Taihoro Nukurangi

An assessment of community water quality monitoring data from Te Waikoropupū Springs

Prepared for Tasman District Council

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Executive summary

Tasman District Council (TDC) has monitored water quality in the main spring basin at Te Waikoropupū Springs near Takaka for over 25 years, with current monitoring conducted at 3-monthly intervals. Since early 2016, a local community group, Friends of Golden Bay (FOGB), began their own independent water quality monitoring programme at Te Waikoropupū. The group take *in-situ* water measurements and samples at weekly intervals from several sites.

In late 2017, the National Institute of Water and Atmospheric Research Ltd (NIWA) received a Ministry of Business, Innovation and Employment (MBIE) Envirolink small advice grant to briefly evaluate:

- the TDC *vs* FOGB discrete water quality data sets for the main spring basin collected between February 2016 and February 2018; and
- a subset of the FOGB data discrete water quality data *vs* estimates of visual clarity collected by NIWA (reported in Gall 2018) between mid-October 2017 and mid-January 2018.

Only variables measured by both FOGB and TDC were compared: water temperature, specific conductivity, chloride, nitrate nitrogen (nitrate-N) and dissolved reactive phosphorus (DRP). The two sets of discrete water quality data closely agreed, despite differences in sampling frequency, dates, and times. This indicates that all sampling personnel appeared to adhere to standard sampling protocols, sampling instruments and laboratory protocols were broadly comparable, and that water quality in the main spring basin at Te Waikoropupū was relatively stable over the two-year period.

While a detailed power analysis could be undertaken to determine the most appropriate sampling frequency, based on the data sets assessed, weekly sampling would appear to provide little additional information over and above TDC's current (quarterly) sampling frequency. Quarterly sampling is consistent with monitoring of most other groundwater systems across New Zealand, including the National Groundwater Monitoring Programme, and reflects the fact that groundwater systems generally exhibit lower variability than surface water. Should diurnal variation and episodic events (e.g., storms) require characterisation, Gall (2018) demonstrated in an earlier report that this is best done through the deployment of high-frequency water quality instruments in the main spring basin.

There were insufficient data for a statistically robust comparison between the weekly FOGB data and NIWA's continuous *in-situ* visual water clarity estimates. Meaningful correlations between discrete water quality measurements with visual clarity can only be made with data that span at least an annual scale, and preferably over several years to account for inter-annual variability.

1 Introduction

Te Waikoropupū Springs are iconic nationally and internationally, particularly for their outstanding visual clarity and volume of discharge (Gall 2018). The Springs are also of great significance to local iwi and are treasured by the wider Golden Bay community (Young et al. 2017), as reflected in the values and management objectives of the Takaka Fresh Water and Land Advisory Group (FLAG). The Takaka FLAG, established to assist the Tasman District Council (TDC) with implementing the National Policy Statement for Freshwater Management (NPS-FM), identified the importance of maintaining *"water flows and quality from spring systems"*, especially Te Waikoropupū.[1]

Tasman District Council has monitored a range of physico-chemical water quality variables in the main spring basin at Te Waikoropupū since 1990 (Joseph[2], pers. comm. 2018). TDC also maintains continuous water temperature and dissolved oxygen sensors in the main spring basin, the former having been deployed since November 2015 (Young et al. 2017).

Since early 2016, a local community group, Friends of Golden Bay (FOGB), began their own independent water quality monitoring programme at Te Waikoropupū. Water samples are collected at weekly intervals from several sites, and tested for a small suite of physico-chemical water quality variables.

In late 2017, NIWA received a MBIE Envirolink small advice grant to briefly evaluate:

- the TDC *vs* FOGB discrete water quality data sets for the main spring basin collected between February 2016 and February 2018; and
- a subset of the FOGB data discrete water quality data *vs* estimates of visual clarity collected by NIWA between mid-October 2017 and mid-January 2018.

The NIWA visual clarity estimates were obtained from the use of a green beam transmissometer deployed in the main spring basin, under Medium Advice Grant TSDC139 (MBIE Contract No. C01X1708). The transmissometer deployment is documented in a separate report (Gall 2018) and includes data from a sonde that was co-deployed with the transmissometer to continuously measure a suite of other water quality properties, including temperature, dissolved oxygen, and electrical conductivity. A broader assessment of water quality at Te Waikoropupū, including an assessment of temporal trends, is provided by Young et al. (2017).

