisation), and little concern for discharge of toxic contaminants generating water quality concerns or achievement of better than national bottom lines (targets).

The 160 km^2 Te Whanga Lagoon in the northern part of the island accounts for approximately 20% of the total area of Chatham Island. It is of comparable size to other large coastal lagoons in New Zealand (e.g., Te Waihora/Lake Ellesmere). It is enclosed by sand dunes to the north and east and operates as a large shallow coastal lake or lagoon system. It both naturally opens to the sea through a sand barrier beach, and it is occasionally necessary to mechanically be opened to the sea to prevent excessive water levels damaging roading and land infrastructure. Te Whanga lagoon is currently considered to be a brackish water lagoon with salinity up to 50% seawater. It was last mechanically opened in 2019 (Owen Pickles- CIC, pers. comm.).

The freshwaters of the Chatham Islands that are clear water and potentially suitable for potable, domestic, and commercial use are largely restricted to the water contained within sand dune lakes along the western coast (Lake Marakapia, Tennants Lake etc.) and in the north (Lake Rangitai); groundwater seeps from the steeper basaltic geology of the island, some limited groundwater aquifers associated with the dune formations or limestone sand strata; and collected rainfall. This limited presence of domestic quality freshwater resources results in widespread collection and storage of roof water runoff from rainfall for domestic use outside the main townships. These limited natural potable freshwater resources are generally only under pressure during annual or sustained drought periods when rainfall collection or aquifer and lake recharge are depleted. It is therefore important that these important freshwater resources are well represented in monitoring activities to ensure their effective management and protection.

To date, monitoring of the waters of the Chatham Islands have not significantly distinguished between the different water quality and waterbody types and have largely focussed on monitoring major surface water bodies representing all parts of the island. No monitoring of water is undertaken on Pitt Island or any of the other offshore islands. The purpose of this water quality summary is to update and review the current water quality state and long-term trends of the sites monitored on the Chatham Islands and give some commentary on probable cause of any change in state or trend. It is also timely to consider whether the current monitoring strategy is providing the appropriate information necessary for water use and management on the island.

There are six Environment Canterbury operated rainfall stations, three in the northern part of the island and three in the south of the island and one other, the nationally monitored site at the airfield (Figure 4-1). Chatham Island also has four long term flow recorders on the four largest surface water drainages (rivers) on the island. Three flow recorder sites sit alongside rainfall sensors; one of these flow recorders is on the northern half of the island and three are on the southern part of the island (Figure 4-1). The recorders measure the water height and then convert it to flow using information from the river profile, which is collected every time the river is gauged (generally 4 to 6 times per year). It is important to consider the value of the ongoing maintenance of these recorders. Their maintenance would normally be considered imperative in most areas of NZ as they would form important functions in flood hazard warning, managing water use limitations at low flow times, and so that we can establish long term trends and determine whether there are any natural or anthropogenic influences on river flow requiring clarification or management. However, many of these functions may be of lesser or limited relevance to an island environment such as the Chatham Islands. The short length and low proximity of infrastructure to the rivers make active or responsive flood hazard management on individual rainfall events a lesser function than in large catchments such as in mainland New Zealand. Furthermore, most stream and river road crossings were nationally funded to be updated to modern high flow capacity culvert crossings in the 2000s. The very low abstractive water use may also make low flow monitoring a similarly low priority function at present. There may already be adequate data to describe the flow regimes and enable future functions to be considered from this current level of understanding without continuing this level of monitoring indefinitely.

The water levels of the major dune lakes have recently begun to be monitored but are not yet reported here. This data will in future enable assessment of the resource and potential sustainable water yield. The groundwater resource is not currently routinely monitored, but recently the available information on the development of groundwater resources (bores and wells) have been gathered, and some one-off measurements of bore characteristics of private bores undertaken (water depth, water quality). It is hoped to incorporate regular groundwater monitoring and assessment of the sustainable groundwater resource in this programme in the future.

2 Methodology and Data analysis

2.1 Water Quality Data

Long term water quality monitoring data is collected quarterly from 22 stream, lake, and lagoon sites across the main island of the Chatham Islands (Figure **Error! Reference source not found.**2-1, Table 2-1). The streams and rivers are sampled at single easily accessible locations near the lower end of their length. The lakes are also sampled from easily accessible lake edge sites by wading rather than by boat. Te Whanga lagoon is also sampled from the lagoon edge by wading at three distinct locations representing the three main basins. Sampling began in 2005 for most of the sites, excluding Nairn River and Te Whanga Lagoon at the Southern Basin, which were first sampled in 2006.

Current water quality state was determined using the most recent five years of water quality monitoring data (July 2017 to June 2022). Long term trends were assessed using the previous ten years of available monitoring data (2012 – 2022).

Table 2-1: Site list and IDs for the Chatham Islands

Site ID	Site Name	Site ID	Site Name
SQ34829	Awamata Stm	SQ34860	Waitāmaki Ck
SQ34830	Awatōtara Ck	SQ34834	Washout Ck
SQ34844	Blind Jim’s Ck	SQ34838	Whangamoe Inlet Stm
SQ34854	Mangahōu Stm	SQ34859	Lake Hurō
SQ34851	Mangapē Ck	SQ34893	Lake Marakapia
SQ35078	Nairn River	SQ34846	Lake Rangitai
SQ34841	North Trib Rakautahi	SQ34887	Lake Te Wāpu
SQ34832	Te Awainanga River	SQ34842	Tennants Lake
SQ34857	Te One Ck	SQ35082	Te Whanga Southern
SQ34863	Waimāhana Ck	SQ34843	Te Whanga Blind Jim’s
SQ34849	Waitaha Ck	SQ34861	Te Whanga Waitāmaki

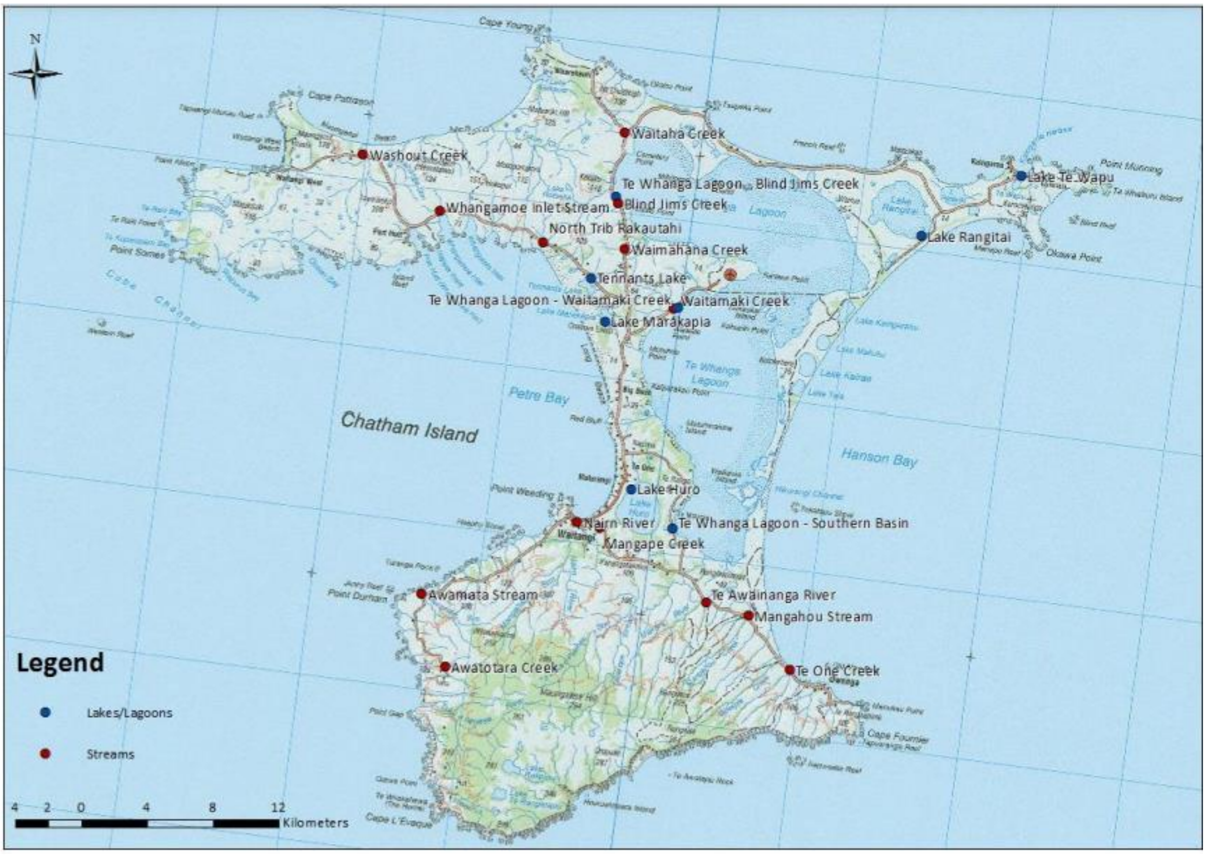

Figure 2-1: Map of Chatham Island showing the river, stream, lake and lagoon water quality monitoring sites

Censored data (values outside of laboratory minimum and maximum detection limits) were adjusted before analysis using the following method. Each parameter at each site has been assessed separately. If 70% or more of any parameter values at a site were censored, that specific site was removed from that measurement analysis as unreliable. If less than 70% of the values were censored, and censored values were below detection, the censored values were converted to half of the highest censored value. Where measured results fell below the highest censored value, the measured result was also included as 'censored' and was converted. There were no values higher than the maximum laboratory value. The issues with censoring of dissolved inorganic nitrogen values are discussed further in section 3.5.2.

The current state data is presented as box and whisker plots of the data distribution displaying the variation in monitoring data over the past five years (where censored data < 70%). For long term trends each parameter at each site was required to have at least 80% available data (no more than 20% missing values). As the Chatham Island sites are only sampled quarterly, there needed to be at least 32 samples over a ten-year period to be considered suitable for determination of long-term trends. Calculations for long term trends were performed using Python software. Long term trends displayed in the relevant section were analysed and reported using Land, Air and Water Aotearoa (LAWA) trend likelihoods.

Trophic Level Index (TLI) values have been calculated for lake and lagoon sites on the Chatham Islands using methods defined in Burns *et al.* (1999). Secchi disk was not able to be measured and so is not included in calculations. This is because sampling is from the lake edges where secchi cannot be readily carried out. TLI therefore does not include Secchi disk measurements and is reported as a TLI3 index.

The Trophic Level Index relies on close correlation between 4 algal biomass attributes. However, reduced water clarity of the Chatham Island lakes is primarily caused by wind resuspension of bed sediments, or from high dissolved colour and suspended peat in peat lakes. Reduced water clarity may not be a result of eutrophication and would correlate poorly with the other TLI biomass attributes - nutrient concentrations and algal biomass. The approach of not including a clarity component in TLI was therefore considered appropriate for lakes of Chatham Island.

2.2 Hydrology Data

2.2.1 Rainfall

NIWA has generated Chatham Island rainfall data from 1956 but there has not been one continuous record, the historical stations have been discontinued and new stations have replaced them, often they're in the same location with most located either near the airport or Waitangi township.

To create a continuous long-term rainfall record on Chatham Island, three historical NIWA stations were combined. Chatham Islands Aws (986105) and the historical NIWA Waitangi site (K98601) were located near Waitangi, the largest settlement on the island, and Chatham Islands Ews (986106) was located close to the airport (Figure 2-2). The NIWA site Chatham Islands Aero Aws (986107) was recording alongside Chatham Islands Ews from 2012 to 2018 and is also located near the airport.

The rainfall at Chatham Islands Aws and Chatham Islands Ews (Waitangi and the Airport) correlated reasonably well with comparable rainfall in wetter years between 2000 – 2008 (Ritson, 2010). The NIWA Waitangi station and Chatham Islands Aws were recording in the same location and therefore the NIWA Waitangi station and The Chatham Islands Ews stations should have correlated similarly. The Environment Canterbury rainfall stations have been assigned site IDs which have been kept in line with the labelling of the NIWA sites (Table 2-2).

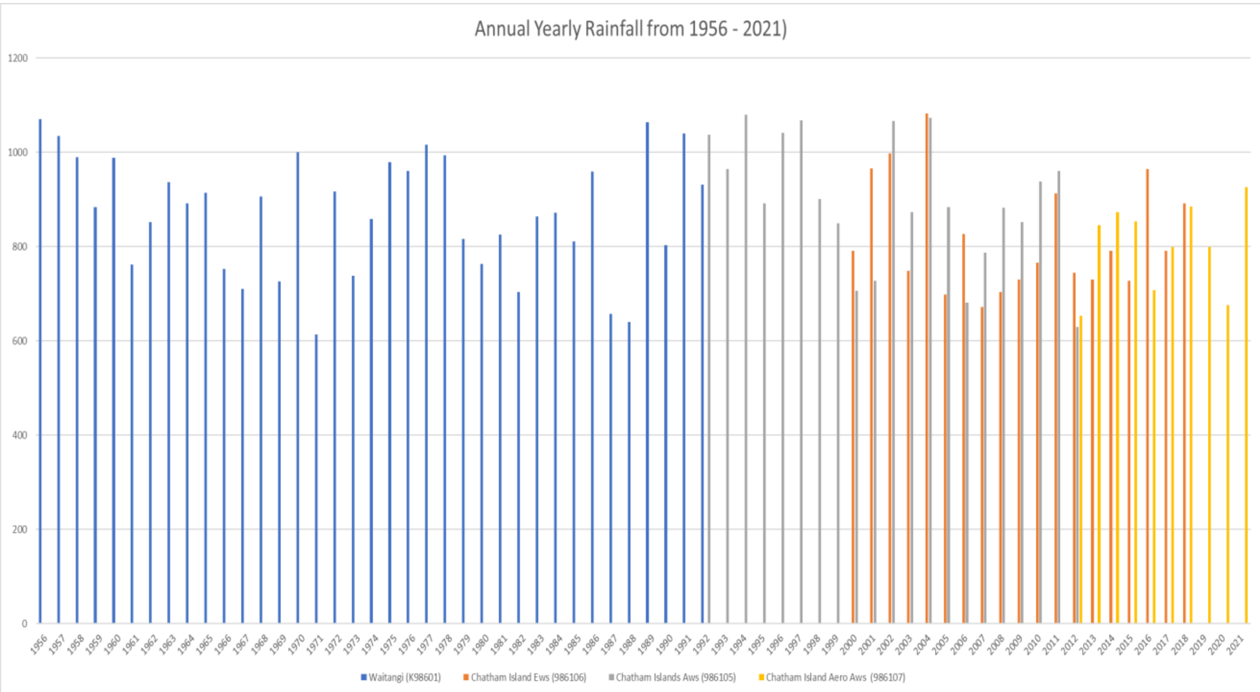

Figure 2-2: Rainfall at four NIWA stations across Chatham Island from 1956 to 2021

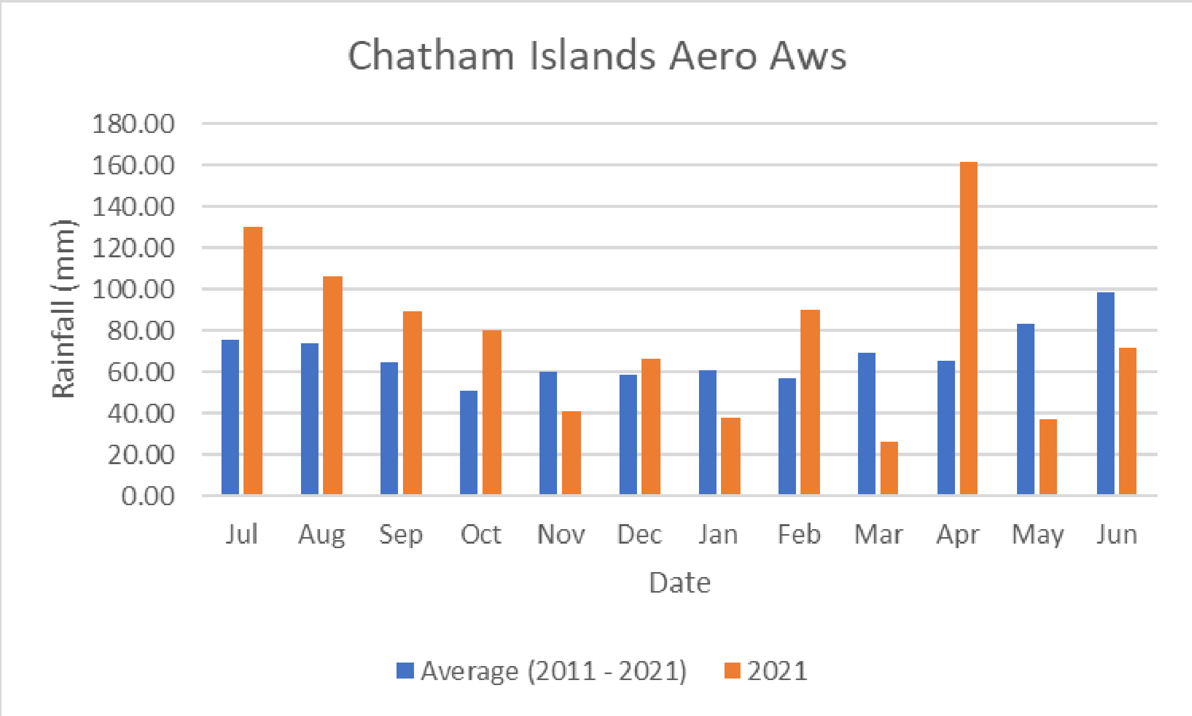

Figure 2-3: Total monthly rainfall (mm) at the national Chatham Islands Aero Aws station (986107) for the 2021 hydrological year and the average rainfall from 2011 – 2021

The rainfall at Chatham Islands Aws and Chatham Islands Ews correlated reasonably well with comparable rainfall in wetter years between 2000 – 2008 (Ritson, 2010) The NIWA Waitangi station and Chatham Islands Aws were recording in the same location and therefore the NIWA Waitangi station and The Chatham Islands Ews stations may have correlated similarly. The Environment Canterbury rainfall stations have been assigned site IDs which have been kept in line with the labelling of the NIWA sites (Table 2-2).

