Chatham Island Water Quality Summary – January 2014

Water quality monitoring is carried out for a number of streams, lakes and lagoons of Chatham Island for physico-chemistry and microbial water quality on a regular long term basis, to assess the current state of the islands natural waterways, and detect short and long term trends.

Water quality is monitored at 14 stream sites and 8 lake or lagoon sites on the main Chatham Island (Figure 1). Te Whanga Lagoon is monitored at 3 sites, while all other streams and lakes are monitored at one site each.

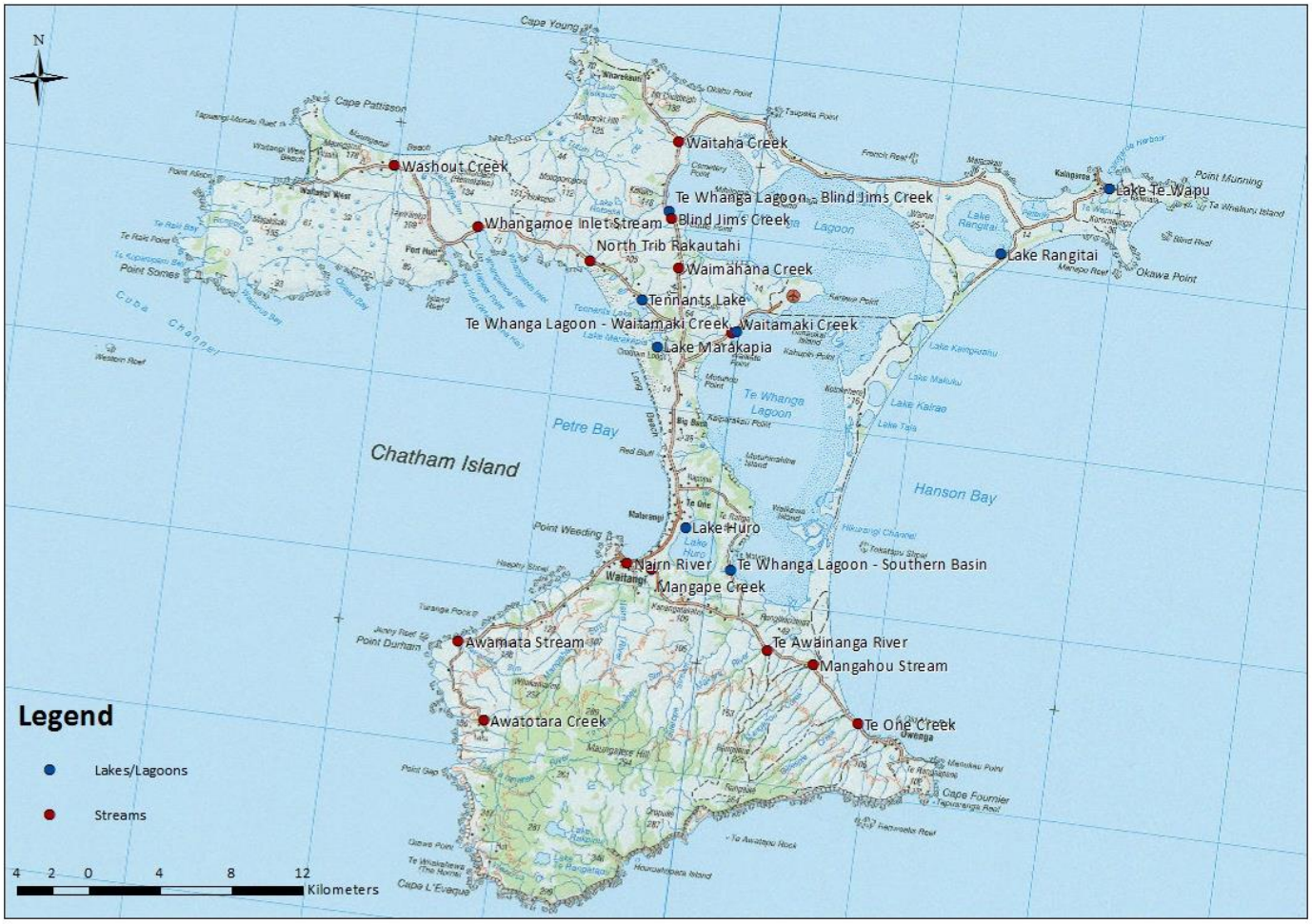


Figure 1: Routine water quality monitoring sites for streams and lakes or lagoons on Chatham Island