[1] p15, Takaka Water Management Catchments Values and Objectives Summary (May 2015). Accessed 4 April 2018 from: http://www.tasman.govt.nz/environment/water/water-resource-management/water-catchment-management/water-management-partnerships-flags/takaka-fresh-water-and-land-advisory-group/flag-outputs-and-supporting-information/values-of-water-takaka-flag/

[2] Thomas Joseph, Resource Scientist – Water, TDC.

2 Monitoring sites and methods

Over the February 2016 to February 2018 reporting period, TDC collected discrete grab surface water samples (using a bucket thrown towards the upwelling) at the main springs from the main walkway/viewing platform, at quarterly intervals (Figure 2-1) and submitted these to Hill Laboratories and GNS for analysis of dissolved concentrations of a range of major anions and cations, including nutrients. Spot *in-situ* measurements of water temperature, dissolved oxygen and pH were also collected. The sampling frequency was increased to monthly intervals during NIWA's deployment of continuous water quality instrumentation in the main Spring between mid-October 2017 and mid-January 2018, with an extension sampler pole used to collect additional samples for determination of coloured dissolved organic matter (CDOM) absorption (see Gall 2018).

Over the reporting period, FOGB collected discrete surface water samples at weekly intervals from the main spring basin (using the same methods as TDC), as well as from two sites along Fish Creek (Figure 2-1). These samples were submitted to GNS for measurements of nitrate nitrogen, dissolved reactive phosphorus and, on occasion, chloride. Discrete *in-situ* measurements of water temperature and electrical conductivity, and the air temperature were also recorded.

Between 13 October 2017 to 17 January 2018, NIWA deployed (suspended) a WET Labs C-Star green beam transmissometer in the main spring basin for the purposes of estimating *in-situ* visual water clarity (Figure 2-1). A YSI EXO-2 sonde was co-deployed with the transmissometer to continuously (10 min intervals) measure water temperature, dissolved oxygen, electrical conductivity, pH, turbidity and fluorescence of dissolved organic matter (fDOM). See Gall (2018) for more details.

