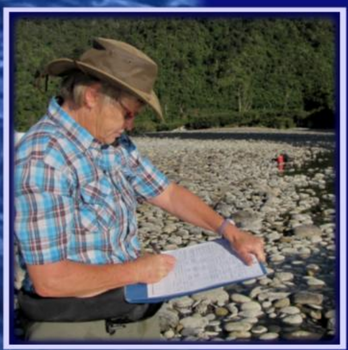
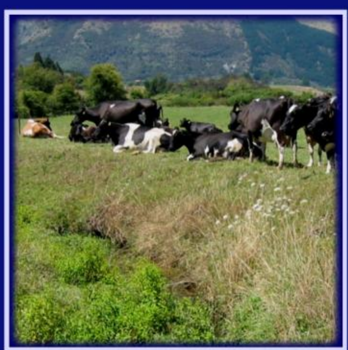
tasman district council

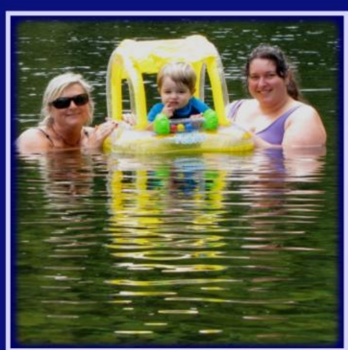
State of the Environment Report

River Water Quality in Tasman District

2015







State of the Environment Report

River Water Quality in Tasman District 2015

Document Status: Final

A technical report presenting results of the Tasman District Council's 'State of the Environment' River Water Quality Monitoring Programme and additional data from the National River Water Quality Network. Indicators measured include: physical, chemical, and bacteriological characteristics of the water, macroinvertebrate indices and periphyton cover. The report highlights water quality condition and trends, from the Waimea, Motueka, Takaka, Aorere and Buller water management areas.

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Cover photos:

1. Claire Webster at the Aorere River
2. Koura from Dall Ck, Golden Bay
3. Jimmy Lee Ck, Washbourne Gardens
4. Mouth of the Motueka River
5. McConnon Ck, Golden Bay
6. Bathers at the Lee River Reserve

Photos taken by Trevor James and Jonathan McCallum.

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Contents

Takaka Water Management Area

This area covers the whole Takaka catchment and all streams from Wainui Bay in the east to Tukurua in the north-west. This is the same area as covered by the Freshwater Management Unit set up under the National Policy Statement for Freshwater Management.

Between 2010 and 2014, there were 15 core River Water Quality sites monitored within the Takaka Water Management Area (Figure 1). There was one reference site, Takaka at Harwoods.

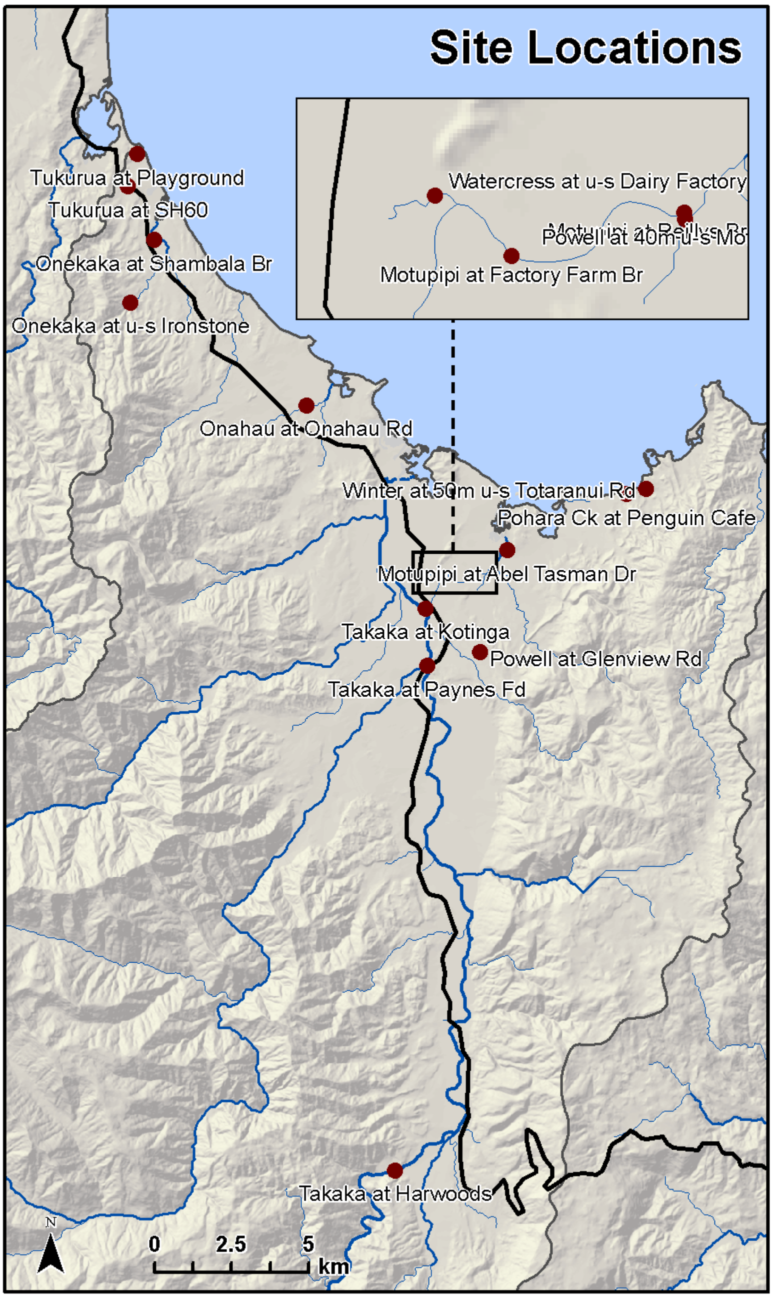


Figure 1. River Water Quality sites in the Takaka Water Management Area

Discussion of Specific Catchments/Areas

This section describes the more **notable aspects of water quality in a given catchment, actions taking place, and recommendations** for further action.