Water quality monitoring state and trends

Long term water quality results were analysed for current state based on 5 years of monitoring data; and long term trends based on 10 years of monitoring data, since monitoring began in April 2005. The current state is represented by box plots in Appendix 1 which portray the median as the middle line (50th %ile), the inter quartile range where 50% of central values fall as the box, the non-outlier minimum and maximum as whiskers, and outliers and extremes as discrete points. Appendix 2

represents long term trends as analysed by a seasonal kendall test for significant increases or decreases (represented by Δ for significant increase or ▼ for significant decrease) and the magnitude of change represented by the relative sen slope estimator (>1 = meaningful).

Dissolved Oxygen

Streams, lakes and Te Whanga Lagoon on Chatham Island are generally well oxygenated with the exception of Washout Creek and Whangamoe Inlet Stream, which often experience decreased dissolved oxygen concentrations, as a potential result of river mouth closures. Dissolved oxygen concentrations have been fairly steady over the 10 years of monitoring with only Te Whanga Lagoon at Blind Jims Creek showing a significant and meaningful increase.

Water Temperature

Water temperature is fairly consistent between streams; and the lakes and lagoon, with the shaded Awatotara Stream slightly cooler than other streams. No significant trends have been detected for water temperature variation.

pH

For many streams on Chatham Island the pH indicates acidic water, typical of peat soils. Blind Jims Creek, Waitamaki Creek, Waimahana Creek and Mangape Creek have a more buffered pH similar to those found in Canterbury, indicating the influence of differing geology throughout the island, with a decrease of peaty soils at these sites. pH of the lakes and Te Whanga Lagoon sites on Chatham Island are fairly similar with median concentrations ranging from 8-9 pH. pH has been fairly steady over the 10 years of monitoring with only Te Whanga Lagoon at Blind Jims Creek showing a significant and meaningful increase.

Dissolved Organic Carbon

Similar to pH, dissolved organic carbon (DOC) concentrations differ for Blind Jims Creek, Waitamaki Creek, Waimahana Creek and Mangape Creek, in comparison to other streams on Chatham Island. The volcanic peaty make up of soils on the island influence the leaching of organic matter, contributing to elevated DOC concentrations for many of the streams on the island. Inflow streams on the north western edge of Te Whanga Lagoon show decreased DOC concentrations where the effects of organic matter from peaty soils are likely reduced via filtration by the more sandy soils of this area. Over the past 10 years, DOC has increased for Awamata Stream, Awatotara Creek, Washout Creek, and the north tributary of Rakautahi.

In comparison to the streams of the island, the lakes and Te Whanga Lagoon sites have much lower DOC concentrations, with the exception of Lake Te Wapu, which has much greater concentrations that all the other lake and lagoon sites.

Nutrients

Phosphorus – Dissolved reactive phosphorus (DRP) concentrations are greatest for Washout Creek, Whangamoe Inlet Stream and Waimahana Creek, with significant and meaningful increases of DRP for Whangamoe Inlet Stream and Waimahana Creek over the past 10 years. Total phosphorus concentrations reflect greater the DRP concentrations for Washout Creek, Whangamoe Inlet Stream

and Waimahana Creek. Additionally, total phosphorus is elevated for Blind Jims Creek, Waitamaki Creek and Mangape Creek in comparison to their dissolved reactive phosphorus concentrations, indicating increased particulate phosphorus, potentially due to increased run-off and soil erosion, or bankside disturbance. However, total phosphorus is significantly and meaningfully decreasing for Mangape Creek.

Dissolved reactive phosphorus concentrations are greatest for Lake Te Wapu, Lake Huro and Te Whanga Lagoon at Blind Jims Creek and Waitamaki Creek, however only Lake Te Wapu and Lake Huro have elevated total phosphorus concentrations. Total phosphorus concentrations for Lake Huro, Lake Marakapia and Te Whanga Lagoon at Blind Jims Creek and Waitamaki Creek show significant and meaningful decreasing trends over the past 10 years.