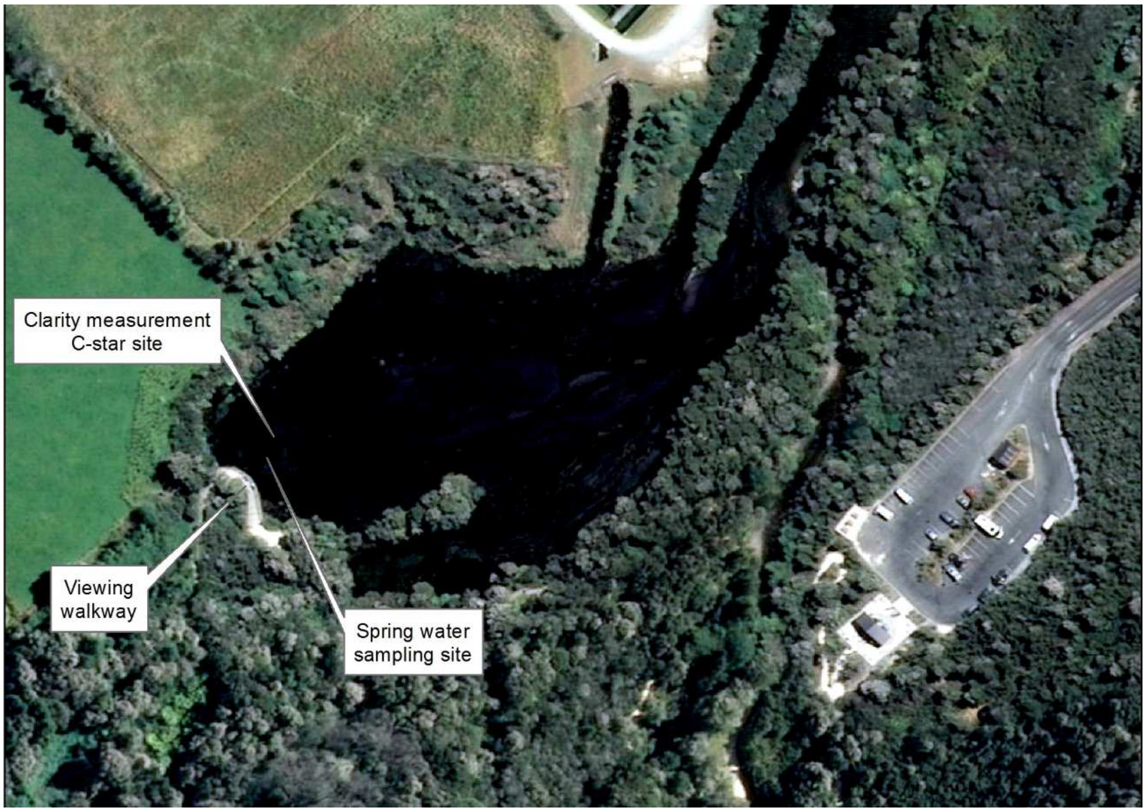

Figure 2-1: Te Waikoropupū Springs showing the location of main spring basin water quality monitoring site adjacent to the viewing platform. The location of the C-star beam transmissometer deployment is also shown. Aerial photo supplied by TDC.

3 Monitoring results and discussion

This section provides a summary and comparison of the FOGB and TDC water quality data collected from the main spring basin at Te Waikoropupū between February 2016 and February 2018. Only variables measured by both FOGB and TDC and are presented: water temperature, specific conductivity, chloride, nitrate nitrogen (nitrate-N) and dissolved reactive phosphorus (DRP).

A comparison between the weekly FOGB data and NIWA's continuous *in-situ* visual water clarity estimates collected over 13 October 2017 to 17 January 2018 was not performed. Fourteen data points were considered too few for a statistically robust assessment. Moreover, the data only span a limited portion of the year, such than no account of seasonality can be made. Seasonality is highly common across some water quality variables (e.g., Ballantine and Davies-Colley 2010), as is inter-annual variability arising from differences in rainfall (e.g., Figure 3-1 illustrates higher conductivity and chloride concentrations during the equivalent 3-month period in 2016/17).

Table 3-1 presents summary statistics for the TDC and FOGB data sets which are reproduced in full in the Appendix. Caution is necessary when comparing these data sets and their summary statistics, as the data were obtained from different sampling intervals, dates and times.[3] As is to be expected, improved resolution is provided in the weekly scale data set (Figure 3-1). However, the time series comparison also illustrates similarities in tracking temporal variability over seasonal (about 3-month) scales (e.g., as indicated in the nitrate-N plot in Figure 3-1).

Both data sets indicate a median water temperature in Te Waikoropupū of 11.7°C, with little variation around this value (Table 3-1) and little, if any, apparent influence of air temperature (see top left plot in Figure 3-1). This finding is consistent with Young et al. 2017) who noted that the water temperature within the aquifer is very stable over time and does not appear to have changed since the 1970s.

Table 3-1: Summary statistics for selected water quality measurements collected by FOGB and TDC. FOGB and TDC data were collected approximately quarterly and monthly, respectively, between February 2016 and February 2018.

	Water Temperature (°C)		Specific Conductivity (µS/cm)		Chloride (mg/L)		Nitrate-N (mg/L)		DRP (mg/L)	
	FOGB	TDC	FOGB	TDC	FOGB	TDC	FOGB	TDC	FOGB	TDC
Minimum	11.6	11.6	466	610	48	70	0.37	0.33	0.0040	0.0036
Median	11.7	11.7	704	685	102	96	0.42	0.44	0.0050	0.0049
Mean	11.7	11.7	691	683	98	97	0.42	0.43	0.0056	0.0047
Maximum	11.8	11.7	779	779	122	117	0.47	0.47	0.0080	0.0060
Standard deviation	0.04	0.05	56	47	18	13	0.03	0.04	0.0010	0.0008
n	105	9	105	11	32	11	104	11	104	10

[3] The TDC data set also comprises nitrate-N and DRP results from two laboratories.