The NIWA Aero Aws site can be used to illustrate seasonal rainfall patterns (Figure 2-3). These can be compared to rainfall at the Environment Canterbury sites (later in this report). However, they show distinct seasonal rainfall patterns at the airfield with wetter than average winter/spring period and a wet months in February and April. There were five dry months in summer and autumn, but overall, the cumulative rainfall reflected an average rainfall year following the two previous dry years.

Table 2-2: Site names and numbers for flow and rainfall

	Rainfall ID	Flow ID
Chatham Island Aero Aws (NIWA)	986107	
The Landing at Muirsons	986206	
Waitangi at Met Station	986207	
Wharekauri at Tonys	986205	
Te Awainanga at John Days	986109	
Te Awainanga at Falls		3446051
Tutuiri River at Shists Outcrop	986108	3436871
Awamata at Old Hydro Intake	986200	3446071

2.2.2 Flow

Site visits and gauging at the Chatham Island sites typically occur quarterly, during these visits the water level recorders are assessed, and the water courses are gauged. By using the relationship between the gauging and the water level, we can determine the flow rate of the water course.

Logistically, it is difficult to get gauging's at different flows but ideally gauging's are undertaken through a range of flows including both low and normal flow conditions. It may be difficult to schedule visits during high flow times and may be unsafe to gauge in high flow situations (Pattle Delamore Partners Ltd, 2020). During the 2021 hydrological year there were five visits to the Chatham Islands, however, Te Awainanga and Tuku a Tamatea Rivers were only gauged two and three times respectively.

The National Environmental Monitoring Standard (NEMS) require gauging's to occur at sufficient intervals to maintain an accurate stage – discharge rating curve and to detect when this relationship may have changed. The gauging frequency may vary year to year but there cannot be an interval greater than 9 months in natural channels. At a site where there is a stable natural control gauging frequency can be reduced provided that the rating is well established and is checked within one month of any event that is likely to affect the rating (National Environmental Monitoring Standard, 2019).

3 Water Quality

3.1 Dissolved oxygen

Lakes, and Te Whanga Lagoon on Chatham Island are generally well oxygenated, generally above 80% saturation, while the oxygen concentrations of streams are more variable (Figure 3-1, Figure 3-2 and Appendix A). Sites in Te Whanga lagoon at Blind Jims and Southern both showed a high range of dissolved oxygen and on occasion above 150% saturation. This indicates a likely high algal biomass with high oxygen generation in daylight (photosynthesis) and lower concentrations (respiration) at night. These may reflect a degree of eutrophication.

The six larger streams and rivers maintain high oxygen concentrations (generally above 80% saturation). This reflects high reaeration from significant turbulent flow over bedrock and rougher terrain. The other seven streams had lower and much greater ranges of dissolved oxygen, often as low as 0% saturation. These streams drain peat basins and so contain high biochemical oxygen demand from dissolved and particulate peat materials and reflect sluggish flow through peaty wetland-like flow paths. This can be exacerbated by pugging and erosion of stream margins by livestock access.

Washout Creek and Whangamoe Inlet Stream have previously recorded very low dissolved oxygen (DO) % saturation, and Washout Creek has remained reasonably stable with consistently low DO% over the past ten years. Mangapē Creek and Waitāmaki Creek have continued to record the lower concentrations of dissolved oxygen over the past year or two than had previously been recorded.

Trend analysis indicate three streams that have significantly decreasing dissolved oxygen concentration (DO % saturation). Mangapē Creek, the North Tributary of Rakautahi Stream and Waitāmaki Creek are all likely decreasing in DO%. Washout Creek is likely increasing in DO% (getting better). Te Whanga lagoon near Blind Jims Creek and Lake Rangitai have a very likely decreasing trend in dissolved oxygen.

These dissolved oxygen patterns and trends are similar to the 2020-21-year results and may still be associated with the 2019-20 and 2020-21 years being often dryer (drought conditions) than normal and so with lower and more sluggish flows in streams (particularly from the peat basins). There may also be more pugging of stream margins generating less well-defined drainage as access to flowing water for livestock may have become more difficult.

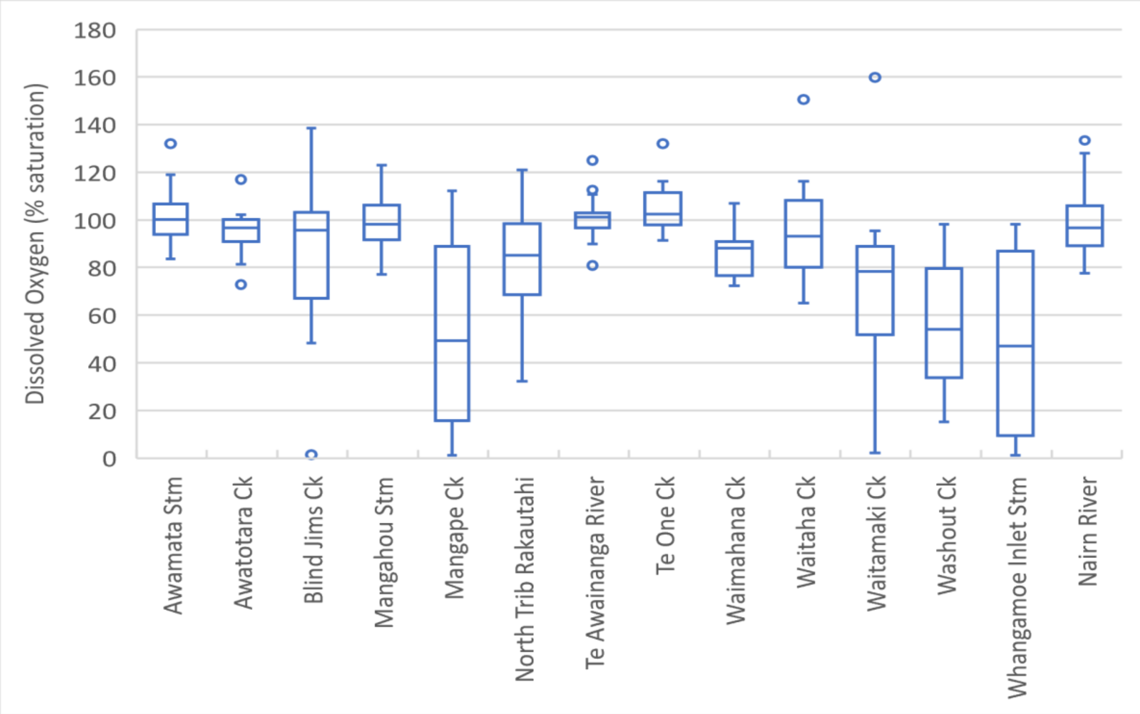

Figure 3-1: Current state of dissolved oxygen for monitored river sites on Chatham Island

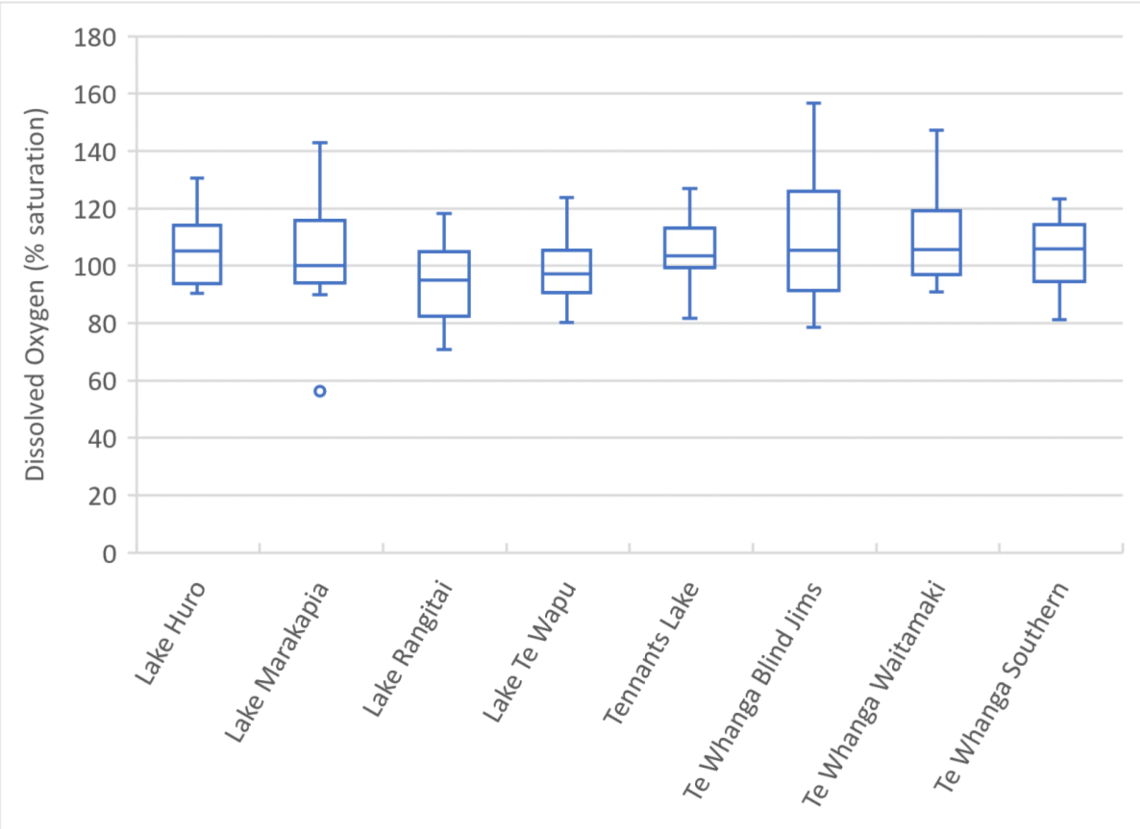

Figure 3-2: Current state of dissolved oxygen for monitored lake sites on Chatham Island

3.2 Water temperature

Water temperature ranges varied greatly between sites (Figure 3-3). This is likely to be due to considerable difference in degree of shading and exposure to sunlight across different drainages on the island. The drainage or flow rate may also have been reduced giving more time for solar heating of waterways. Awatotara and Waimahana creeks were the coolest streams and with the lowest temperature ranges and correspondingly are the most forested sites. Blind Jims Creek was the warmest stream (maximum of 24°C) and with a high seasonal temperature range. This is an open more regularly grazed peat basin stream with high exposure to sunlight. Increased peat discolouration may also influence (increase) the degree of solar heating of streams. In 2020/21 many streams recorded very likely increasing trends in water temperature (Appendix A), but in 20212/22 water temperature showed neither an increasing nor decreasing trend. This illustrates that the warm and low flow drought period appeared to be coming to an end in 2021/22.

Many of the lakes continued to show peak summer temperatures as high as 24 or 25°C (Figure 3-4). However, these lakes were no-longer showing increasing trends in water temperature (Appendix A). These high peak temperatures continue to be of concern and may put the ecology (fishes and other aquatic life) of the lakes at risk. However, the end of the current drought period has seen temperatures ceasing to show increasing trends.

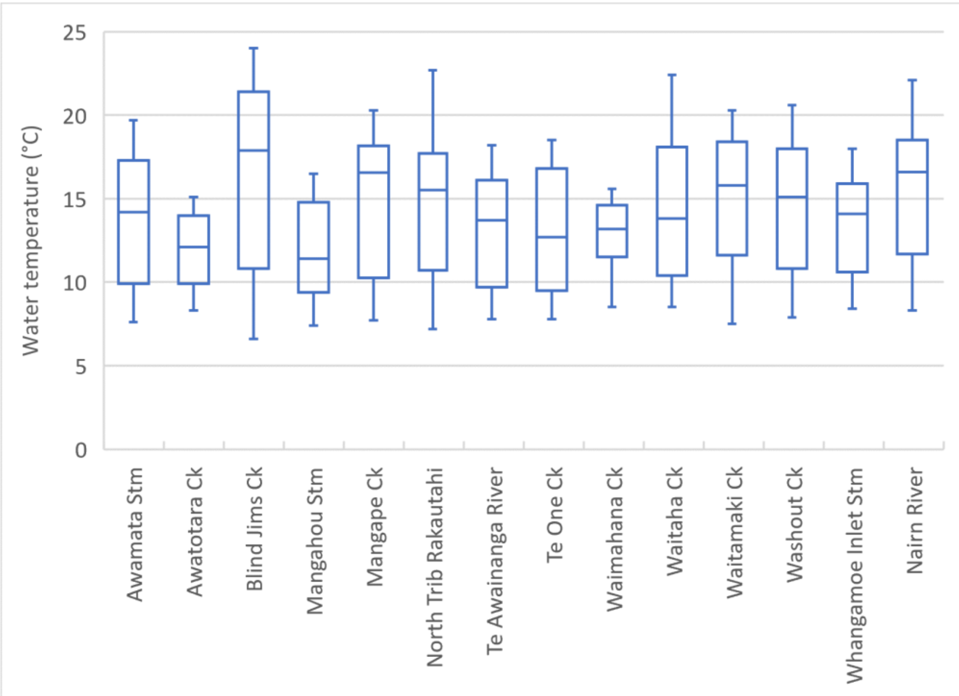

Figure 3-3: Current state of water temperature for monitored river sites on Chatham Island

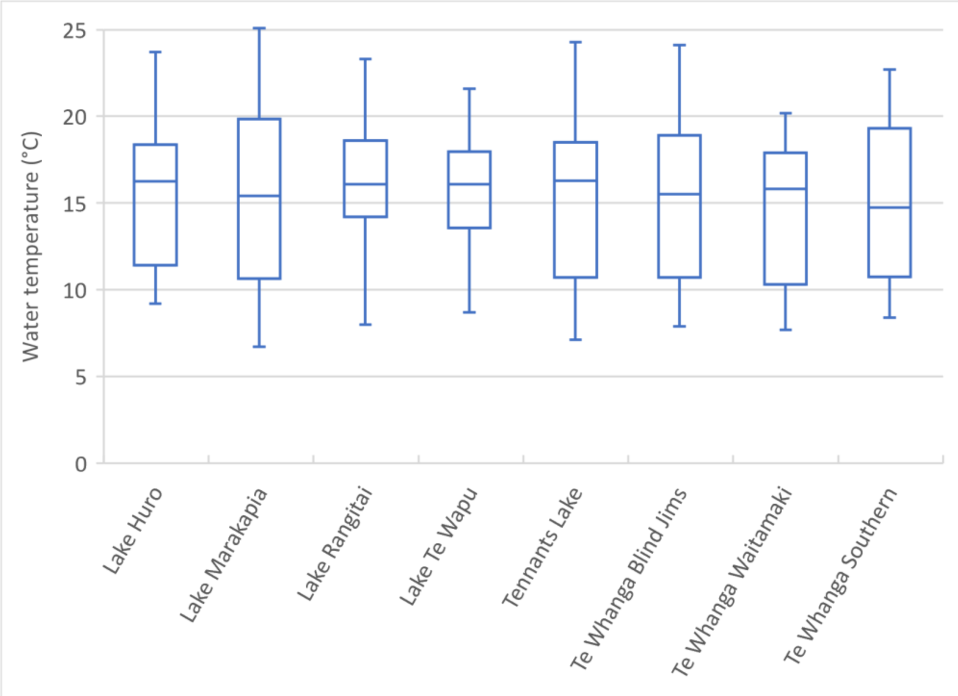

Figure 3-4: Current state of water temperature for monitored lake sites on Chatham Island

3.3 pH

Water acidity (pH) of Chatham Island was measured in-situ by field technicians until June 2013 using YSI field meters. All pH measurements after June 2013 were undertaken by R J Hill Laboratories Limited (Hills) from stored samples. To produce long term trends for pH, field and laboratory measurements have been combined. Due to a difference in methods and the time samples take to arrive at Hills, the data may vary between these timeframes and these comparisons should be treated with caution.

The pH of Chatham Island streams varied greatly in both median pH and range (Figure 3-5). The acidic pH levels of many streams are due to the drainage from naturally acidic peat soils, but Chatham Island peats are not as naturally acidic as peat in many other parts of the country. For example, Awatotara Creek on the south of the island has very acidic water in the range 4-5 while peat streams on the north of the island (i.e., Blind Jims Creek and Mangape Creek) were consistently alkaline. These differences may also be associated with the prevalence of limestone in the catchments buffering the pH. (Appendix A, **Error! Reference source not found.**).

The pH of the monitored lakes and lagoon sites are all alkaline and similar with median pH ranging from 8-9 (Figure 3-6). There are no significant long-term trends for pH at any stream or lake sites on Chatham Island (Appendix A).