Nitrogen – Dissolved inorganic nitrogen (DIN) and total nitrogen concentrations are greatest for Mangape Creek and Lake Huro and Lake Te Wapu. Long-term nitrogen trends vary among the island. Awamata Stream and Te Awainanga River are significantly and meaningfully decreasing for DIN, while Awatotara Creek and Waimahana Creek are increasing for total nitrogen indicating an increase of organic nitrogen. Te Whanga Lagoon at Blind Jims Creek and Lake Rangitai are both significantly and meaningfully decreasing for total nitrogen.

Chlorophyll *a*

Chlorophyll *a* concentrations for the lakes and Te Whanga Lagoon sites reflect the levels of nutrient enrichment of each site. Chlorophyll *a* concentrations are greatest for Lake Te Wapu and Lake Huro, where nitrogen and phosphorus concentrations are greatest. A significant and meaningful decrease of chlorophyll *a* concentrations for Te Whanga Lagoon at Blind Jims Creek are likely related to decreases of TN and TP, while chlorophyll *a* reductions for Lake Huro reflect the trend of decreasing TP.

Water Clarity

Water clarity (measured by a clarity tube) of the streams on Chatham Island are heavily influenced by leaching from the peaty organic soils, therefore show similar trends among sites to DOC concentrations. The clearest of streams are those with the lower DOC concentrations such as Blind Jims Creek, Waitamaki Creek and Waimahana Creek, where the sandy soils of the stream catchments filter out particles that may reduce water clarity. Conversely, Mangape Creek has reduced water clarity, but low DOC concentrations, suggesting the source of reduced water clarity is more related to suspended particles such as sediment, rather than discoloration of water from leaching of peat soils. Sources of suspended particles may be related to overland flow and unrestricted stock access. However, water clarity for Mangape Creek is significantly and meaningfully improving.

Water clarity in the lakes and Te Whanga Lagoon is more related to in-lake nutrient and chlorophyll *a* concentrations, where water clarity is influenced by algal production, supported by nutrient enrichment. Water clarity for Lake Te Wapu and Lake Huro reflect increased chlorophyll *a* concentrations. These chlorophyll *a* concentrations indicate increased algal production that requires elevated nutrient concentrations to support and promote algal growth; and limits the visible water clarity of a lake.

Water clarity is significantly and meaningfully increasing for both Te Whanga Lagoon at Blind Jims Creek and Lake Huro in response to decreasing trends of chlorophyll *a* and nutrient concentrations over the past 10 years.

Lake Eutrophication

The trophic level index for lake and lagoon sites of Chatham Island is a calculation derived from annual average total nitrogen, total phosphorus and chlorophyll *a* concentrations; used to indicate the level of eutrophication. The eutrophic and supertrophic states of Lake Huro and Lake Te Wapu reflect the nutrient enrichment and subsequent increased chlorophyll *a* concentrations and reduced water clarity. However both these lakes have shown decreases from a hypertrophic state in 2010-11. Te Whanga Lagoon also shows a recent decline of eutrophication over recent years at all three sites, reflecting the significant decline of TP in particular (Tables 1 and 2).

Table 1: Annual Trophic State for Lake and Lagoon sites of Chatham Island

Site Name	2010-11	2011-12	2012-13	2013-14
Tennants Lake	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic
Lake Huro	Hypertrophic	Supertrophic	Supertrophic	Eutrophic
Lake Marakapia	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic
Lake Rangitai	Eutrophic	Mesotrophic	Mesotrophic	Oligotrophic
Lake Te Wapu	Hypertrophic	Supertrophic	Supertrophic	Supertrophic
Te Whanga Lagoon - Blind Jims Creek	Supertrophic	Supertrophic	Eutrophic	Mesotrophic
Te Whanga Lagoon - Southern Basin	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic
Te Whanga Lagoon - Waitamaki Creek	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic