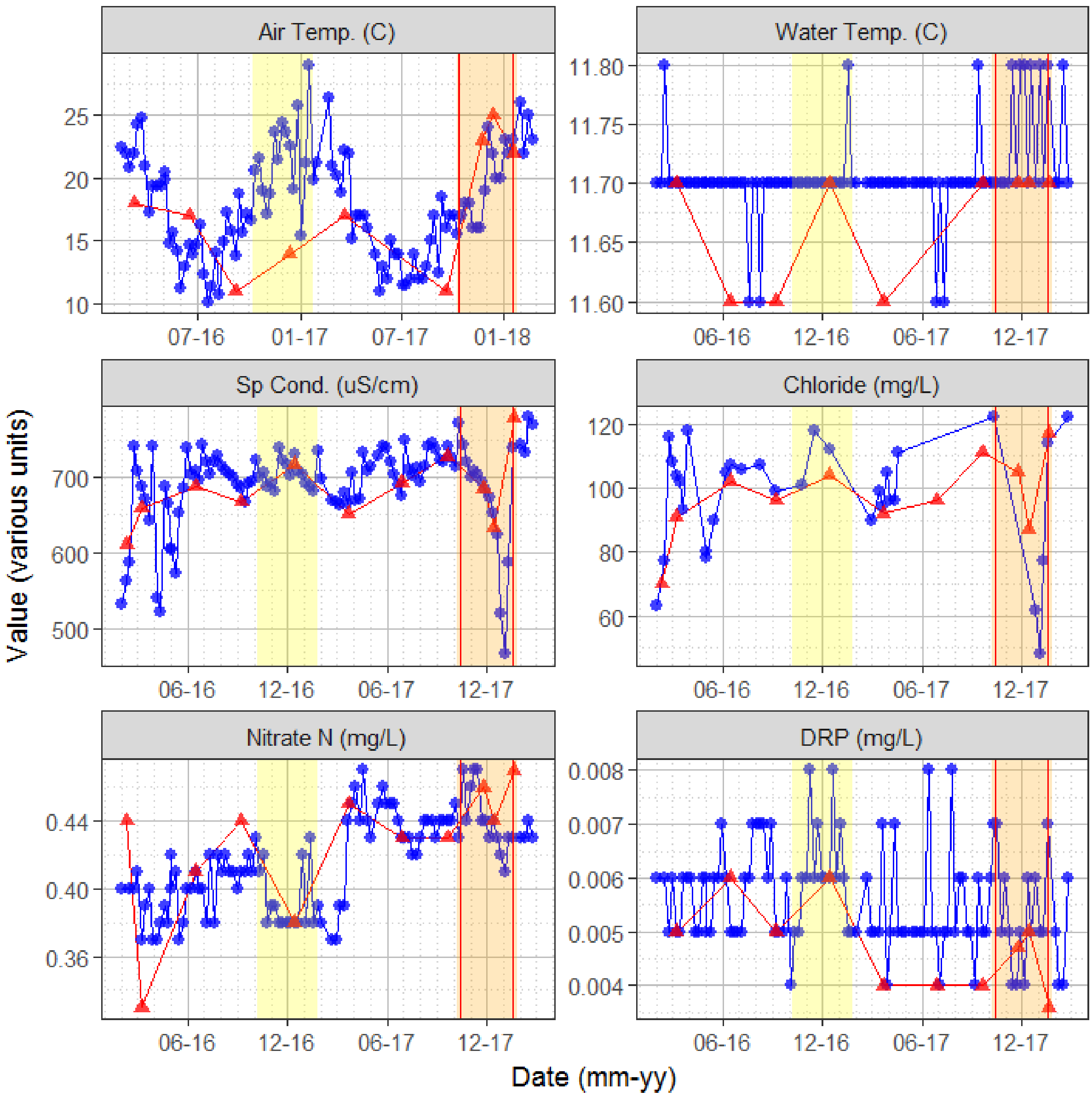

Figure 3-1: Time series comparison of discrete water sample measurements collected by FOGB (blue) and TDC (red). FOGB data were collected weekly while TDC data were collected approximately 3-monthly. Note: *y*-axes scales do not start at zero. The red bordered shaded area indicates the 2017/18 NIWA continuous deployment period, highlighting the short period of time over which FOGB and NIWA measurements have been compared. The yellow shaded area indicates the equivalent 3-month period in 2016/17.