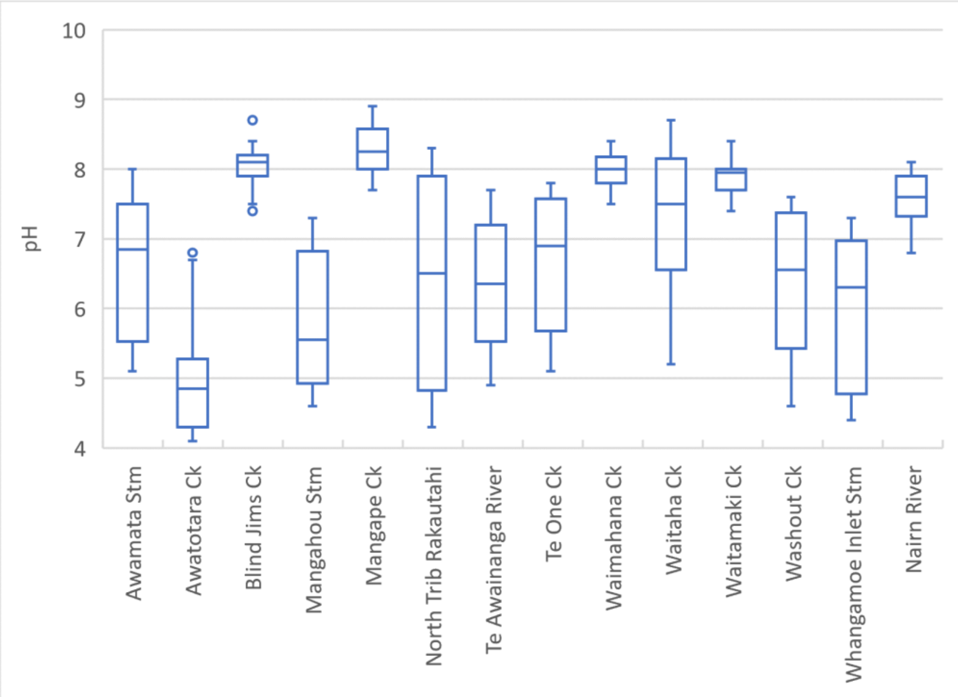

Figure 3-5: Current state of pH for monitored river sites on the Chatham Island

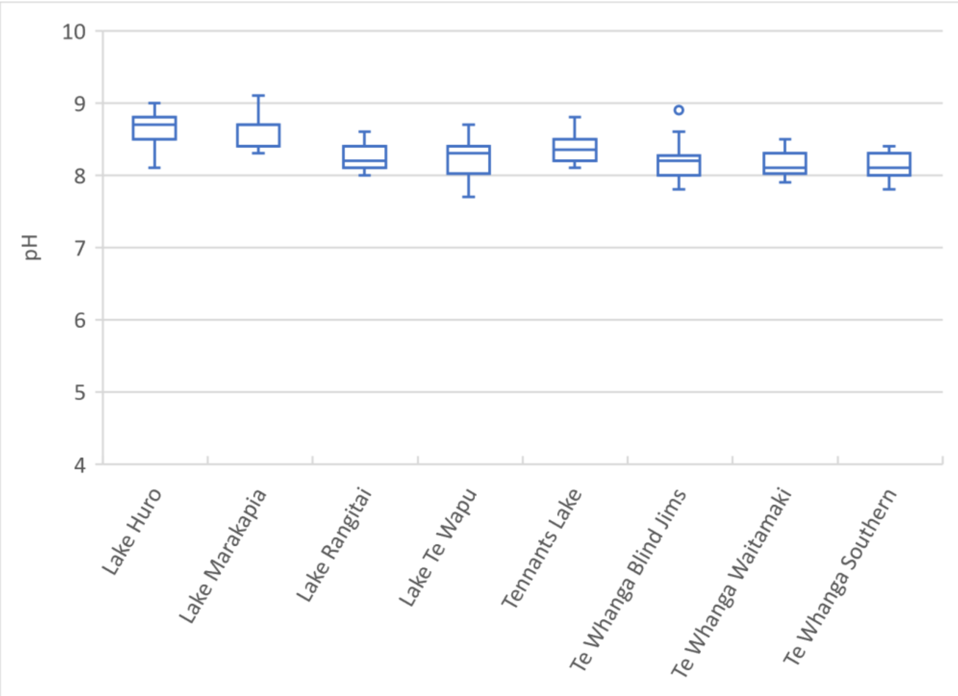

Figure 3-6: Current state of pH for monitored lake sites on Chatham Island

3.4 Dissolved organic carbon

Dissolved organic carbon concentrations (DOC) are measured as an indication of the degree of dissolved peat/peat staining of waterways. DOC median concentration and range varies greatly between the streams on Chatham Island (Appendix A, Figure 3-7). Blind Jim's Creek, Mangapē Creek, Waitāmaki Creek, and Waimāhana Creek are the clearest water but still with appreciable DOC (visible discolouration) compared to streams in mainland New Zealand. The other rivers and streams were much more strongly coloured by DOC concentrations.

Many of the streams continue to show increasing trends for DOC concentration, except Mangapē and Waimāhana Creeks, which had no (indeterminate) trend (Appendix A). Again, these generally increasing trends in DOC concentration may be associated with lower flows associated with the previous dry climate period leading up to and including 2021. Under drought conditions there is likely to be increased time for leaching of highly coloured peat materials and less dilution with rainfall runoff.

The monitored lake and lagoon sites have much lower concentrations of DOC than the streams, excepting Lake Te Wapu (Figure 3-8). However, we no longer monitor many of the more highly peat-stained lakes of Chatham Island. Most lake and lagoon sites had increasing DOC concentrations (Appendix A). Lake Te Wāpu and Te Whanga Lagoon at the Southern Basin have decreasing trends over time. Lake Hurō has no significant long-term trend (Appendix A). These trends may also be associated with the previous dry climate period up to and including 2021 that allowed peat materials to settle and oxidise.

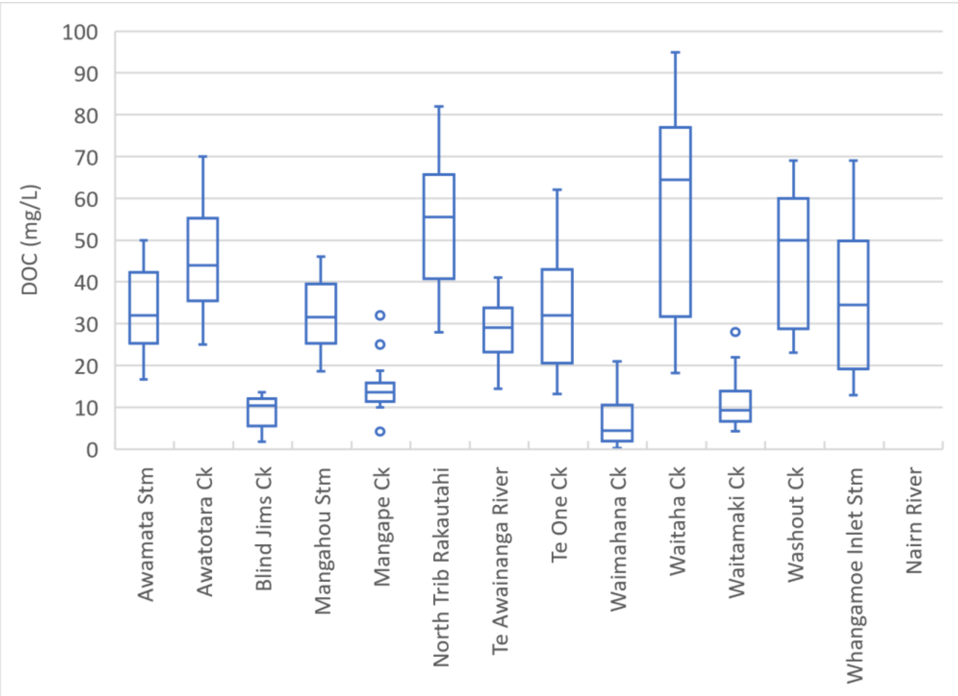

Figure 3-7: Current state of dissolved organic carbon (DOC) for monitored river sites on Chatham Island

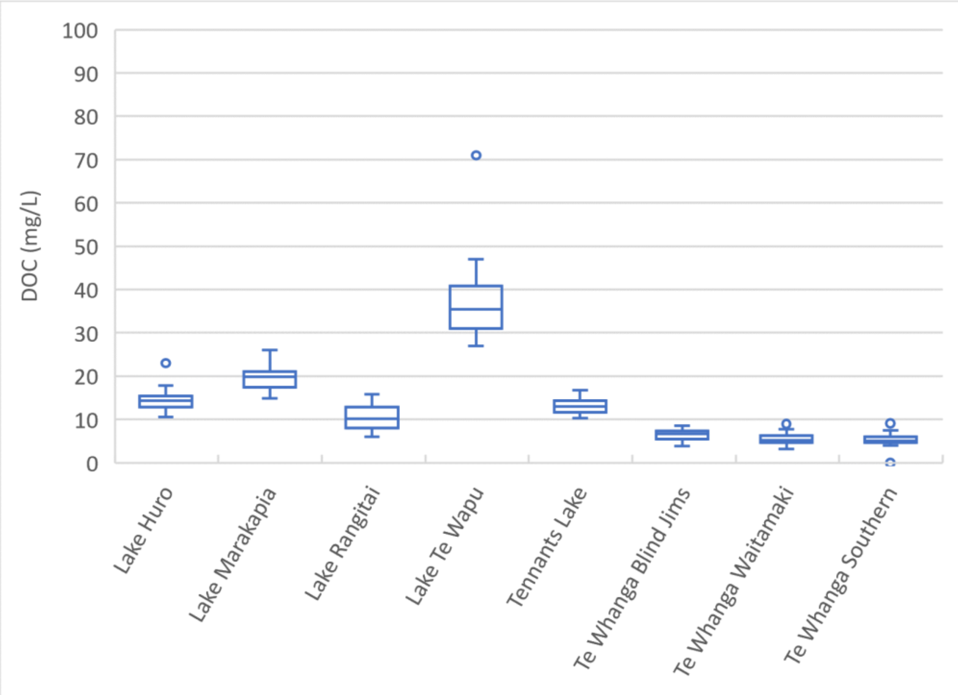

Figure 3-8: Current state of dissolved organic carbon (DOC) for monitored lake sites on Chatham Island

3.5 Nutrients

3.5.1 Phosphorus

Washout Creek, Waimāhana Creek, Mangapē Creek and generally creeks on the north of the island have the highest concentrations of both dissolved reactive phosphorus (DRP) and total phosphorus (TP) (Figure 3-9 and Figure 3-12). This may reflect the differing geology on the north of the island compared to the basaltic geology in the south. Mangapē Creek and Te Awainanga River continue to have increasing DRP and TP trends, other streams on the Chatham Islands either have no significant trends or have decreasing DRP concentrations (Appendix A). These trends may have a number of likely causes, but again may be following the preceding dry climate period from 2019 to 2021. In some waterways the natural phosphorus concentrations may not be being diluted as effectively by rainfall runoff, but in other streams increasing growth of macrophytes and mosses may be taking up more of the natural phosphorus of the island's geology.

DRP and TP concentrations in the Chatham Island lakes were consistently low (Figures 3-10 and 3-12). This is not surprising with many lakes being phosphorus limited and sequestering all available phosphorus in bed sediments or algae. Te Whanga Lagoon sites still had an increasing dissolved DRP trend (very likely increasing) but a decreasing TP trend (Appendix A). This may be influenced by the brackish (marine) nature of the lagoon with seawater being more phosphorus rich and nitrogen poor. Lake Marakapia and Tennants Lake continued to have increasing TP trends possibly reflecting the lakes becoming increasingly eutrophic as a result of the lowered lake levels and nutrient recycling.

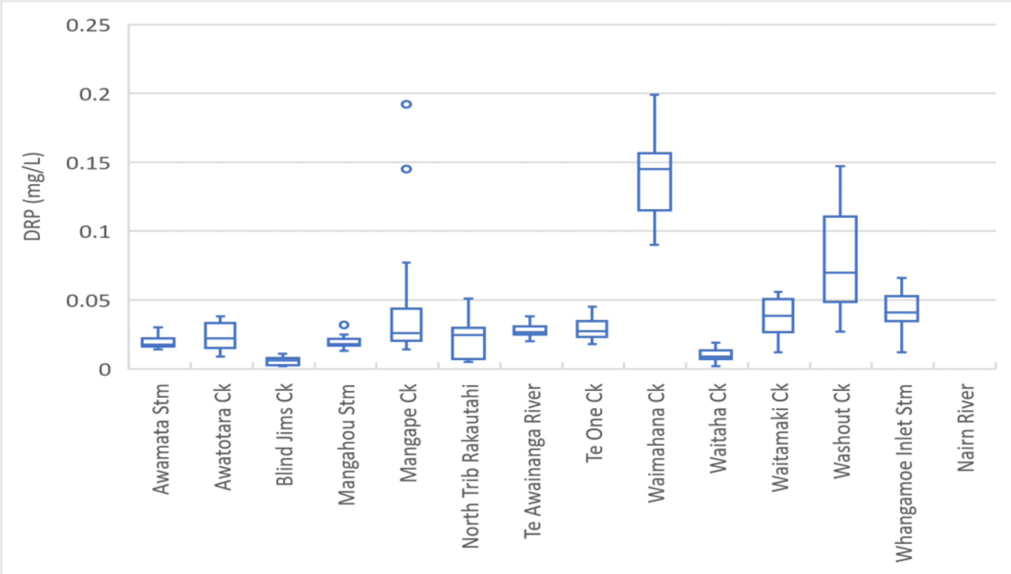

Figure 3-9: Current state of dissolved reactive phosphorus for monitored river sites on the Chatham Island

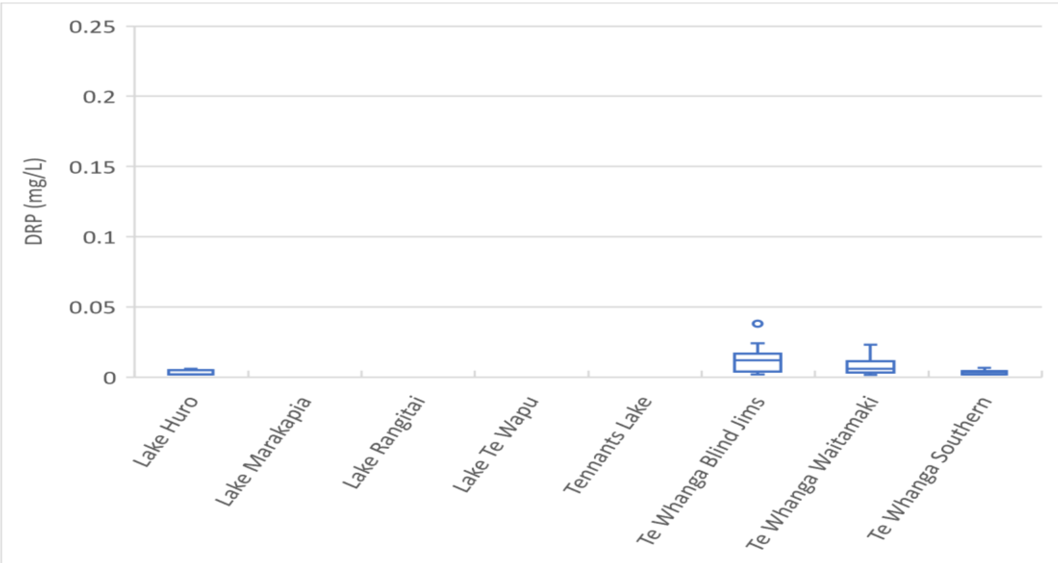

Figure 3-10: Current state of dissolved reactive phosphorus for monitored lake sites on the Chatham Island

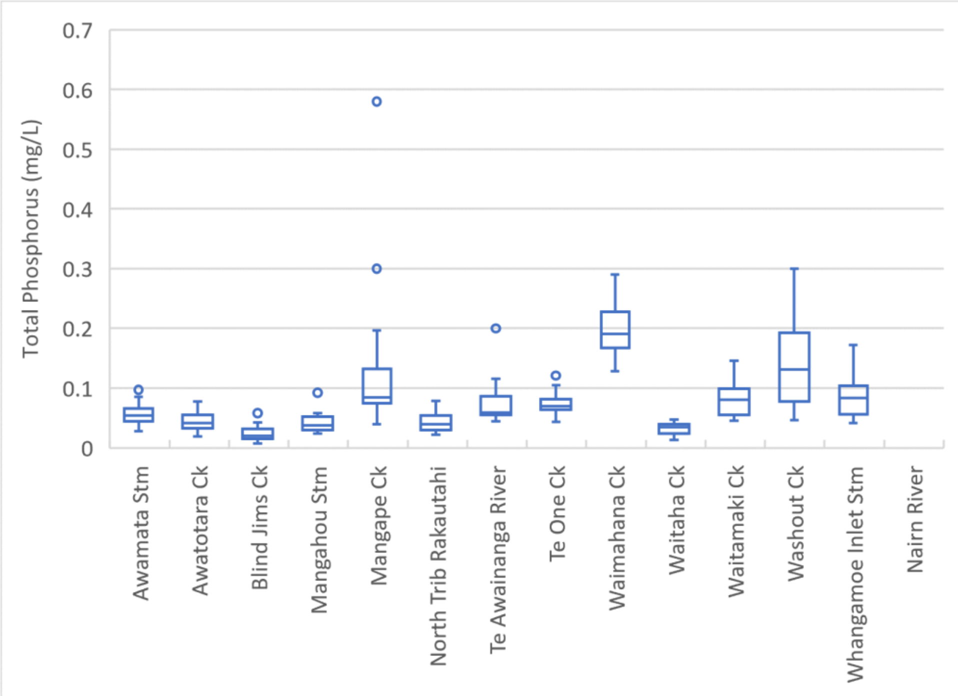

Figure 3-11: Current state of total phosphorus for monitored river sites on Chatham Island

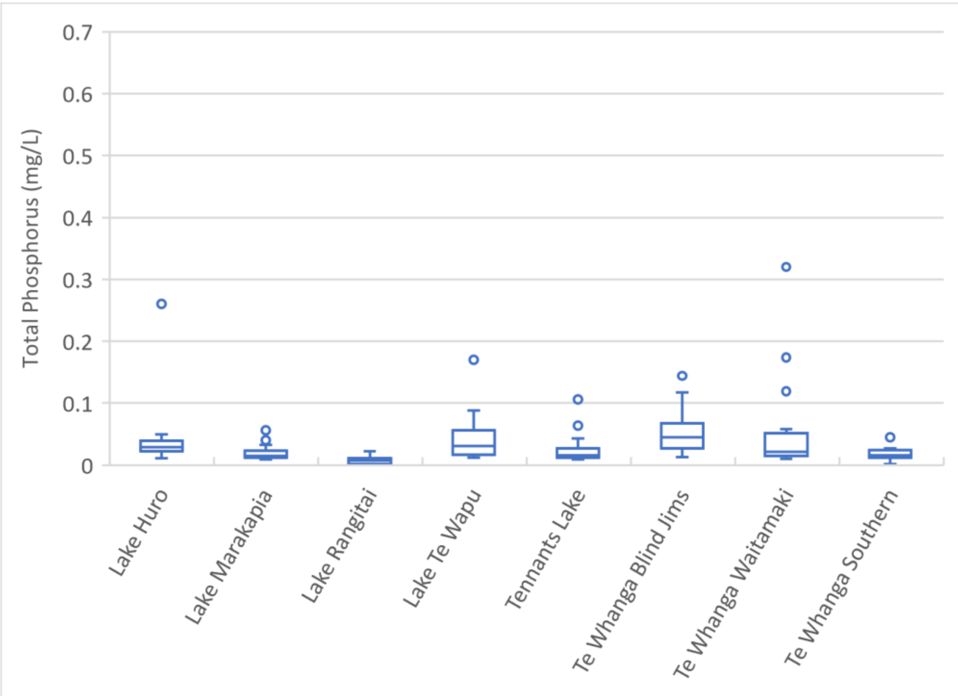

Figure 3-12: Current state of total phosphorus for monitored lake sites on Chatham Island

3.5.2 Nitrogen

Total nitrogen concentrations (TN) were relatively consistent between the streams, lakes, and lagoon sites on Chatham Island with median concentrations between 0.5 and 1.5 mg/l (Figures 3-12 and 3-13). These are relatively low in a national context and reflect a natural level of nitrogen in Chatham Island waters. These TN concentrations are predominantly organic or particulate nitrogen and do not generally reflect the loss of high nitrogen loads from pastoral farming dominating management considerations in mainland New Zealand.