Table 2: Description of Trophic States

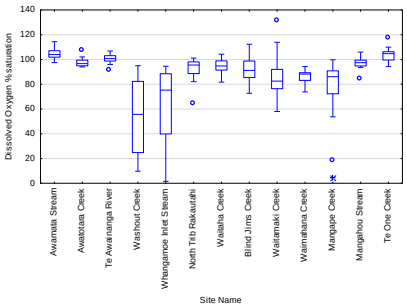
TLI	Tropic state	General Description
<1	Ultra-microtrophic	practically pure, very clean, often have glacial sources
1-2	Microtrophic	very clean, often have glacial sources, very low nutrient enrichment
2-3	Oligotrophic	clear and blue, with low levels of nutrients and algae
3-4	Mesotrophic	moderate levels 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

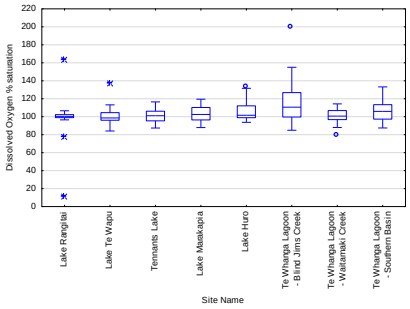
Microbial Water Quality

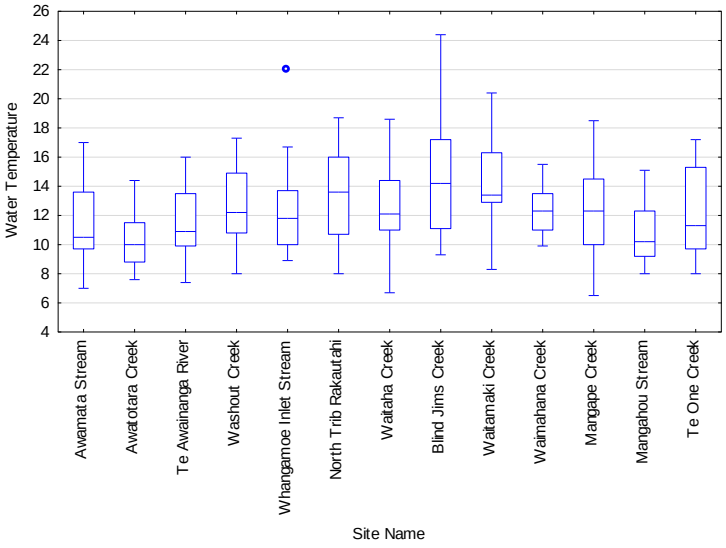
Microbial water quality is monitored for faecal indicator bacteria such as *Escherichia coli* in freshwater, and both *E. coli* and *Enterococci* in water with a saline influence such as Te Whanga Lagoon and the Nairn River at the mouth. Generally, stream sites such as Mangape Creek and Nairn River had the greatest faecal indicator bacteria concentrations, as opposed to the lagoon and Lake Rangitai. Both Mangape Creek and Nairn River are likely influenced by overland run-off and unrestricted stock access in grazed pasture catchments. Occasional spikes in *E.coli* for Te Whanga Lagoon at Blind Jims Creek

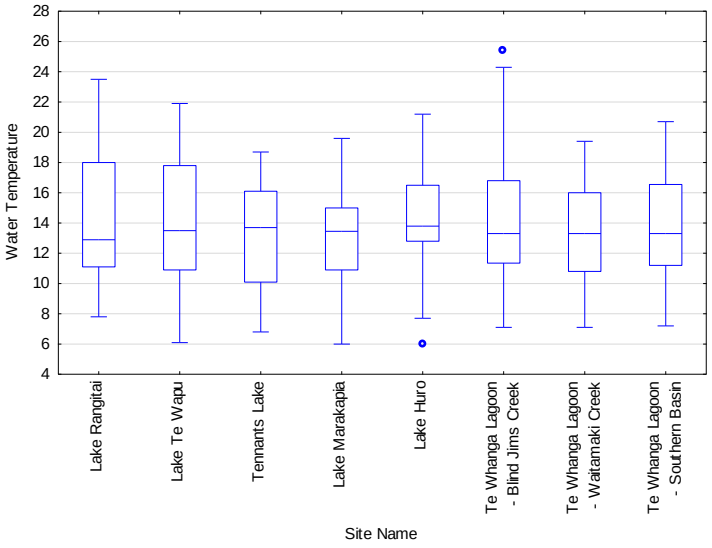
may be caused by re-suspension of benthic sediment reservoirs of faecal bacteria during strong wind, or unrestricted stock access combined with run-off near the lakes edge.