The median specific conductivity across the two data sets was also comparable, at 704 and 685 µS/cm for FOGB and TDC, respectively (Table 3-1). The wider ranges of results captured in the FOGB data set likely reflects the greater number of observations. Conductivity will be influenced by rainfall, in particular storm events that lead to surface runoff entering the springs, as occurred on 16 January 2018 (Figure 3-1).

The median chloride concentration was similar for both the FOGB (102 mg/L) and TDC (96 mg/L) data sets (Table 3-1). Again, the greater range, particularly the much lower minimum (48 mg/L) in the FOGB data set, reflects the greater number of observations and the capturing of data during the January 2018 rainfall-runoff event when overland flow entered the main spring basin (see Gall 2018).

There is close agreement in the median nitrate-N concentrations recorded by FOGB and TDC over the two years from February 2016 (Table 3-1). The medians (0.42 and 0.44 mg/L, respectively) are also consistent with the majority of measurements recorded from all monitoring to date (Young et al. 2017). While less seasonality is evident in the data set compared with the typical signature of surface waters (e.g., Figure 3-1), of interest is a small but apparent ‘step change’ in the FOGB data set in early 2017. A Mann-Whitney test confirms a statistically significant ($p < 0.001$) difference between the median nitrate-N concentration from February 2016 to January 2017 and the median from February 2017 to January 2018, the latter period showing higher concentrations. However, the difference is small and not likely to be environmentally meaningful. The reason for this small difference is unclear and unlikely to be laboratory analysis related as there were no method changes over the reporting period. We note from the 47-year monitoring record presented in Young et al. (2017), that nitrate-N concentrations have ranged between 0.29 and 0.66 mg/L (excluding outliers).

The median DRP concentrations recorded by FOGB and TDC over February 2016-2018 were identical (0.005 mg/L), with little variation in concentrations observed (Table 3-1). The lower minimum value for TDC (0.0036 mg/L) appears to reflect a recent shift to a lower laboratory detection limit. This action reflects an observation by Young et al. (2017) that most DRP values were relatively low and close to analytical detection limits.

4 Conclusions

Discrete water quality data sets, collected independently by TDC and FOGB over the period February 2016 and February 2018, were in close agreement, despite differences in sampling frequency (quarterly vs weekly, respectively), dates, and times. This indicates that both parties appeared to adhere to standard sampling protocols, sampling instruments and laboratory protocols were broadly comparable.

While a detailed power analysis could be undertaken to determine the most appropriate sampling frequency, based on the data sets assessed, weekly sampling would appear to provide little additional information over and above TDC's current (quarterly) sampling frequency. Quarterly sampling is consistent with monitoring of most other groundwater systems across New Zealand, including the National Groundwater Monitoring Programme. Groundwater systems generally exhibit lower variability than surface water and autocorrelation has been observed at sampling frequencies of greater than monthly (e.g., Barcelona et. al. 1989).[4] Should diurnal variation and episodic events (e.g., storms) require characterisation, this is best done through the deployment of high-frequency water quality instruments in the main spring basin (Gall 2018).

There were insufficient data for a statistically robust comparison between the weekly FOGB data and NIWA's continuous *in-situ* visual water clarity estimates collected over October 2017 to January 2018. Meaningful correlations between discrete water quality measurements and visual clarity can only be made with data that span at least an annual scale, and preferably over several years to account for inter-annual variability.

[4] High auto-correlation results in sampling redundancy. Barcelona et. al. (1989) evaluated groundwater quality data from 12 wells sampled at fortnightly intervals over 18 months and concluded that sampling more frequent than two-monthly was inefficient for operational monitoring programmes.

5 Acknowledgements

Dr Charlotte Jones-Todd (NIWA) provided statistical advice. Joseph Thomas, Trevor James and Rob Smith (Tasman District Council) provided comments on a draft version of this report.