Lowest TN concentrations were in Blind Jims Creek and Waimahana Creek. The highest nitrogen concentrations were measured at Mangapē Creek and Lake Te Wāpu and may reflect the river and lake with highest additional nutrient loss from higher livestock density and historic landfill leachate respectively.

Most sites monitored on Chatham Island had increasing TN trends (Appendix A). Only Lake Hurō and Lake Te Wāpu have decreasing TN trends, while Mangapē Creek and Te Whanga Lagoon at the Southern Basin had no significant trends. The increasing trends may reflect changing livestock type (cattle) and livestock density, as soluble nitrogen loss originates primarily from biological sources rather than from geological sources.

The concentrations of dissolved inorganic nitrogen (Nitrate and ammonia) are very low (Figures 3-14 and 3-15). Due to the high number of censored values within the ammoniacal nitrogen (NH_4N) and nitrate-nitrite-nitrogen (NNN) datasets (mostly below detection levels) the resulting dissolved inorganic nitrogen (DIN) was unable to be calculated for the most sites on Chatham Island. This analysis reinforces the conclusion that most of the nitrogen in waterways of Chatham Island are composed of particulate or dissolved organic nitrogen. Some of this may be from natural leaching of peat materials but increasing quantities may be a result of livestock activity, particularly with the increasing predominance of cattle numbers accessing waterways on the island.

Most sites on Chatham Island had no significant trend for NH_4N (Appendix A). However, Mangapē Creek and Waitamaki Creek had increasing and decreasing trends of NH_4N respectively (Figure 3-16). The increasing trend in NH_4N in Mangapē Creek may be associated with either the stream reaches becoming increasingly anoxic and providing a reducing environment for nitrogen, and/or increased losses of soluble N from livestock that are not oxidised to nitrate because of the anoxic/reducing conditions.

Te Awainanga River, Waimāhana Creek, Waitaha Creek and Washout Creek have increasing NNN (Nitrate) trends (Appendix A). These trends can only be readily explained from the perspective of increased N losses from livestock or wildlife, and may be affected by changes in livestock type, density, and their access to water. As Te Awainanga River is the dominant (85%) source of freshwater to Te Whanga lagoon, this increasing trend is of concern. Mangapē Creek and Te Whanga Lagoon at Blind Jim's Creek have decreasing NNN trends, but in the case of Mangapē Creek this may be explained by the anoxic conditions and nitrogen remaining as ammonia.

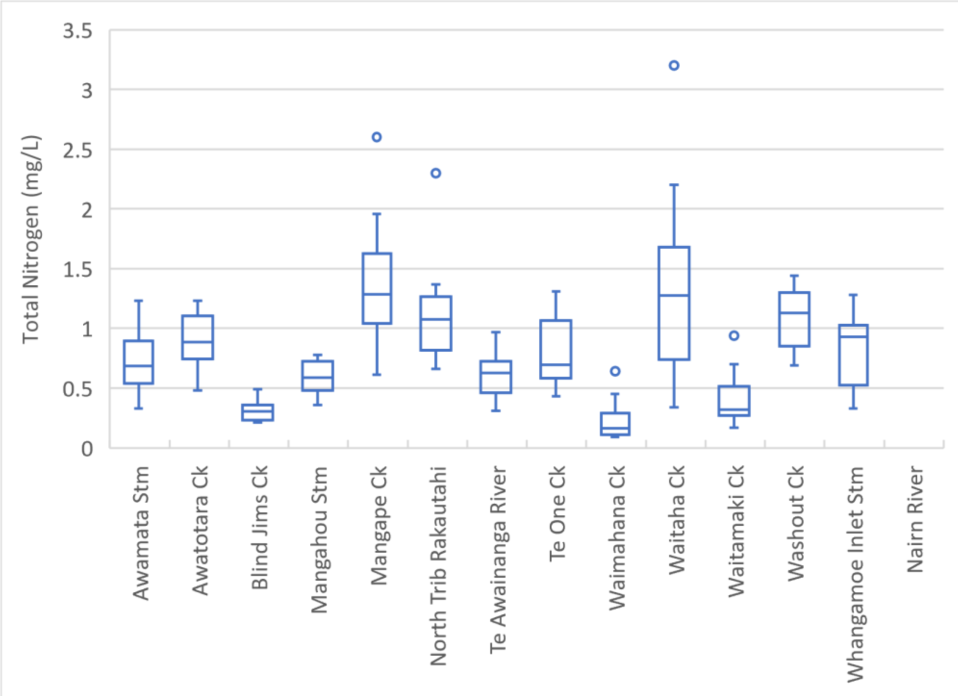

Figure 3-13: Current state of total nitrogen for monitored river sites on Chatham Island

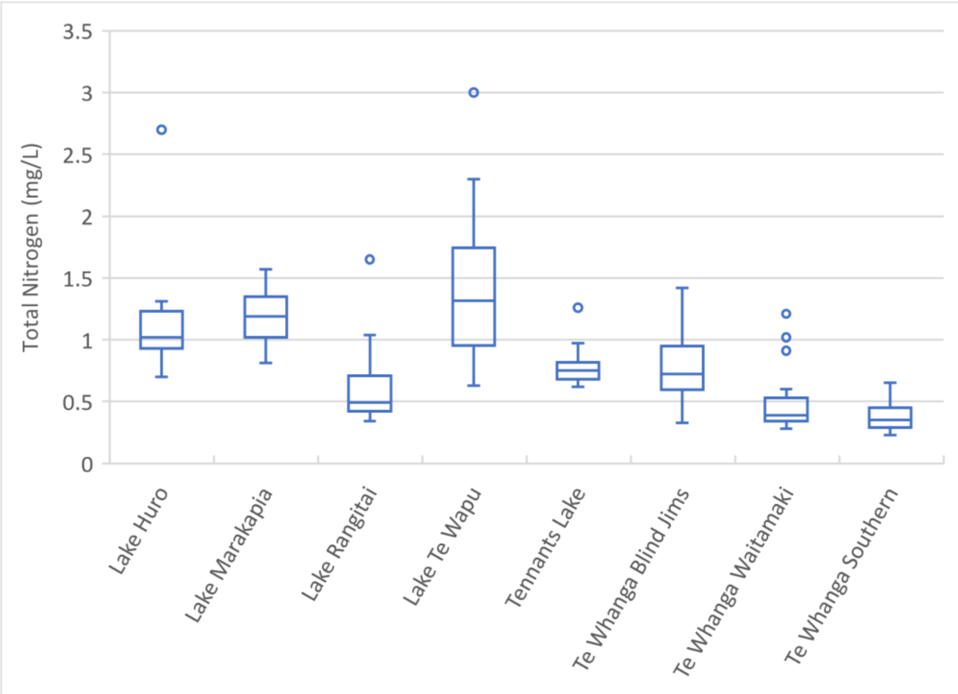

Figure 3-14: Current state of total nitrogen for monitored lake sites on Chatham Island

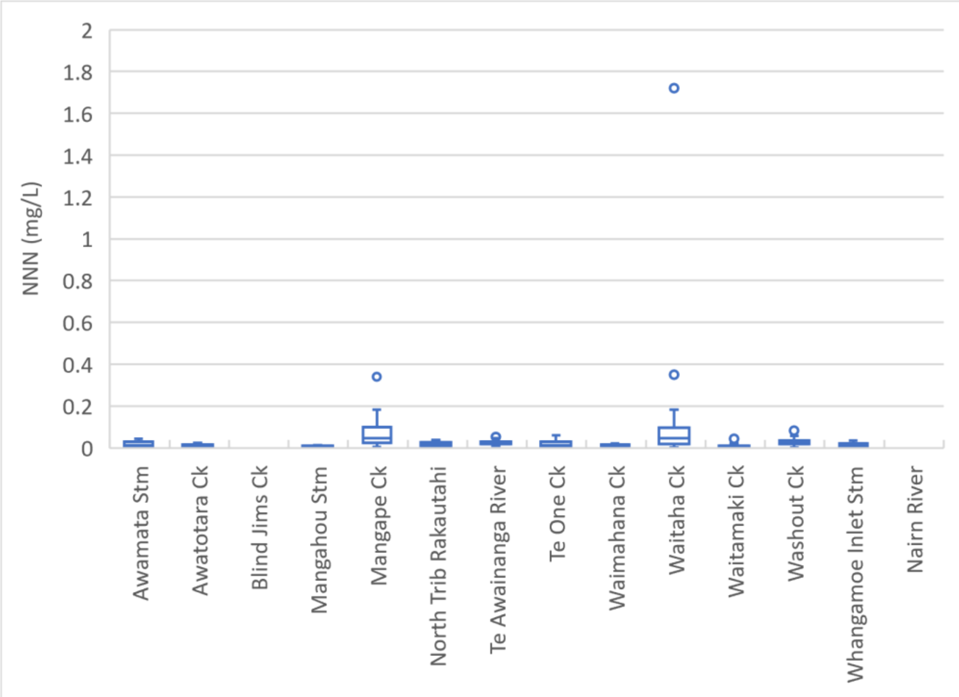

Figure 3-15: Current state of nitrate-and-nitrite nitrogen for monitored river sites on Chatham Island

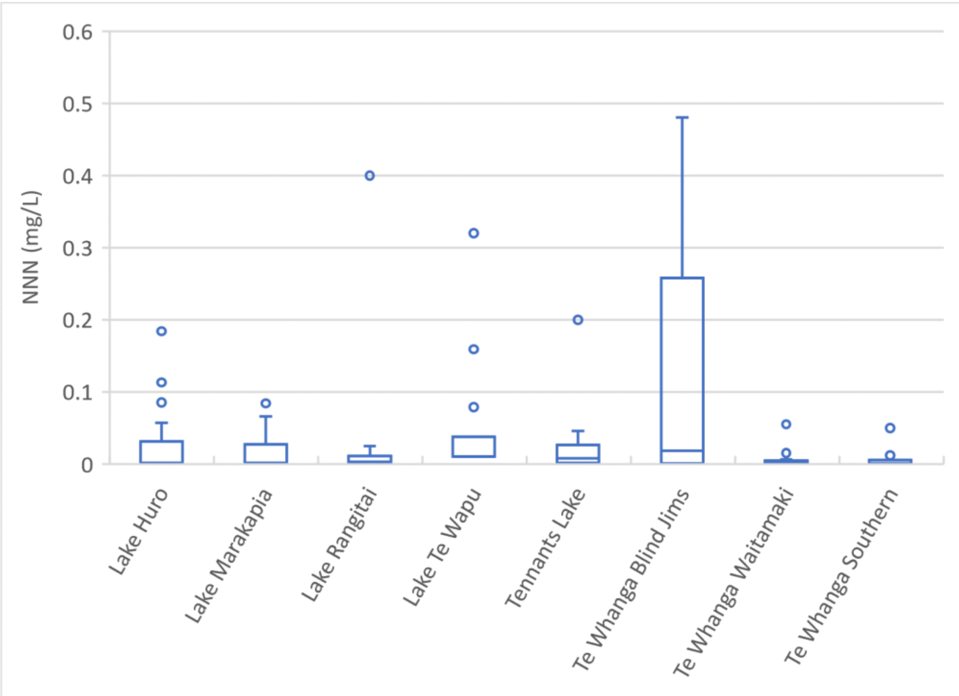

Figure 3-16: Current state of nitrate-and-nitrite nitrogen for monitored river sites on Chatham Island

3.6 Chlorophyll *a*

Chlorophyll *a* concentration for the lakes and Te Whanga Lagoon sites are generally low (<5 ug/l) but there are significant high concentration outliers in the dataset for most lakes (Figure 3-17). Chlorophyll a is the photosynthetic pigment in algae and so is an indicator of algal biomass in water. Chlorophyll a is generally higher when there are corresponding increased nutrient concentrations (TP and TN) also predominantly in the algal biomass. Chlorophyll *concentrations* were greatest for Lake Te Wāpu (Figure 3-17) however, Lake Te Wāpu also has a decreasing trend for chlorophyll *a* (Appendix A). Worryingly, most lake and lagoon sites on Chatham Island had significantly increasing trends for chlorophyll *a* concentration, meaning they will be becoming increasingly productive or green. Only Lake Hurō was not showing an increasing trend.

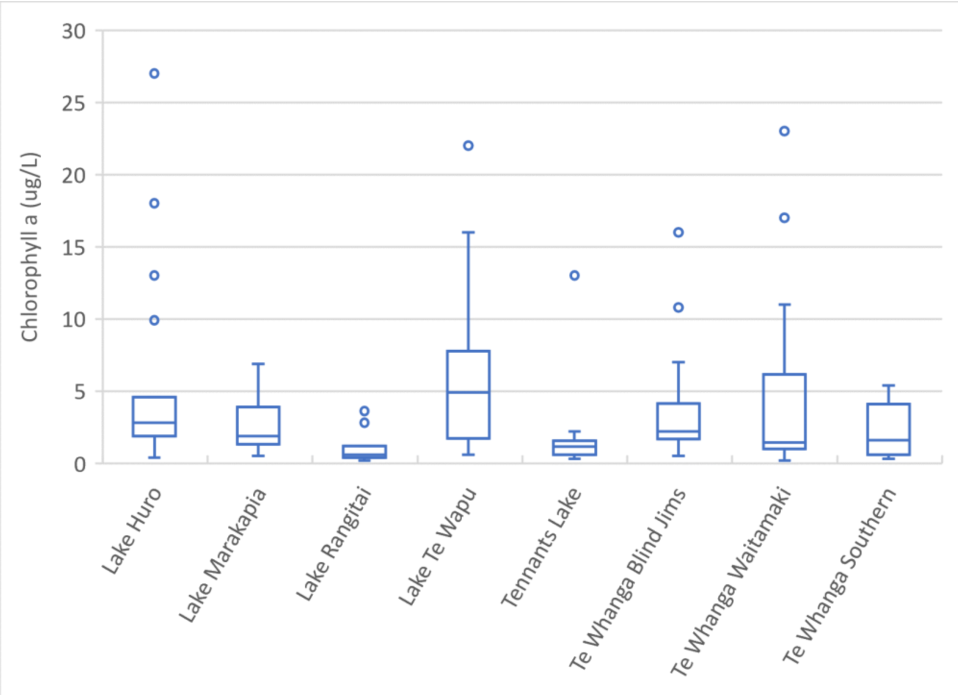

Figure 3-17: Current state of chlorophyll-a for monitored lake sites on Chatham Island

3.7 Water clarity

Water clarity for the streams, lakes and lagoon on the Chatham Islands is measured using a SHMAK clarity tube, which can measure water clarity up to 100 cm (Figures 3-18 & 3-19). Water clarity is often greater than 100 cm for Blind Jim's Creek and Waimāhana Creek. Other streams on Chatham Island have varying water clarity, with medians mostly between 20 cm and 40 cm. Water clarity trends in most streams is either decreasing or has no significant trend (Appendix A). This suggests that many waterways on Chatham Island are becoming more highly coloured or more turbid or both. The exception to this is Mangapē Creek which had increasing (improving) clarity. This may be associated with the similarly improving clarity of Lake Hurō that drains to Mangapē Creek.