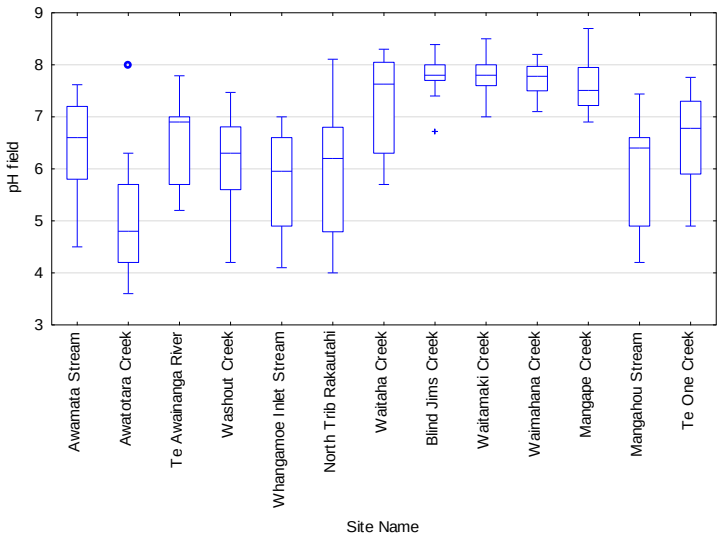
Appendix 1 Box and Whisker plots of current state for Streams, and Lakes and Lagoons on Chatham Island (5 years)