6 References

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Young, R., Fenwick, G., Fenemor, A., Moreau, M., J., T., McBride, G., Stark, J., Hickey, C., Newton, M. (2017) *Ecosystem health of Te Waikoropupū. Prepared to Support Decision Making by the Takaka Freshwater Land Advisory Group*. Cawthron Report No. 2949: 47 p plus appendices.

Appendix

The FOGB and TDC data sets compared in Section 3 are presented below. Some caution is advised in terms of the nitrate-N and DRP comparisons; the TDC data set comprises data from two different laboratories. Limiting the comparison with FOGB to the results from only one laboratory would have yielded too few TDC data points.

Date	Water Temperature (°C)	Specific Conductance (µS/cm)	Chloride (mg/L)	Nitrate-N (mg/L)	DRP (mg/L)
Friends Of Golden Bay (FOGB) data					
02/02/2016	11.7	533	63	0.4	0.006
11/02/2016	11.7	563	NA	NA	NA
16/02/2016	11.8	588	77	0.4	0.006
23/02/2016	11.7	741	116	0.4	0.005
01/03/2016	11.7	709	108	0.41	0.006
09/03/2016	11.7	688	104	0.37	0.005
15/03/2016	11.7	671	102	0.39	0.005
22/03/2016	11.7	643	93	0.4	0.006
29/03/2016	11.7	741	118	0.37	0.006
05/04/2016	11.7	541	NA	0.37	0.006
12/04/2016	11.7	522	NA	0.38	0.005
19/04/2016	11.7	688	NA	0.39	0.005
26/04/2016	11.7	666	NA	0.38	0.006
03/05/2016*	11.7	606	80	0.42	0.006
03/05/2016*	11.7	603	78	0.4	0.005
10/05/2016	11.7	574	NA	0.41	0.005
17/05/2016	11.7	654	90	0.37	0.006
25/05/2016	11.7	686	NA	0.38	0.006
31/05/2016	11.7	740	NA	0.4	0.007
07/06/2016	11.7	705	105	0.4	0.006
15/06/2016	11.7	709	107	0.41	0.005
21/06/2016	11.7	696	NA	0.4	0.005
28/06/2016	11.7	743	NA	0.4	0.005
05/07/2016	11.7	721	106	0.38	0.005
12/07/2016	11.7	705	NA	0.42	0.006
19/07/2016	11.6	721	NA	0.38	0.006
26/07/2016	11.7	729	NA	0.42	0.007
02/08/2016	11.7	715	NA	0.41	0.007
09/08/2016	11.6	709	107	0.42	0.007
16/08/2016	11.7	705	NA	0.41	0.007
23/08/2016	11.7	701	NA	0.41	0.006
30/08/2016	11.7	689	NA	0.4	0.007
07/09/2016	11.7	685	99	0.41	0.005
13/09/2016	11.7	668	NA	0.41	0.005
20/09/2016	11.7	692	NA	0.42	0.005
27/09/2016	11.7	693	NA	0.41	0.006
04/10/2016	11.7	722	NA	0.43	0.004