Lake Hurō and Lake Te Wāpu have water clarity medians around 60 cm. The other lakes and lagoon sites are around 100 cm or greater. Water clarity is very likely to be increasing (improving) in Lake Hurō but decreasing at Lake Te Wāpu and Tennants Lake. The lagoon sites have no significant long-term trends for water clarity. The improvement in Lake Hurō may be associated with the observations of conspicuous aquatic macrophyte growth (*Myriophyllum sp*.) in the lake in recent months. Lakes with healthy macrophyte growths across their beds are generally in a more stable clear water condition. This is a very positive situation. However, the macrophyte growth may not be sustained if it was triggered by a period of sustained low water level. A similar pattern of a brief period of *Myriophyllum sp*. growth was seen in Lake Forsyth/Te Wairewa following a drought period, but growths of this magnitude did not persist. It will be important to maintain scrutiny of these macrophyte growths.

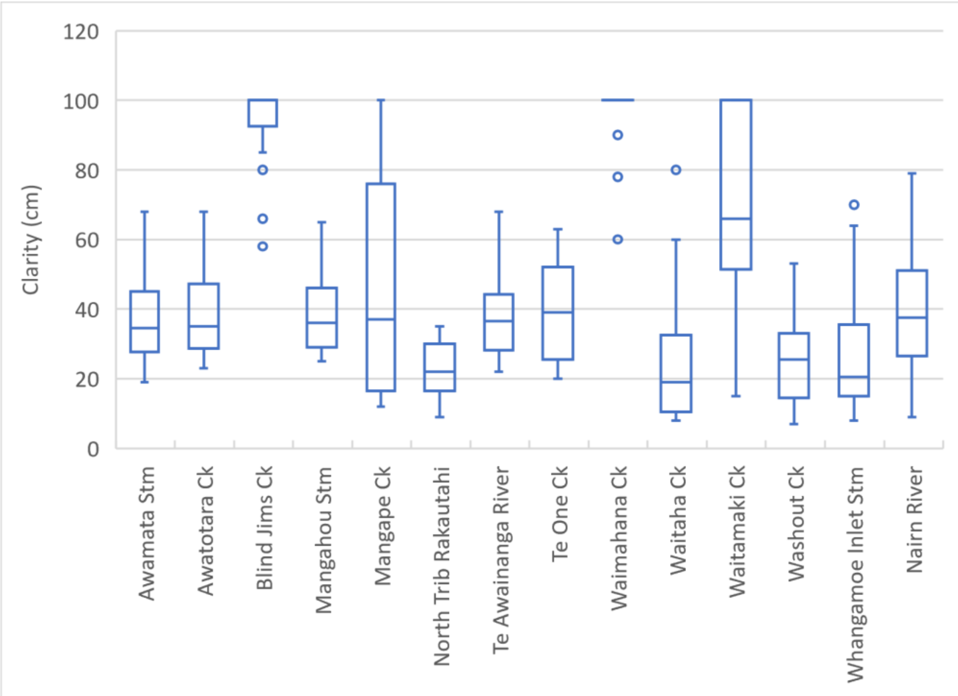

Figure 3-18: Current state of water clarity for monitored river sites on the Chatham Island

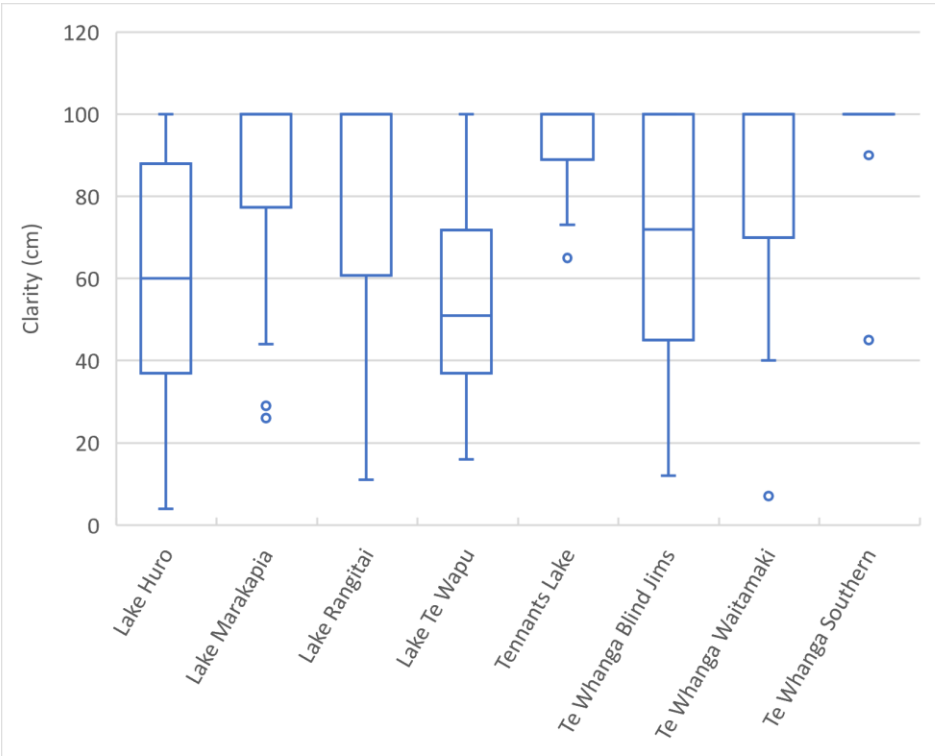

Figure 3-19: Current state of water clarity for monitored lake sites on the Chatham Island

3.8 Lake eutrophication

The TLI3 for lake and lagoon sites of the Chatham Islands is a calculation derived from annual averages of total nitrogen, total phosphorus, and chlorophyll a concentration; and are used to indicate the level of eutrophication or nutrient enrichment (Burns, Rutherford, & Clayton, 1999). All lake and lagoon sites, except Te Whanga Lagoon at the Southern Basin, were graded eutrophic during the 2020 – 2021 year and reflected a moderately high degree of nutrient enrichment. However for 2021-2022 two sites (Lake Huro and Te Whanga Waitāmaki) had degraded much further into a Supertrophic state and most other sites had increased in their TLI condition (getting worse) (Table 3-2). The dune lakes Tennants and Rangitai had improved with both moving from a eutrophic to a mesotrophic state. These different changes indicate the lakes may be very sensitive to nutrient additions and are all responding to different challenges.

Lake Hurō is certainly on a trend of TLI increasing (getting worse) every year for the past 5 years and this trend should be halted or reversed. The consequences are beyond just the state of the lake and how it is perceived, as Lake Huro discharges ito Mangape Creek which discharges to Nairn River and ultimately into Petrie Bay. The potential effects of ongoing lake degradation can be felt further afield.

Conversely, Lake Rangitai's improvement from a degrading state over the previous 4 years, and a subsequent improvement from eutrophic to mesotrophic status this last year may be as much to do with the lake beginning to refill after being drawn down by high water abstraction over the preceding drought. These findings indicate the sensitivities of such lakes to excessive abstraction and how rapidly they can be adversely affected. The refilling indicates rapid improvement in TLI can be achieved, but restoration or improvement in other values such as lake ecology may be much slower.

The absolute high TLI gradings (i.e., eutrophic) will be of concern in a national context but may be somewhat elevated by stable organic nutrient components that may be unavailable for stimulating algal growth. The increasing trends are therefore of more concern than simply reporting TLI state. There should be ongoing scrutiny of the water use and land use surrounding these lakes to ensure poor management practices are identified and addressed. In particular, the intensity of grazing and livestock access to lake margins need to be examined to ensure these trends are not generated by inappropriate landuses and do not continue to cause degradation.

Table 3-1: Description of trophic states

TLI	Tropic state	General description
<1	Ultra-microtrophic	Practically pure, very clean, often have glacial sources
1-2	Microtrophic	Very clean, often have glacial sources, very low nutrient concentrations
2-3	Oligotrophic	Clear and blue, with low levels of nutrients and algae
3-4	Mesotrophic	Moderate levels of nutrients and algae
4-5	Eutrophic	Green and murky, with higher amounts of nutrients and algae
5-6	Supertrophic	Very high nutrient enrichment and high algae growth
>6	Hypertrophic	Saturated in nutrients, highly fertile, excessive algae growth

Table 3-2: Annual trophic state for lake and lagoon sites on Chatham Island

Site	TLI					Five-year average TLI
	2017 - 2018	2018 - 2019	2019 - 2020	2020 - 2021	2021 - 2022	
Lake Hurō	4.07	4.67	4.73	4.88	5.38	4.746
Lake Marakapia	4.4	4.03	4.11	4.36	4.57	4.294
Lake Rangitai	2.87	2.86	3.47	4.04	3.51	3.35
Lake Te Wāpu	5.21	5.59	4.63	4.49	4.7	4.924
Te Whanga Blind Jim's	4.32	5.12	4.45	4.36	4.79	4.616
Te Whanga Southern	3.01	4.07	3.64	3.68	3.76	3.632
Te Whanga Waitāmaki	3.54	4.09	3.37	4.16	5.6	4.152
Tennants Lake	4.61	3.97	3.58	4.04	3.54	3.948

3.9 Microbial water quality

Water samples are tested for faecal indicator bacteria such as *E. coli* in freshwater, and both *E. coli* and *Enterococci* in water with a saline influence (such as Te Whanga Lagoon and the Nairn River at the river mouth).

Mangapē Creek and Nairn River have the highest faecal indicator bacteria concentrations, while the lagoon sites have the lowest concentrations (Figure 3-20). Lake Rangitai and Nairn River both have increasing trends for *E. coli* concentrations (Appendix A). The southern basin of Te Whanga lagoon also has a trend of increasing microbiological concentrations. Other sites on Chatham Island sampled for *E. coli* have no significant trends over time or are indeterminate.

Sources of these microbiological contaminants should be identified and minimised wherever possible. While the wetted area of Lake Rangitai may have been increasing from the previously greatly reduced lake area from high water abstraction, it is of concern that the *E coli* concentration remains high and is increasing. This may continue to be due to high waterfowl numbers in the smaller area on the lake, and/or stock access may be a problem with dry lake margins.

Mangape Creek and the lower reaches of the Nairn River continue to have high levels of *E. coli* contamination and the Nairn River trend is increasing. The microbiological contamination of the Nairn River catchment therefore remain a significant issue. This catchment supports high numbers of livestock than elsewhere on the island, but are also potentially within the catchment for any human effluent losses from the urban infrastructure in the area of Te One, from several individual residence effluent systems alongside the lower Nairn River, and is the receiving environment if there were any losses from the Waitangi wastewater treatment plant system. These range of sources should all be examined more closely as they represent a potential health risk, particularly any that are of human effluent origin. These results could warrant further investigation such as Feacal source tracking (FST) to differentiate the presence of various sources of the E coil (i.e., whether the contamination is of human, bovine, avian, or other (dog?) sources).

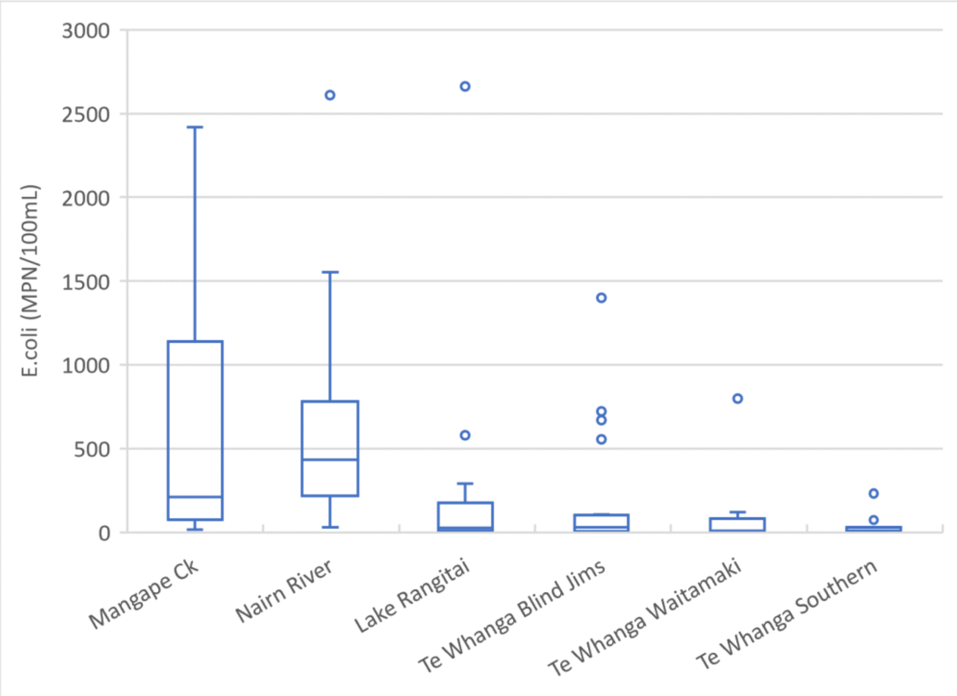

Figure 3-20: Current state of *E. coli* for monitored river and lake sites on Chatham Island

3.10 National Policy Statement objectives and limits

The NZ Freshwater National Policy Statement (NPS) was released initially in 2011 and variously replaced and updated in 2014, 2017 and 2020 to guide freshwater management at a national level within New Zealand and to set or guide establishment of water quality limits.

Appendix 2A within the NPS provides a framework of numeric values and attribute states for freshwater management and sets national bottom lines of minimum acceptable states for the compulsory values of ecosystem health and human health for recreation. The framework is structured in a grading-based format from A to E, with the national bottom-line state generally set between the "C" and "D" bands (at the bottom of the C band). For more information refer to "National Policy Statement for Freshwater Management 2020" (Ministry for the Environment, 2020).

All streams on Chatham Island have NNN (Nitrate-N) median and 95%ile concentrations consistently within the "A" band attribute state. This can indicate a high conservation value where there is unlikely to be toxicity effects of nitrate-N on sensitive species (Table 3-3). However, in the Chatham Island environment where the peat soils are likely to support both a highly reducing environment, and a high denitrification potential, Nitrate-N is very unlikely to persist in surface waters. While the A banding are a very good state, they should be interpreted with caution for these reasons.

Mangapē Creek and Washout Creek both have median NH_4N concentrations that fall within the "B" attribute band. Maximum (95%ile) NH_4N concentrations for most streams also fall within the "B" attribute band and some remain in the "A" band. Again, the somewhat elevated presence of nitrogen in the NH_4N form may be more a consequence of hypoxic or anoxic water, and the reducing peat soil environment as nitrogen leached will be denitrified or reduced.

All of the lake and lagoon sites fall into the "A band for median NH_4N. All sites fall into the "B" band for maximum (95%ile) except Te Whanga Southern basin which is in the A band. This distribution of grades is an improvement on the previous year and indicate a wetter year supports lesser ammonia concentrations.

TN median concentrations for the lakes and lagoon sites on Chatham Island are all in attribute band “C” (5 sites) or “D” (3 sites: “D” attribute band is below the national bottom line). TP median concentration at Lake Rangitai is within the “A” attribute band, other lakes and lagoon sites are between attribute band “B” (3 sites) and “C” (4 sites). Lakes and lagoon sites on Chatham Island have median and maximum chlorophyll *a* concentration between attribute band “A” and “B”, excepting Lake Hurō has a “C” chlorophyll a maximum classification.

These grades can be difficult to reconcile together, as they should correlate (to give rise to the TLI). The most notable difference is the TN grades in the C and D bands, and these are at variance with the expectation of Chathams waters being P rich and N poor. The D and C bands for TN (and to a lesser extent TP) may however be a consequence of particulate and/or dissolved organic nutrients derived from the peat environment rather than from agricultural sources. These organic nutrient sources may not be reactive or directly available for eutrophication of the water bodies. Care should be exercised in assessing the significance of these gradings and whether they require any urgent action.

Table 3-3: National attribute states[1] for streams and lakes on Chatham Island

Site ID	Site	NNN		NH4N		TN	TP	Chlorophyll a	
		Median	95th %ile	Median	95th %ile	Median	Median	Median	Max
SQ34829	Awamata Stm	A	A	A	B	X	X	X	X
SQ34830	Awatotara Ck	A	A	A	B	X	X	X	X
SQ34844	Blind Jims Ck	A	A	A	A	X	X	X	X
SQ34854	Mangahou Stm	A	A	A	B	X	X	X	X
SQ34851	Mangape Ck	A	A	B	B	X	X	X	X
SQ35078	Nairn River					X	X	X	X
SQ34841	North Trib Rakautahi	A	A	A	B	X	X	X	X
SQ34832	Te Awainanga River	A	A	A	B	X	X	X	X
SQ34857	Te One Ck	A	A	A	A	X	X	X	X
SQ34863	Waimahana Ck	A	A	A	A	X	X	X	X
SQ34849	Waitaha Ck	A	A	A	B	X	X	X	X
SQ34860	Waitamaki Ck	A	A	A	B	X	X	X	X
SQ34834	Washout Ck	A	A	B	B	X	X	X	X
SQ34838	Whangamoe Inlet Stm	A	A	A	B	X	X	X	X
SQ34859	Lake Huro	X	X	A	B	D	C	B	C
SQ34893	Lake Marakapia	X	X	A	B	D	B	A	A
SQ34846	Lake Rangitai	X	X	A	B	C	A	A	A
SQ34887	Lake Te Wapu	X	X	A	B	D	C	B	B
SQ34842	Tennants Lake	X	X	A	B	C	B	A	B
SQ35082	Te Whanga Southern	X	X	A	A	C	B	A	A
SQ34843	Te Whanga Blind Jims	X	X	A	B	C	C	B	B
SQ34861	Te Whanga Waitamaki	X	X	A	B	C	C	A	B

E. coli results range across all the NPS attribute bands for the streams, lakes, and lagoon on Chatham Island (Table 3-4). The two streams sampled for *E. coli* (Mangapē Creek and Nairn River) both fall within the “E” attribute band, the category with the highest risk of Campylobacter infection (Ministry for the Environment, 2020). Lake Rangitai is also within the “E” attribute band (a worse grading than the “D” band the previous year), where the predicted average infection risk is >3%. The lagoon sites fall between attribute bands “A” and “C,” where the predicted average infection risk is 1% - 3%. These

[1] Attribute states have been assessed using quarterly monitoring data over five years (2017 – 2022). NPSFM (2020) recommends using monthly data to assess attribute states.

microbiological concentrations and gradings indicate some concern, especially where Lake Rangitai is used as an untreated stockwater resource and as a treated potable water source for Kaingaroa township. Mangape Creek and Nairn River contamination are of concern as they are close to the main township of Waitangi. The sources of this contamination should be assessed and minimised.