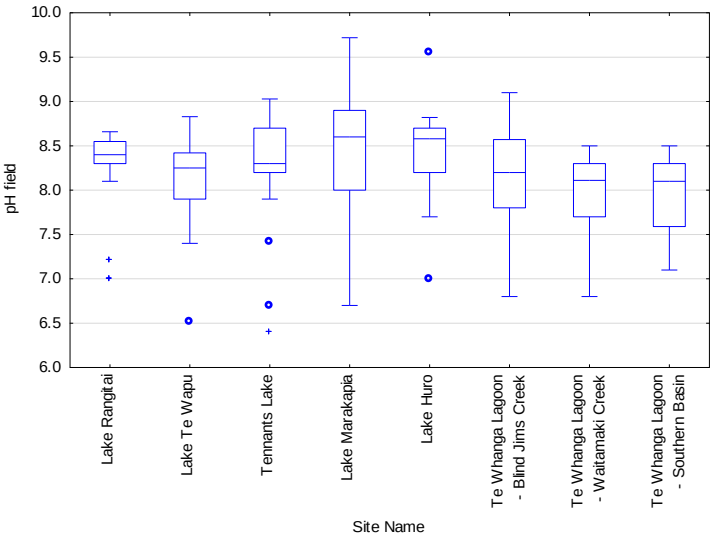


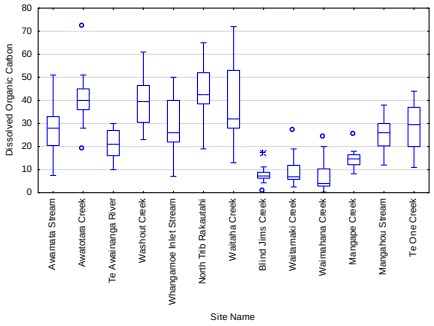


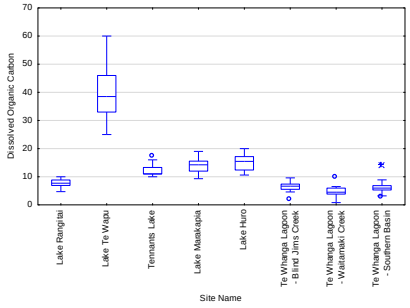


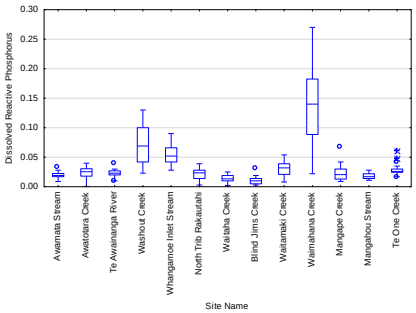


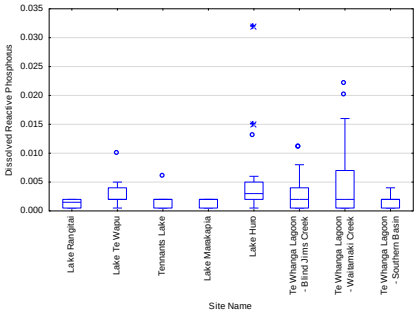


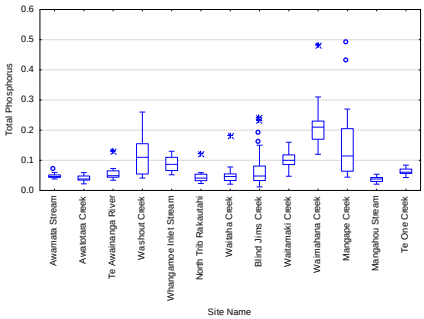


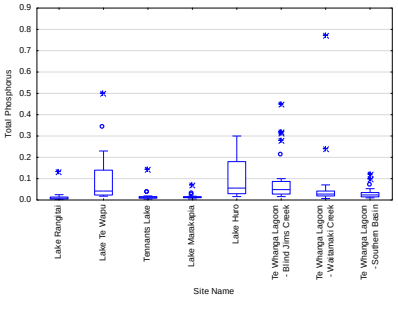

Dissolved Organic Carbon
80
70
60
50
40
30
20
10
0
Avamata Stream
Avatotara Creek
Te Awainanga River
Washout Creek
Whangamoe Inlet Stream
North Trib Rakautahi
Waitaha Creek
Blind Jims Creek
Waitamaki Creek
Waimahana Creek
Mangapoe Creek
Mangahou Stream
Te One Creek
Site Name

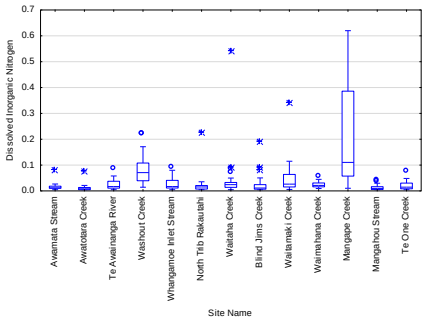

Dissolved Organic Carbon
70
60
50
40
30
20
10
0
Lake Rangitaiai
Lake Te Waipu
Tennants Lake
Lake Maskapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name

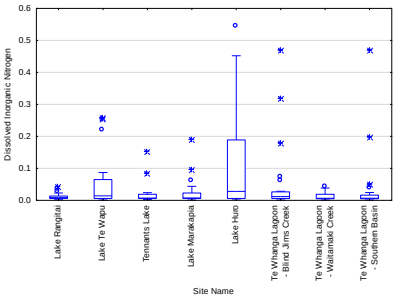

Dissolved Reactive Phosphorus
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Avamata Stream
Avatotara Creek
Te Awainanga River
Washout Creek
Whangamoe Inlet Stream
North Trib Rakautahi
Waitaha Creek
Blind Jims Creek
Waitamaki Creek
Waimahana Creek
Mangapoe Creek
Mangahou Stream
Te One Creek
Site Name

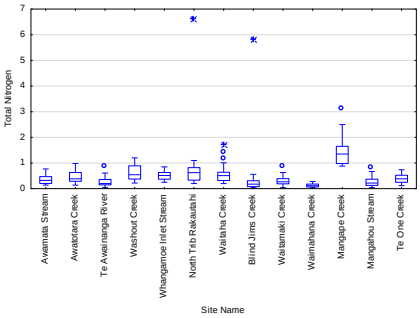

Dissolved Reactive Phosphorus
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Lake Rangitaiai
Lake Te Waipu
Tennants Lake
Lake Maskapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name