Date	Water Temperature (°C)	Specific Conductance (µS/cm)	Chloride (mg/L)	Nitrate-N (mg/L)	DRP (mg/L)
11/10/2016	11.7	700	NA	0.41	0.005
18/10/2016	11.7	706	NA	0.42	0.005
25/10/2016	11.7	687	101	0.38	0.006
01/11/2016	11.7	691	NA	0.39	0.006
08/11/2016	11.7	682	NA	0.39	0.008
15/11/2016	11.7	740	118	0.38	0.006
22/11/2016	11.7	723	NA	0.38	0.007
29/11/2016	11.7	716	NA	0.38	0.006
06/12/2016	11.7	703	NA	0.38	0.006
13/12/2016	11.7	731	112	0.38	0.006
20/12/2016	11.7	709	NA	0.38	0.008
27/12/2016	11.7	704	NA	0.42	0.006
03/01/2017	11.7	692	NA	0.38	0.007
10/01/2017	11.7	688	NA	0.43	0.006
17/01/2017	11.8	681	NA	0.38	0.005
24/01/2017	11.7	734	NA	0.39	0.005
31/01/2017	11.7	699	NA	0.38	0.005
21/02/2017	11.7	670	NA	0.37	0.006
28/02/2017	11.7	668	90	0.37	0.005
07/03/2017	11.7	664	NA	0.39	0.005
15/03/2017	11.7	679	99	0.39	0.005
21/03/2017	11.7	665	94	0.44	0.007
28/03/2017	11.7	706	105	0.45	0.004
04/04/2017	11.7	669	96	0.46	0.005
11/04/2017	11.7	671	96	0.44	0.007
18/04/2017	11.7	732	111	0.47	0.005
26/04/2017	11.7	709	NA	0.44	0.005
02/05/2017	11.7	715	NA	0.43	0.005
16/05/2017	11.7	728	NA	0.45	0.005
23/05/2017	11.7	742	NA	0.46	0.005
30/05/2017	11.7	739	NA	0.45	0.005
06/06/2017	11.7	720	NA	0.45	0.005
13/06/2017	11.7	704	NA	0.45	0.008
20/06/2017	11.7	690	NA	0.44	0.005
27/06/2017	11.6	676	NA	0.43	0.005
04/07/2017	11.7	750	NA	0.43	0.004
11/07/2017	11.6	711	NA	0.43	0.005
17/07/2017	11.7	703	NA	0.42	0.005
25/07/2017	11.7	712	NA	0.42	0.008
01/08/2017	11.7	694	NA	0.43	0.005
08/08/2017	11.7	715	NA	0.44	0.006
15/08/2017	11.7	741	NA	0.44	0.006
22/08/2017	11.7	746	NA	0.44	0.005
29/08/2017	11.7	737	NA	0.43	0.005

Date	Water Temperature (°C)	Specific Conductance (µS/cm)	Chloride (mg/L)	Nitrate-N (mg/L)	DRP (mg/L)
05/09/2017	11.7	723	NA	0.44	0.004
12/09/2017	11.8	720	NA	0.44	0.006
19/09/2017	11.7	741	NA	0.44	0.005
26/09/2017	11.7	726	NA	0.44	0.005
03/10/2017	11.7	714	NA	0.45	0.006
10/10/2017	11.7	771	122	0.43	0.007
17/10/2017	11.7	743	NA	0.47	0.007
24/10/2017	11.7	721	NA	0.44	0.005
31/10/2017	11.7	700	NA	0.46	0.006
07/11/2017	11.7	709	NA	0.47	0.005
14/11/2017	11.8	705	NA	0.47	0.004
21/11/2017	11.7	694	NA	0.44	0.004
28/11/2017	11.8	684	NA	0.44	0.005
05/12/2017	11.8	674	NA	0.43	0.004
12/12/2017	11.7	654	NA	0.44	0.006
18/12/2017	11.8	624	NA	0.43	0.005
26/12/2017	11.7	519	62	0.42	0.006
03/01/2018	11.8	466	48	0.41	0.005
09/01/2018	11.7	588	77	0.43	0.005
16/01/2018	11.8	739	114	0.43	0.007
30/01/2018	11.7	743	NA	0.43	0.005
07/02/2018	11.7	732	NA	0.43	0.004
13/02/2018	11.8	779	NA	0.44	0.004
23/02/2018	11.7	769	122	0.43	0.006
Tasman District Council (TDC) data					
11/02/2016**	NA	610	70	0.44	NA
09/03/2016	11.7	659	91	0.33	0.005
15/06/2016	11.6	688	102	0.41	0.006
07/09/2016	11.6	667	96	0.44	0.005
13/12/2016	11.7	717	104	0.38	0.006
22/03/2017	11.6	651	92	0.45	0.004
28/06/2017	NA	693	96	0.43	0.004
19/09/2017	11.7	728	111	0.43	0.004
24/11/2017**	11.7	685	105	0.46	0.0047
13/12/2017	11.7	634	87	0.44	0.005
19/01/2018**	11.7	779	117	0.47	0.0036

* Two sample results for the same day, approximately 30 min apart – an average of both sets would ideally have been used in the comparison but with 105 data points, the effect of including both sets of values is expected to be minimal.

** Results provided by a different laboratory provider. This laboratory also tested samples collected by TDC on 7 June 2016 and 13 December 2017 but these test results were removed to avoid duplicate samples from the same month being used in the comparison against FOGB data.