Table 3-4: National *E. coli* attribute states for streams and lakes on Chatham Island

Site ID	Site	% exceedances over 540/100mL	% exceedances over 260/100mL	Median	Hazen 95th percentile	Attribute Band
SQ34851	Mangape Ck	29	41	210	2268	E
SQ35078	Nairn River	30	70	435	2081	E
SQ34846	Lake Rangitai	17	22	28	>1697	E
SQ35082	Te Whanga Southern	0	0	10	167	A
SQ34843	Te Whanga Blind Jims	20	20	31	1062	C
SQ34861	Te Whanga Waitamaki	5	5	10	493	B

4 Rainfall and Flow

Figure 4-1: Environment Canterbury rainfall and flow stations across Chatham Island. Site names are found in Table 2-2

The four water level recorders appear to all correspond closely to rainfall events; however, the potential evaporation often causes a deficit in the water balance. During the warmer months the flow of some of these water courses can dwindle, especially during longer droughts (Ritson, 2010).

Table 4-1: Long term seven-day annual low flow (7D ALF) and overall mean seven-day annual low flow (7D MALF) for the four Environment Canterbury recorder locations over the 2007 - 2021 hydrological years (m^3/s)

	Te Awainanga	Tuku a Tamatea	Tutuiri	Awamata
2007			0.003	
2008			0.001	
2009		0.109	0.005	
2010		0.067	0.004	
2011		0.058	0.004	
2012		0.071	0.003	
2013	0.361	0.106	0.002	0.006
2014	0.321	0.048	0.002	0.009
2015	0.390	0.037	0.001	0.014
2016	0.296	0.092	0.003	0.021
2017	0.210	0.044	0	0.004
2018	0.249	0.048	0.001	0.005
2019	0.312	0.049	0	0.016
2020	0.255	0.063	0.001	0.017
2021	0.398	0.088	0.002	0.024
7D MALF	0.310	0.068	0.002	0.013

The seven-day mean annual low flow is the average annual low flow (Table 4-1), which shows the lowest seven day rolling average flow over the hydrological year. The Mean annual low flows are calculated from Environment Canterbury's archived records and is an average of all the yearly average low flows that are on record. These show that the ALF flows for all four catchments were higher than the previous four or more years. This indicates the 2021-22 year was a wetter summer period with higher low flows.

4.1 The Landing

The Landing had the largest February rainfall out of the Six stations and a similar annual rainfall of 849 mm over 154 days. There is 93 days of raw telemetry data between 30 March and 30 June as the site wasn't visited during June 2022.

The Landing had monthly rainfall that were higher than average in 11 of the 12 months. A particularly wet February with 100.5 mm of rainfall compared to the average 44.9 mm of rainfall during February. May was the only dry month with only 22 mm of rainfall compared to the average of 67.2mm.

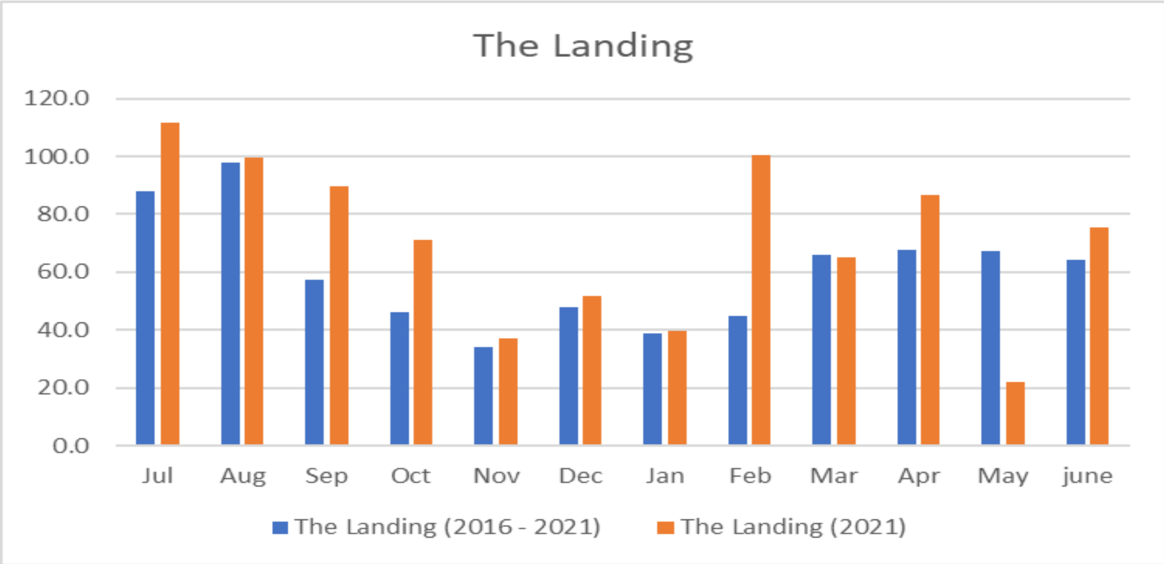

Figure 4-2: Monthly rainfall (mm) for The Landing site through the 2021 hydrological year

4.2 Waitangi

Waitangi, the newest Environment Canterbury rainfall station, had an annual rainfall of 816 mm for the 2021 hydrological year where it rained for 159 days. There were 26 days between 5 June and 30 June where raw telemetry data has been used and 92 days between 21/10 and 20/01 that has been rated as poor due to gaps in the telemetry data caused by satellite issues. This may have also contributed to the poor-quality data at the other rainfall stations.

The average rainfall the 2021-22 data are compared to are from a similar gauge in a much earlier period (1991-2012). These averages may therefore be considerably different to more recent "average" data at other sites. However, they are presented to give some context to the current data but should be interpreted with some care or caution.

The Waitangi area had drier than usual months of March and May with 17 and 31.5 mm respectively compared to averages of 84.4 and 95.6mm respectively. However, a higher-than-average rainfall was observed in April with 131 mm (compared to an average of 82mm).

The Waitangi rainfall gauge was installed after a recommendation from PDP (2020) to re-establish a site to match with the longest previous record, so that there would be a station in the same location as historical data. It has 16 months of archived data between June 2021 to Sept 2022. The data used for a long-term average was taken from NIWAs rainfall station Chatham Islands Aws which was in the same general geographic location as the Waitangi site.

There is currently not enough data to determine if the current rainfall in the area is similar to the historic records from NIWA.

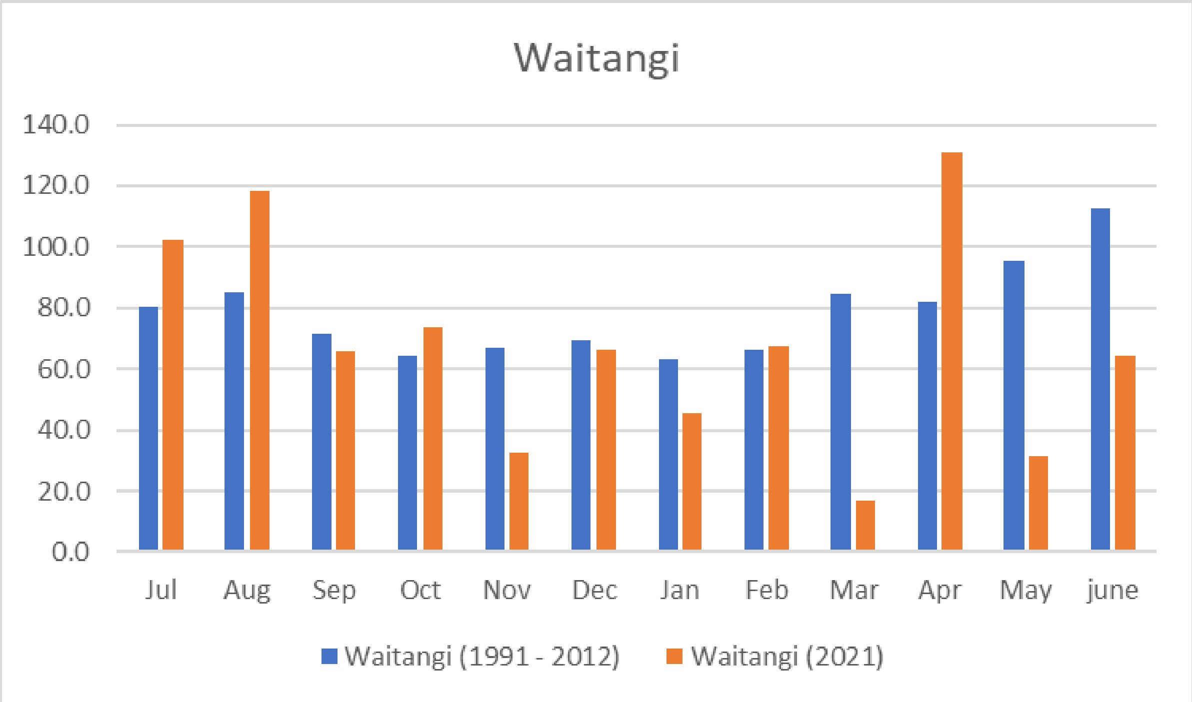

Figure 4-3: Monthly rainfall (mm) for the Waitangi site through the 2021 hydrological year

4.3 Wharekauri

The Wharekauri station had total rainfall of 836 mm for the 2021 hydrological year with 155 days of rain. There are 27 days between 4 June and 30 June where raw telemetry data was used as the sites have not been visited as the time this report was written. Like the Waitangi station, Wharekauri had a dry March and May with 16 and 23 mm of rainfall respectively where the average rainfall over 2016 to 2021 was 47 and 62.7 mm respectively. April was a wet month with 154 mm rainfall compared to the average of 63.4 mm. It also experienced more rainfall during February with 81.5mm compared to an average rainfall of 36.4 mm.

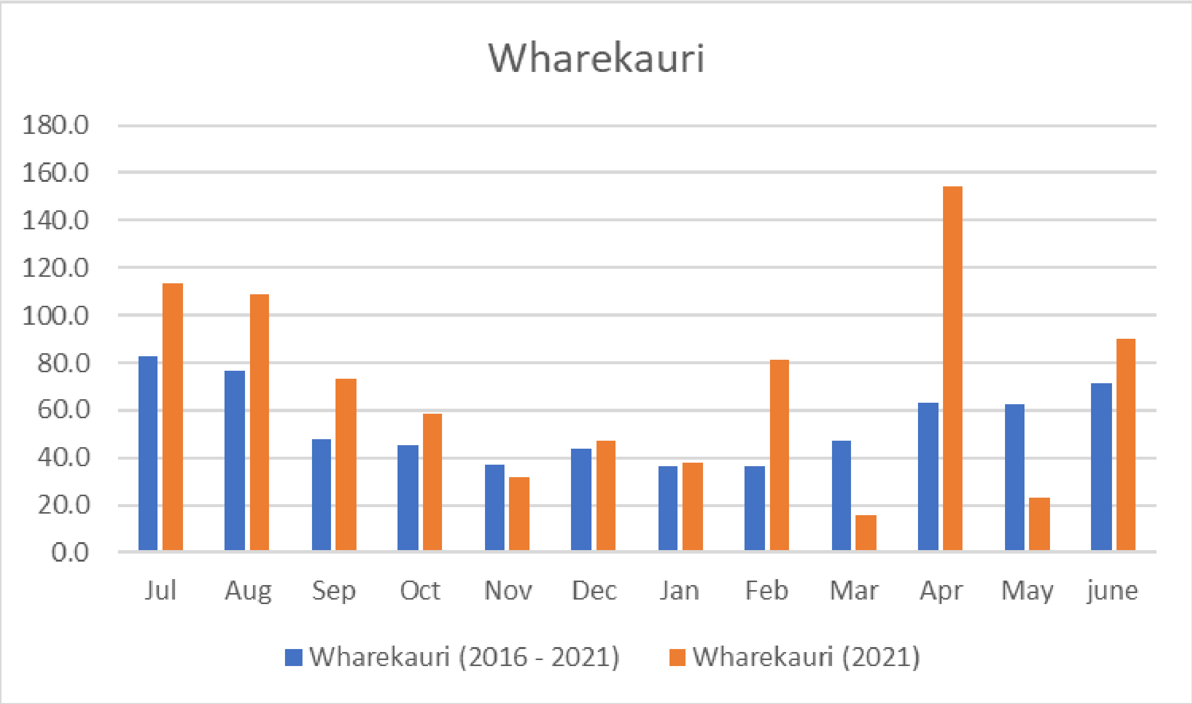

Figure 4-4: Monthly rainfall (mm) for the Wharekauri site through the 2021 hydrological year

4.4 Te Awainanga River

The 2021 hydrological year had 165 days of recorded rainfall with a total volume of 830 mm at the Te Awainanga site There was an unexplained gap within the year of 50.1 days between February and March and 25 days between 6 June and 30 June where raw telemetry data has been used.

There are three peaks in the flow readings which could be associated with rain events (Figure 4-5) as there were also rain and increases in flow for the Tutuiri and Awamata locations. There is most likely a rainfall event that wasn't captured during February which can be seen as a peak in the hydrograph and possibly a dry period during March where the graph flattens out (Figure 4-5Figure 4-6).

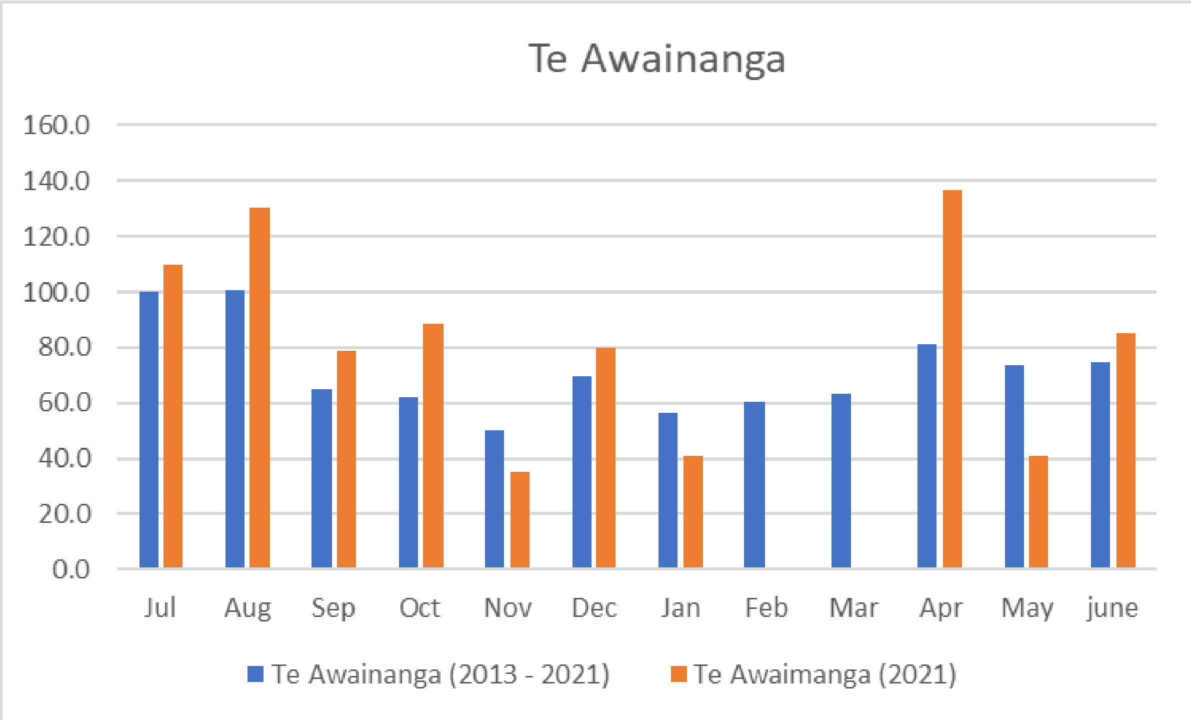

Figure 4-5: Monthly rainfall (mm) for the Te Awainanga site through the 2021 hydrological year

The maximum annual flow at the Te Awainanga recorder, site number 3446051, for the 2021 hydrological year was 36.5 m^3/s with an average rate of 2.19 m^3/s, the 7D ALF was a point during March when the flow was 0.398 m^3/s.