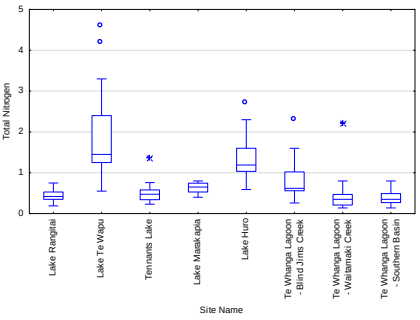

Total Phosphorus
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Avamata Stream
Avatotara Creek
Te Awainanga River
Washout Creek
Whangamoe Inlet Stream
North Trib Rakautahi
Waitaha Creek
Blind Jims Creek
Waitamaki Creek
Waimahana Creek
Mangapoe Creek
Mangahou Stream
Te One Creek
Site Name

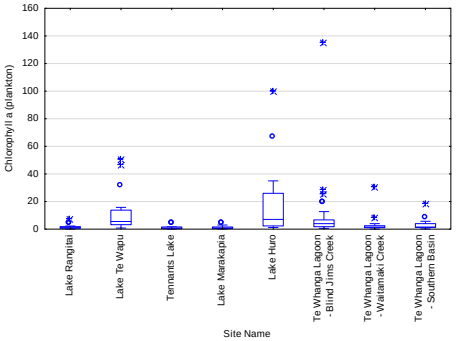

Total Phosphorus
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Lake Rangitaiai
Lake Te Waipu
Tennants Lake
Lake Maskapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name

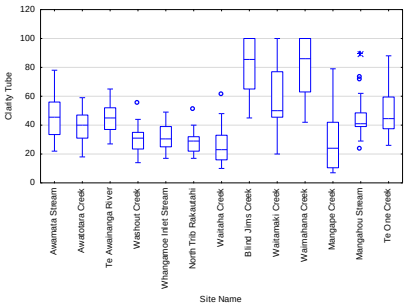

Dissolved Inorganic Nitrogen
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Awamata Stream
Awatotara Creek
Te Awainanga River
Washout Creek
Whangamoe Inlet Stream
North Trib Rakautahi
Waitaha Creek
Blind Jims Creek
Waitamaki Creek
Waimahana Creek
Mangapae Creek
Mangahou Stream
Te One Creek
Site Name

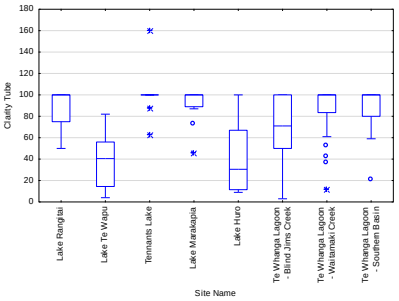

Dissolved Inorganic Nitrogen
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Lake Rangitai
Lake Te Wapu
Tennants Lake
Lake Marakapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name

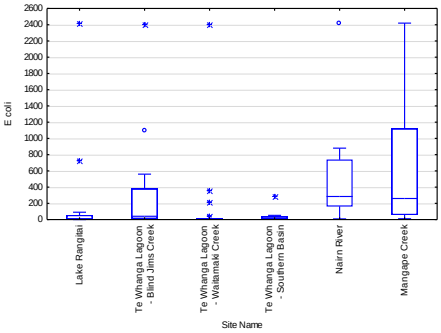

Total Nitrogen
7
6
5
4
3
2
1
0
Awamata Stream
Awatotara Creek
Te Awainanga River
Washout Creek
Whangamoe Inlet Stream
North Trib Rakautahi
Waitaha Creek
Blind Jims Creek
Waitamaki Creek
Waimahana Creek
Mangatae Creek
Mangahou Stream
Te One Creek
Site Name

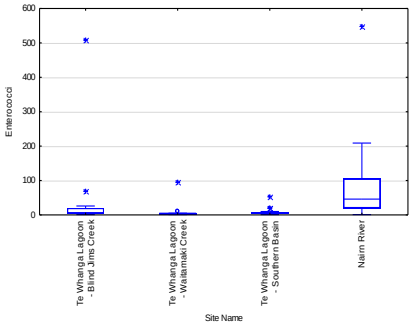

Total Nitrogen
5
4
3
2
1
0
Lake Rangitai
Lake Te Wapu
Tennants Lake
Lake Maakapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name