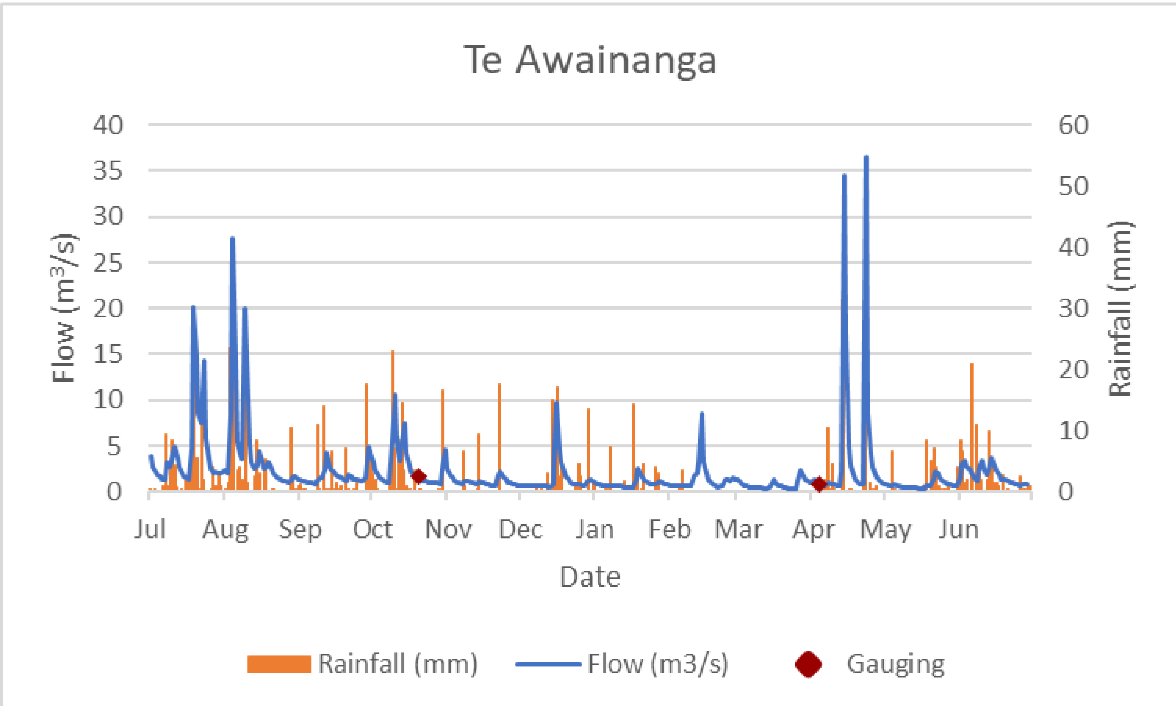

Figure 4-6: Daily mean flow at the Te Awainanga flow recorder over the 2021 hydrological year with the associated rainfall station along with the associated rainfall for the period

4.5 Tutuiri River

There was an annual rainfall of 829 mm at the Tutuiri station for the 2021 hydrological year over the 160 days which rained. there are 27 days between 4 June and 30 June where raw telemetry data was used and 58 days 21/10 and 16/12 with data that has been rated as poor.

Like the other stations on the west side of the island, Tutuiri experienced less rainfall in in March and May 17 and 30 mm, and significantly more in April with 160 mm of rain, most of this rainfall occurred in two different rainfall events with 87 mm over the 13^{th} – 14^{th} and 50 mm over the 22^{nd} – 23^{rd}.

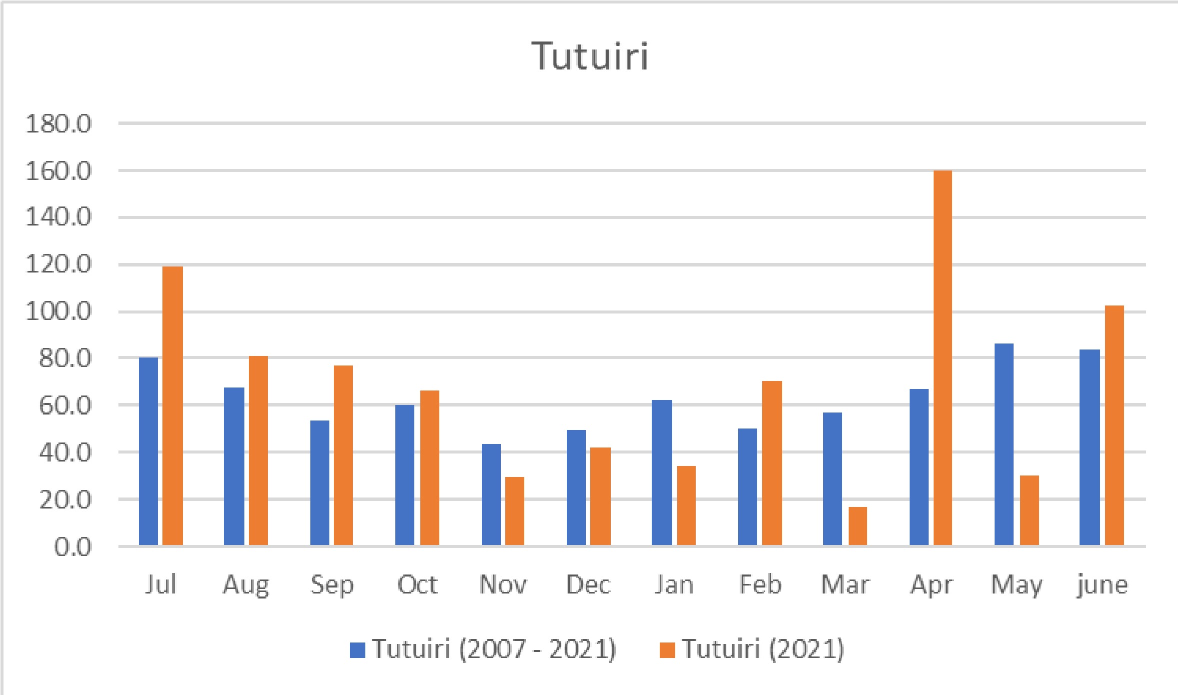

Figure 4-7: Monthly rainfall (mm) for the Tutuiri site through the 2021 hydrological year

The maximum annual flow at the Tutuiri recorder, site number 3446871, was 5.11 m^3/s with an average rate of 0.24 m^3/s. The 7D ALF was 0.002 m^3/s in late March representing a flow rate of 2 L/s. During the 2021 hydrological year, the Tutuiri river did not run dry and had a smaller 7D ALF than the 2020 hydrological year.

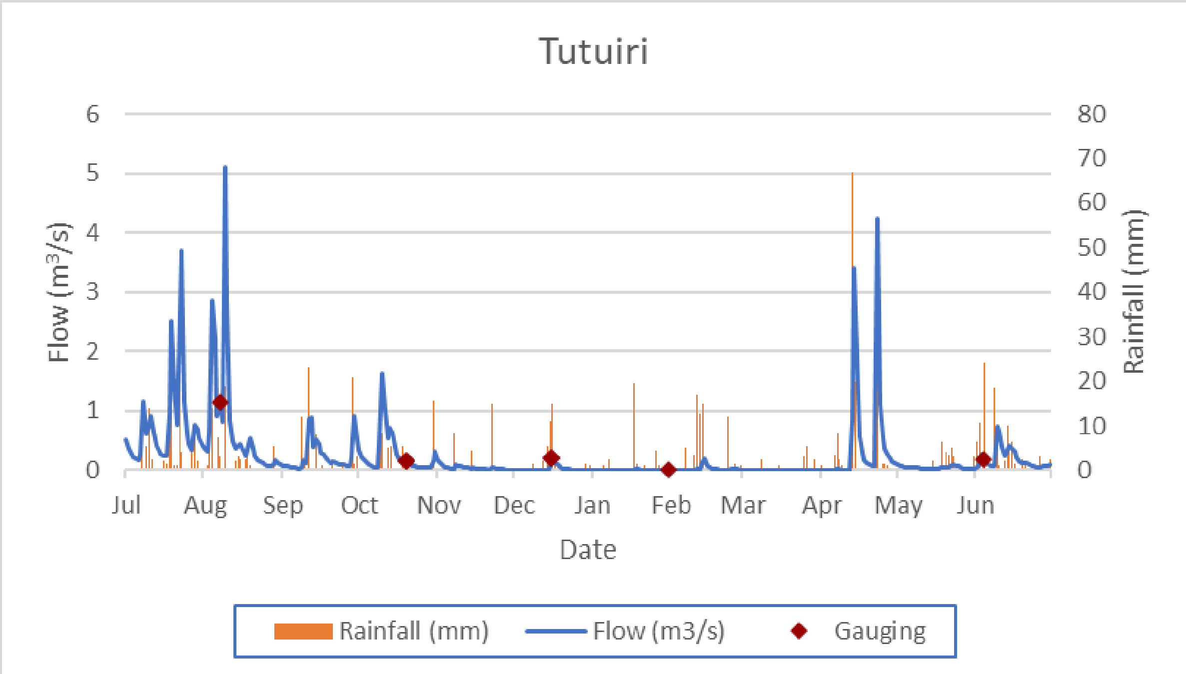

Figure 4-8: Daily mean flow at the Tutuiri flow recorder over the 2021 hydrological year with the associated rainfall station along with the associated rainfall for the period

4.6 Awamata River

The total rainfall at the Awamata Station during the 2021 hydrological year was of 749 mm over 143 days which rained. There were 26 days between 5 June and 30 June where raw telemetry data was used and 163 days between 21/10 and 1/4 with data that has been rated as poor.

Due to the geographical location of the Awamata station, which is located west of the Tutuiri station, most of the April rainfall was on the same four days with 44.5 and 58.5 mm over the two periods and a total April rainfall of 123 mm. The two drier months either side of April experienced 155 and 36.5 mm of rainfall respectively.

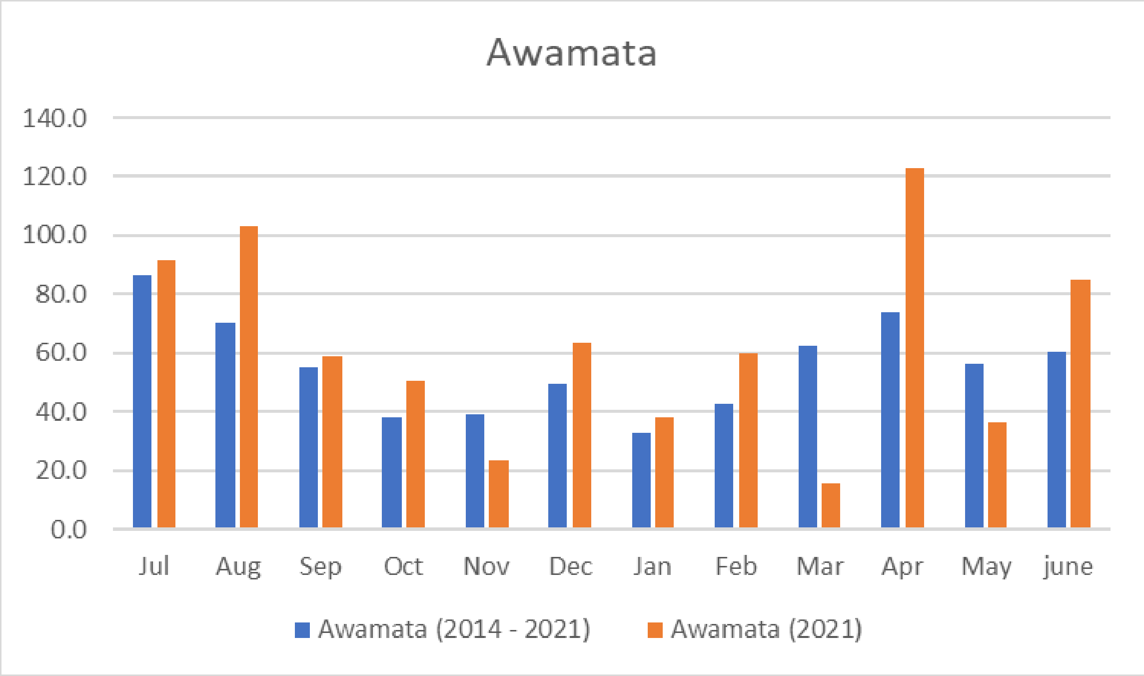

Figure 4-9: Monthly rainfall (mm) for the Awamata site through the 2021 hydrological year

Awamata River had an annual maximum flow of 4.09 m^3/s with an average rate of 0.19 m^3/s. The seven-day annual low flow was 0.024 m^3/s which occurred during a dry period in late March. There are corresponding peaks in the hydrograph where there was significant rainfall.

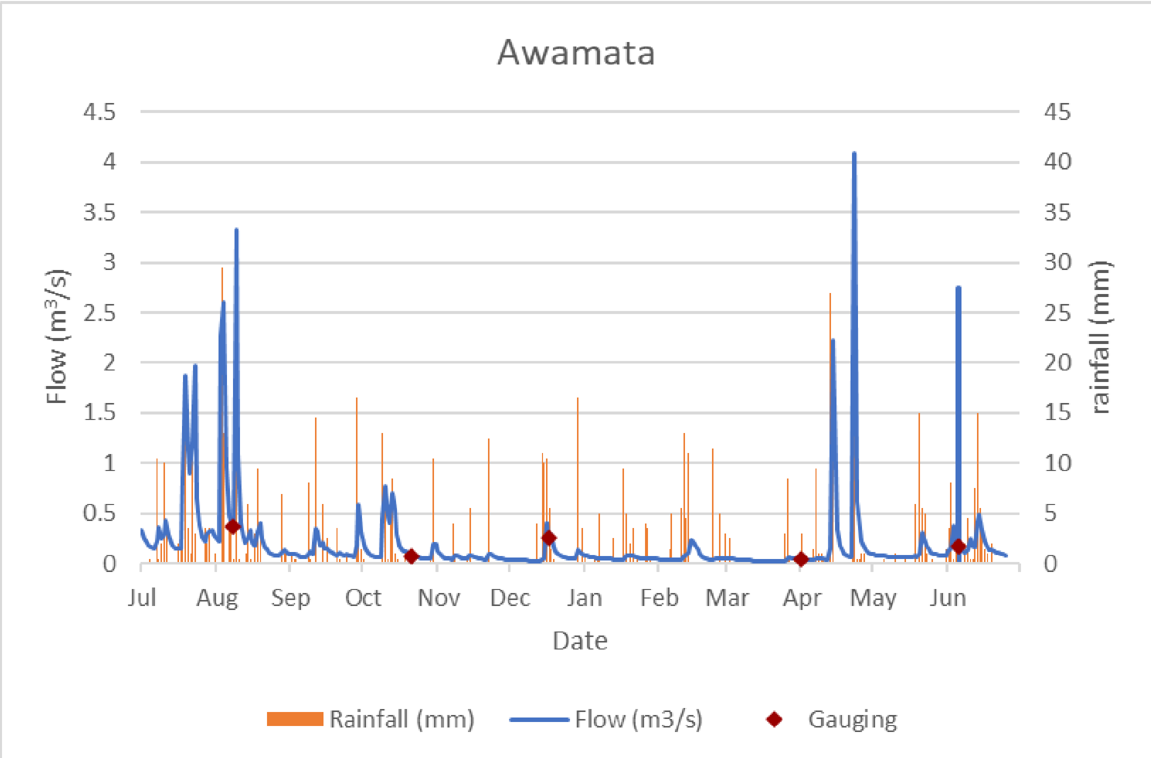

Figure 4-10: Daily mean flow at the Awamata flow recorder over the 2021 hydrological year with the associated rainfall station

4.7 Tuku a Tamatea River

Tuku a Tamatea, site 3779428, had a maximum flow of 10.4 m^3/s over the 2021 hydrological year with an average rate of 0.75 m^3/s. The 7D ALF of 0.088 m^3/s representing a lowest rolling seven-day flow of 8.8 L/s.

There is no rainfall monitor located with the Tuku a Tamatea flow monitor, the closest geographical rainfall monitor is the Awamata station, close to Te Ngaio. The Tuku a Tamatea hydrograph peaks are in the same date ranges as Awamata, these two locations could experience similar rainfall patterns.

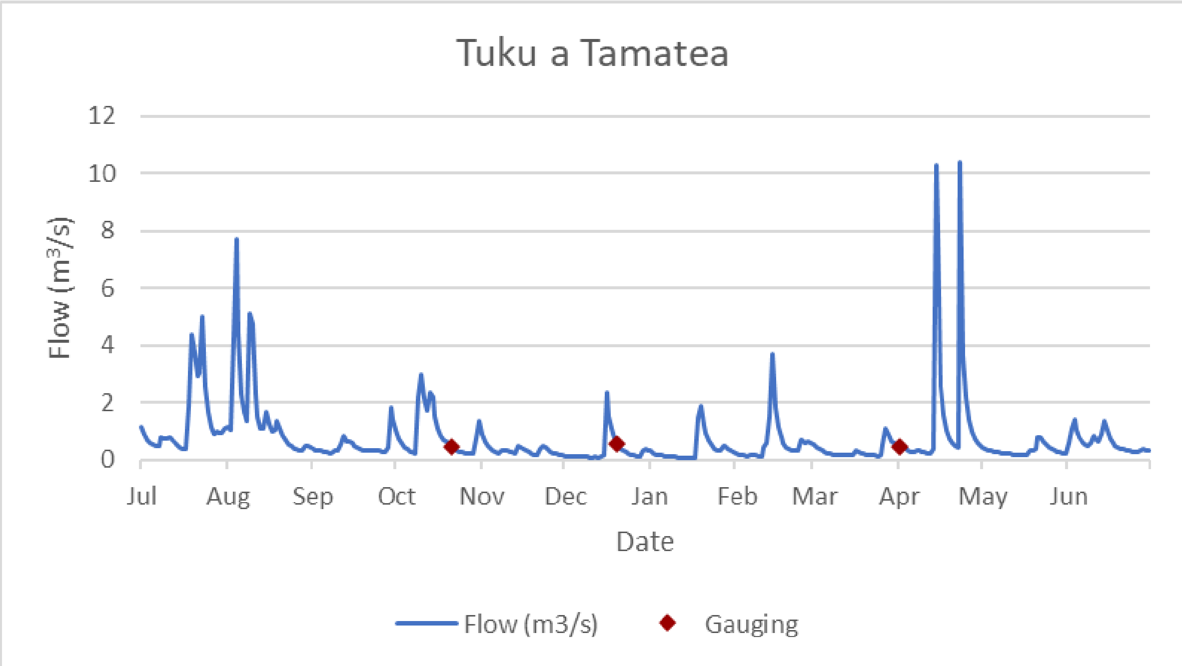

Figure 4-11: Daily mean flow at the Tuku a Tamatea flow recorder over the 2021 hydrological year

5 Discussion

An understanding of the climate, particularly rainfall, of Chatham Island is an important determinant. This is because like many island communities, rainfall runoff collection is particularly important as a collected domestic water source and as a diffuse stock water resource. Rainfall is generally considered to be regularly distributed throughout the year, but at times it varies greatly and can be considered to reflect regular drought periods. Previously these may have been associated with decadal or ENSO cycles and weather patterns, but there is now concern whether we must now project forward for assessing possible further climate change patterns. It is therefore important to maintain an understanding of past, present and future rainfall patterns to maintain and manage community resilience.