Chlorophyll a (plankton)
160
140
120
100
80
60
40
20
0
Lake Rangitai
Lake Te Wapu
Tennants Lake
Lake Marakapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name


Clarity Tube
120
100
80
60
40
20
0
Awarmata Stream
Awatobira Creek
Te Awahianga River
Waihout Creek
Whangamoe Inlet Stream
North Trib Rakaitahi
Waitaha Creek
Blind Jims Creek
Waitamaki Creek
Waimahana Creek
Mangape Creek
Mangahou Stream
Te One Creek
Site Name


Clarity Tube
180
160
140
120
100
80
60
40
20
0
Lake Rangitai
Lake Te Waru
Tennants Lake
Lake Marakapia
Lake Huro
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Site Name


E coli
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Lake Rangitai
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Nairn River
Mangape Creek
Site Name


Enterococci
600
500
400
300
200
100
0
Te Whanga Lagoon - Blind Jims Creek
Te Whanga Lagoon - Waitamaki Creek
Te Whanga Lagoon - Southern Basin
Nairn River
Site Name

Appendix 2 Long term trends for streams, lakes and lagoons on Chatham Island (10 years)

	Dissolved Reactive Phosphorus	Dissolved Inorganic Nitrogen	Total Nitrogen	Total Phosphorus	Dissolved Organic Carbon	Clarity Tube	Dissolved Oxygen % saturation	pH	Water Temperature	Chlorophyll *a*	*E. coli*	*Enterococci*
Awamata Stream	NS	▼* -7.95468	NS	NS	Δ* 3.72634	NS	NS	NS	NS			
Awatotara Creek	NS	NS	Δ** 7.84039	NS	Δ*** 5.61319	NS	NS	NS	NS			
Te Awainanga River	NS	▼* -6.25279	NS	NS	NS	NS	NS	NS	NS			
Washout Creek	NS	NS	NS	NS	Δ*** 4.7122	NS	NS	NS	NS			
Whangamoe Inlet Stream	Δ* 6.34574	NS	NS	NS	NS	NS	NS	NS	NS			
North Trib Rakautahi	NS	NS	NS	NS	Δ** 4.85224	NS	NS	NS	NS			
Blind Jims Creek	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Waitaha Creek	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Mangape Creek	NS	NS	NS	▼*** -7.59261	NS	Δ*** 19.25223	NS	NS	NS		NS	
Mangahou Stream	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Te One Creek	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Waitamaki Creek	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Waimahana Creek	Δ* 9.62018	NS	Δ* 4.38303	NS	NS	NS	NS	NS	NS			
Tennants Lake	Insufficient data	Insufficient data	Δ* 4.52419	NS	NS	NS	NS	NS	NS	NS		
Te Whanga Lagoon - Blind Jims Creek	Insufficient data	Insufficient data	▼** -7.48819	▼*** -26.837	NS	Δ** 7.44294	Δ* 2.73431	Δ* 0.64103	NS	▼*** -30.32	NS	NS
Lake Rangitai	Insufficient data	Insufficient data	▼** -5.4367	NS	NS	NS	NS	NS	NS	NS	NS	
Lake Huro	Insufficient data	Insufficient data	NS	▼*** -18.151	NS	Δ* 29.81024	NS	NS	NS	▼*** -25.39		
Te Whanga Lagoon - Waitamaki Creek	Insufficient data	Insufficient data	NS	▼*** -12.637	NS	NS	NS	NS	NS	NS	NS	NS
Lake Te Wapu	Insufficient data	Insufficient data	NS	NS	NS	NS	NS	NS	NS	NS		
Lake Marakapia	Insufficient data	Insufficient data	NS	▼** -15.630	NS	NS	NS	NS	NS	NS		
Te Whanga Lagoon - Southern Basin	Insufficient data	Insufficient data	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nairn River											NS	NS

NS = not significant * P<0.05 ** P<0.01 *** P<0.005 Insufficient data = Insufficient data (<10 years) required for trend analysis