Unfortunately, there have been considerable changes in the maintenance of weather stations on the island. In particular, the previous long-term weather station at the main town Waitangi was disestablished after 2012. It was subsequently recommended by PDP (2020) that the rainfall monitor was re-established in the Waitangi area, and while now re-established it will take some time to re-establish adequate records to determine a consistency with the historic long-term records.

In addition to this, PDP (2020) also recommended a rainfall sensor could be established within the southern uplands as this is likely to be the highest rainfall zone. This was rationalised to better understand the rainfall patterns in that area noting that the logistics would need to be discussed. However, the resources (population, roading, infrastructure etc.) are minimal in the southern uplands and so while this information may be of academic interest it may be of little practical or management use. This recommendation therefore remains unactioned. We do not consider this recommendation would constitute good value for limited monitoring resources.

As illustrated in this report there are several weather stations across the island. The rainfall patterns recorded at these are similar. The six rain gauges recorded between a range of 749 to 849 mm of rain and 143 to 165 days of rain. These are similar and indicate little significant difference in rainfall across the island. The gauge at the Awamata River had both the lowest annual rainfall and lowest number of rain days (749 mm and 143 days). The other 5 sites were much more closely bracketed (816-849 mm and 154 to 160 days). The previously described pattern of higher rainfall in the south and lower rainfall in the north of the island was therefore not represented in 2021-22. The most southerly site (Awamata River in the Southwest) was the driest site. This data therefore shows little consistent difference in rainfall north to south or east to west. Chatham Island has a higher average rainfall during the winter period compared to the summer period, but overall rainfall is generally well spread and periods without rain are short (days to weeks).

The 2020-21 year illustrated a year of average to slightly above average rainfall, and dry months were only recorded in March and May across all weather stations on the island. Dry months such as these are not drought periods but are simply randomly aberrant months. Furthermore, they may not be seen as contributing to water deficits as they occurred later in the year when water supplies may not be so critical. The previous years (2019-20 and 2020-21) were lower-than-average rainfall years recording longer periods of below average rainfall particularly in summer when water supplies are under more stain. The 2021-22 year can therefore be considered a year where some of the rainfall deficit or water supply deficit was starting to be replenished. Lake water levels, particularly Lake Rangitai are expected to have risen, and streams will have not reached such low flow levels generating concern for stock water sources. Roof water storages are also likely to have been replenished.

The four main river flow recorder sites continue to illustrate that only the Te Awainanga River has an appreciable base flow (a MALF of approximately 300 l/s). The other three rivers have base flows (MALF) of only 2 - 66 l/s. Corresponding annual floods recorded in 2021 ranged from only 4.09 to 36.5 m^3/s (an increase of approximately 50% on the previous year. While the Awamata Stream has historically supported a small hydro-electric structure only the Te Awainanga River has the hydraulic capacity for a community sized hydro-electric facility. It has been proposed in the past for a combined hydro-electric wind turbine battery facility but has to date failed to secure the necessary financial support. Therefore, there is good reason to maintain a strong hydrological record for the Te Awainanga River to support future assessments or initiatives.

The Nairn River flow recorder site has been closed in recent years and the upper reaches of the Nairn River catchment border the Te Awainanga, the Tuku a Tamatea, and the Awamata catchments. The Nairn River flow correlated most strongly with the Tuku a Tamatea catchment (r^2 = 0.98). Therefore, although it would be nice to have flow recorder data on the Nairn River it is not currently considered necessary. The management issues for the Nairn River are also in its lower reaches that are also fed by wetlands and Lake Huro, and so headwater catchment hydrology may be of lesser relevance than issues in the lower catchment to the required monitoring and management of the catchment.

In future it may be necessary to review whether this intensity of climate (rainfall) monitoring and hydrological monitoring is necessary as there appear to be little difference in rainfall and good flow relationships between the different sites. Further, it may be necessary to consider whether the logistics and investment in monitoring some remote sites such as the Tuturiri River is still necessary. Other recorder sites such as Awamata and Tuku a Tamatea Rivers are relatively close together on one part of the island and could be rationalised to a single site if the rivers themselves do not- warrant explicit monitoring. Only the Te Awainanga River warrants explicit ongoing resource monitoring given its potential for future development.

Many of the notable changes in water quality state and trend across the island relate to the preceding climate drought period of 2019-2021, including physico-chemical features such as decreasing dissolved oxygen concentration, higher water temperatures, higher DOC concentrations and lower water clarity. The waters of Chatham Island are particularly sensitive to such climactic patterns because catchments are relatively small and so flow recessions and lake level reductions can occur quite rapidly. Similarly, improvements during the recovery from drought conditions appear to take some time. This may be partly due to sustained riparian habitat damage being slow to recover (if at all).

The low intensity livestock land uses can also operate in tandem with climate patterns, as the effects of increasingly difficult access to stock water from natural streams and lakes can lead to increasing riparian pugging effects. An extreme effect of this can be higher casualty stock issues with stock becoming bogged or trapped within stream and lake peat margins. This has been noted in our reports in the past and become most conspicuous during sustained droughts. The Chatham Islands are not covered by the national low slope maps for stock exclusion from waterways regulations in the Essential Freshwater package, but are still required to avoid adverse effects such as pugging, compaction and casualty issues in riparian areas. While stock exclusion is not explicitly required, it would be prudent to prioritise actions addressing stock exclusion from waterway reaches adjacent to the roading network particularly leading to infrastructure such as the airport and between towns.

Care will always be needed in interpreting the significance of water quality state and trends on the Chatham Islands because of the high incidence of deep peat soils and the properties peat imparts to the waterways and lakes. The nutrient state can be misinterpreted if significant measured nutrient concentrations arise from stable organic peat materials such as tannins and lignins that are not generally available for driving primary production (i.e., used for algal growth or macrophyte growth).

We have previously identified that Chatham Island has seen a significant shift from sheep farming to drystock beef farming. This increase in cattle numbers has resulted in increased pugging and soil compaction, and a significant change in the vegetation state (lower plant height and increase in cover such as bracken fern) of scrub or poorly developed grazing land. All these changes can affect the water quality of island waterways and lakes through reduced shading, increased pugging and sediment runoff and altered drainage rate and patterns.

Overall, the identified changes (degradation) in water quality on the island are likely to be caused by several interacting influences. The climate patterns (and in this case a previous sustained drought) may be the biggest influence, but the changes in farming type strongly interact with the climate influences when cattle as larger and heavier livestock have higher water requirements and have greater effect on riparian environments. Particularly where the peat soils are poor at supporting heavy animals.

There are also particular sites within the water quality network worthy of comment, that illustrate these broader water quality issues more clearly.

Blind Jims Creek on the north basin of Te Whanga Lagoon is very conspicuous from the road and in previous years has shown visible impacts of extensive pugging by cattle. The corresponding DOC and nitrogen concentrations have become less under a heavier rainfall year but are still of note. Phosphorus concentrations are all decreasing. However, the nearby monitoring of Te Whanga Lagoon at Blind Jims continues to show widespread degradation trends in all water quality parameters. This therefore indicates that creeks such as Blind Jims are not only significant conspicuous indicators of creek water quality but also contribute to at least localised degradation of valued water bodies such as Te Whanga Lagoon. As recommended earlier, waterways such as this deserve added attention/priority in reaches close to roads to address the conspicuous and water quality effects of livestock entering these waterways.

Mangape Creek, that flows between Lake Huro and the Nairn River is another creek that is showing a significant range of adverse effects. Many effects may be partly a result of the previous drought conditions and sluggish flows contributing to periods of stagnant or anoxic conditions. However, the significant livestock densities in this wetland area may be directly contributing to increasing nutrient concentrations, high levels of ammonia and high microbiological concentrations. These then flow into the Nairn River on the edge of Waitangi township and show similar degraded water quality conditions. The Nairn River is probably the highest recreationally used water body on the island but with the greatest risk profile. The sources of contaminants and land use in the catchment and wetlands and waterways associated with these water bodies deserve much closer scrutiny and management. We would be remiss not to note that the urban infrastructure of Te One, residences along the lower Nairn River and even the Waitangi sewage treatment plant are within this drainage catchment. It would be prudent to examine the microbiological contaminants with techniques such as faecal source tracking (FST) to ensure none of these were contributing or posing a health hazard.

Lake Rangitai also stands out in this report. The degrading water quality is highly likely to be a result of the greatly reduced area of this lake as it is highly abstracted from for stockwater and domestic water use for the township of Kaingaroa. These water resources were largely being mined under the previous sustained drought conditions, and the water quality is slow to show any improvement. More careful or strategic management of this water resource is warranted.

Te Whanga Lagoon is a highly valued taonga and community resource but is very sensitive to its contributing catchment. The Te Awainanga River and its tributaries contribute 85% of the freshwater to the lagoon (PDP 2020) and so its flow and water quality are fundamental to the health of the lagoon. The very likely increasing trends in nitrogen, phosphorus and DOC to the lagoon are therefore of some notable concern. However, as illustrated above the remaining 15% from small creeks can also have at least localised effects on lagoon water quality if left unmanaged. This is especially true as the norther basins are much shallower and lesser flushed by the south-eastern outfall to the ocean. Scrutiny of these water quality results and trends for freshwaters in and flowing into Te Whanga lagoon should not be ignored.

6 Conclusion

Quality assured rainfall records are needed to maintain and manage community resilience. Therefore, maintaining consistent rainfall monitoring sites particularly at Waitangi and the Airport are necessary for maintaining long term trends. Rainfall records indicate 2021/22 had higher than average rainfall and should have started making in-roads into the water deficit of the previous two years.

Flow regimes of the major river systems are now well understood and characterised for both low flow and flood conditions. Flow monitoring of the rivers could be rationalised to monitoring priority rivers such as Te Awainanga and Nairn Rivers. Flows in 2021-22 were approximately 50% higher than in the previous drought year.

Degrading water quality of waters across the island are likely caused by several influences. Climate patterns (previous drought) appears to be the biggest influence, although changing farming emphasis to heavier livestock (sheep to cattle) appear to strongly interact with climate particularly where organic (peat) soils are poor at supporting heavier animals and contribute to erosion, pugging, compaction and casualty animal effects.

Reduction in state or degrading trends were particularly notable at key sites. Degrading trends in water quality at Blind Jims Creek appear to have been halted by increased flows but impacted riparian habitats and poor instream habitat persist. Mangape Creek and the lower reaches of the Nairn River it discharges to were both showing effects of anoxic water, increasing nutrient concentrations and high microbiological concentrations. These catchments show conspicuous effects and a high water quality risk profile and deserve closer scrutiny of catchment, land and stream management effects. In particular, the microbiological results and grades are of particular concern. They deserve further investigation to ensure there are no high-risk contaminant sources that pose health risks to the community.

Lake Rangitai also stands out in this report. The degrading water quality is highly likely to be a result of the previously reduced area of this lake as it has been highly abstracted from for stock water and domestic water use for the township of Kaingaroa. These water resources were largely being mined under sustained drought conditions, and as the lake becomes relatively small and shallow the water quality deteriorates. Despite a higher rainfall year, the water quality of Lake Rangitai has not appreciably improved. More careful or strategic management of this water resource is warranted.

Te Whanga lagoon is a highly visible and important taonga or community asset. The very likely increasing trends in nitrogen, phosphorus and DOC to the lagoon are therefore of some notable concern. Scrutiny of these water quality results and trends for freshwaters in and flowing into Te Whanga lagoon should not be ignored.

Closer attention to monitoring the limited domestic and potable water resources of the island are warranted including scoping monitoring of the groundwater resources and assessing the capacity of potential potable water resources.

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Appendix A – 10-year Trends of the Chatham Islands Water Quality Monitoring Sites

Table A1: 10-year trends of the Chatham Islands water quality monitoring sites

Site ID	Site	Dissolved oxygen %	Water Temperature	pH	DOC	DRP	TP
SQ34829	Awamata Stm	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Decreasing	Likely Increasing
SQ34830	Awatotara Ck	Indeterminate	Indeterminate	Very Likely Decreasing	Very Likely Increasing	Likely Decreasing	Indeterminate
SQ34844	Blind Jims Ck	Indeterminate	Indeterminate	Indeterminate	Likely Increasing	Very Likely Decreasing	Likely Decreasing
SQ34859	Lake Huro	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate
SQ34893	Lake Marakapia	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Indeterminate	Very Likely Increasing
SQ34846	Lake Rangitai	Very Likely Decreasing	Indeterminate	Indeterminate	Very Likely Increasing	Indeterminate	Indeterminate
SQ34887	Lake Te Wapu	Indeterminate	Indeterminate	Indeterminate	Very Likely Decreasing	-	Likely Decreasing
SQ34854	Mangahou Stm	Indeterminate	Indeterminate	Very Likely Decreasing	Very Likely Increasing	Indeterminate	Indeterminate
SQ34851	Mangape Ck	Likely Decreasing	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Likely Increasing
SQ35078	Nairn River	Insufficient data	Indeterminate	Indeterminate	-	-	-
SQ34841	North Trib Rakautahi	Likely Decreasing	Indeterminate	Indeterminate	Very Likely Increasing	Likely Increasing	Likely Increasing
SQ34832	Te Awainanga River	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Increasing	Very Likely Increasing
SQ34857	Te One Ck	Indeterminate	Indeterminate	Indeterminate	Likely Increasing	Likely Increasing	Very Likely Increasing
SQ34843	Te Whanga Blind Jims	Very Likely Decreasing	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Increasing
SQ35082	Te Whanga Southern	Indeterminate	Indeterminate	Indeterminate	Very Likely Decreasing	Indeterminate	Indeterminate
SQ34861	Te Whanga Waitamaki	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate
SQ34842	Tennants Lake	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing
SQ34863	Waimahana Ck	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Very Likely Decreasing	Indeterminate
SQ34849	Waitaha Ck	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Decreasing	Likely Decreasing
SQ34860	Waitamaki Ck	Likely Decreasing	Indeterminate	Indeterminate	Likely Increasing	Likely Decreasing	Likely Decreasing
SQ34834	Washout Ck	Likely Increasing	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Decreasing	Indeterminate
SQ34838	Whangamoe Inlet Stm	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Decreasing	Likely Increasing

Site ID	Site	NH4N	NNN	TN	Chla	Clarity	E.coli	Entercocci
SQ34829	Awamata Stm	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34830	Awatotara Ck	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34844	Blind Jims Ck	Indeterminate	Indeterminate	Likely Increasing	-	Indeterminate	-	-
SQ34859	Lake Huro	Indeterminate	Indeterminate	Very Likely Decreasing	Indeterminate	Likely Increasing	-	-
SQ34893	Lake Marakapia	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Indeterminate	-	-
SQ34846	Lake Rangitai	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Increasing	Indeterminate	Likely Increasing	-
SQ34887	Lake Te Wapu	Indeterminate	Indeterminate	Indeterminate	Likely Decreasing	Likely Increasing	-	-
SQ34854	Mangahou Stm	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34851	Mangape Ck	Very Likely Increasing	Likely Decreasing	Likely Decreasing	-	Likely Increasing	Indeterminate	-
SQ35078	Nairn River	-	-	-	-	Very Likely Decreasing	Very Likely Increasing	Indeterminate
SQ34841	North Trib Rakautahi	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34832	Te Awainanga River	Indeterminate	Very Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34857	Te One Ck	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34843	Te Whanga Blind Jims	Indeterminate	Very Likely Increasing	Indeterminate	Very Likely Increasing	Indeterminate	Indeterminate	Indeterminate
SQ35082	Te Whanga Southern	Indeterminate	Indeterminate	Likely Decreasing	Very Likely Increasing	Indeterminate	Very Likely Increasing	Indeterminate
SQ34861	Te Whanga Waitamaki	Indeterminate	Indeterminate	Indeterminate	Very Likely Increasing	Indeterminate	Indeterminate	Indeterminate
SQ34842	Tennants Lake	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Increasing	Indeterminate	-	-
SQ34863	Waimahana Ck	Indeterminate	Likely Increasing	Very Likely Increasing	-	Indeterminate	-	-
SQ34849	Waitaha Ck	Indeterminate	Very Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34860	Waitamaki Ck	Indeterminate	Very Likely Decreasing	Indeterminate	-	Indeterminate	-	-
SQ34834	Washout Ck	Indeterminate	Very Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34838	Whangamoe Inlet Stm	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-

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