The key to the colour-coding for each water quality attribute state (A to D) is shown to the right. The cut-offs used for each attribute are shown in **Error! Reference source not found.**.

Attribute State
A (Excellent)
B
C
D (Poor)

The dataset used to determine the attribute states was collected at base-flow over the period from 2010-2014 unless a comment is made otherwise. White (no colouring) indicates there are no data available to determine the attribute state.

Trends in water quality attributes are reported if they are statistically significant (p-value<0.05) and ecologically meaningful (RSKSE>1%). An increasing trend can have a positive or negative effect on the stream ecosystem, depending on the attribute. To indicate the ecosystem effect of the trend, we have used a smile symbol (☺) for improving trends and a frown symbol (☹) for degrading trends.

Table 1. Numerical attribute states for each water quality attribute for the protection of river ecosystem health, aesthetics, and human health. Attributes highlighted in blue are included in the National Policy Statement for Freshwater Management (NPSFM 2014).

Attribute	Statistic	Units	Attribute State				Source
			A	B	C	D	
Water clarity	Single measurement	m	≥5	3 - 5	1.6 - 3	<1.6	-
Turbidity	Single measurement	NTU	≤5.6	>5.6	N/A	N/A	ANZECC & ARMCANZ (2000)
Resuspendable solids	Shuffle score (1 to 5)	N/A	1	2	3	≥4	-
Dissolved oxygen concentration	7-day mean minimum	g/m^3	≥8	7 - 8	5 - 7	<5	NPSFM (2014)
	Lowest 1-day minimum	g/m^3	≥7.5	5 - 7.5	4 - 5	<4	
Water Temperature	Midpoint of daily mean and daily maximum	^{o}C	≤18	18 - 20	20 - 24	>24	Davies-Colley et al. (2013)
pH	Single measurement	N/A	6.5 - 8.5	5 - 6.5, 8.5 - 9	>5 or >9	N/A	-
Ammonia-N	Annual median	g/m^3	≤0.03	0.03 – 0.24	0.24 - 1.3	>1.3	NPSFM (2014)
	Annual maximum	g/m^3	≤0.05	0.05 - 0.4	0.4 - 2.2	>2.2	
Nitrate-N	Annual median	g/m^3	≤1.0	1.0 - 2.4	2.4 – 6.9	>6.9	NPSFM (2014)
	Annual 95^{th} percentile	g/m^3	≤1.5	1.5 - 3.5	3.5 - 9.8	>9.8	
Dissolved reactive phosphorus	Single measurement	g/m^3	<0.01	≥0.01	N/A	N/A	ANZECC & ARMCANZ (2000)
E. coli	Annual median	CFU/100 ml	≤260	260 - 540	540 - 1000	>1000	NPSFM (2014)
	95^{th} percentile	CFU/100 ml	≤260	260 - 540	540 - 1000	>1000	
Macroinvertebrates	MCI	N/A	≥120	100 - 120	80 - 100	<80	Stark & Maxted (2007)
	SQMCI	N/A	≥6	5 - 6	4 - 5	<4	
Phormidium	Percentage cover	%	<20	≥20	N/A	N/A	MfE (2009)
Filamentous green algae	Percentage cover	%	<10	10-19	20-29	>30	Biggs and Kilroy (2000)
Periphyton	Periphyton score (1 to 10)	N/A	≥8	6 - 8	5 - 6	< 5	-

How to read a site summary

The site summaries in this report are based on data collected quarterly (monthly for selected sites) from 2010-14, with two exceptions: (1) macroinvertebrate community index values were from 2011-2015 and (2) dissolved oxygen measurements were taken over several days in a summer period from 2005-2015.

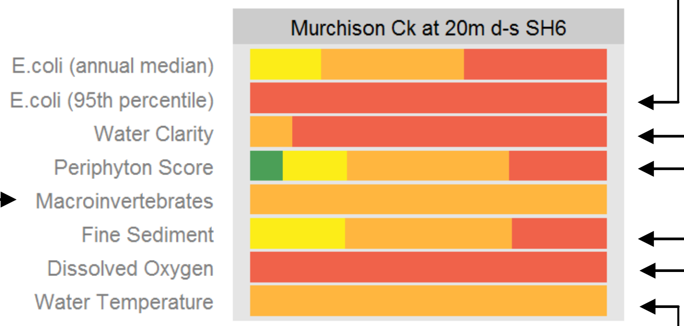
The rows of a site summary represent water quality attributes. The colours indicate attribute states **A** (very good), **B** (good), **C** (fair) **D** (poor).

Proportion of periphyton scores in each attribute state.

Proportion of water clarity measurements (m) in each attribute state.

Attribute state for the 95th percentile *E. coli* concentration. Minimum 10 samples.

Attribute states for the annual median *E. coli* concentration. No minimum sample size.



Proportion of macroinvertebrate community index (MCI) values in each attribute state.

Attribute state for the highest midpoint of daily mean and daily maximum temperature from a continuous record.

Attribute state for the mean minimum dissolved oxygen concentration over 3 or more days during summer. For sites with fewer than 3 days of continuous measurements, the 1-day minimum value was used.

Proportion of resuspendable solids (fine sediment) scores in each attribute state.

Water Clarity

Two sites had at least three water clarity records below the guideline value of 1.6 m during the five-year reporting period (Powell at 40 m u-s Motupipi Rv and Winter at 50 m u-s Totaranui Rd). This indicates a pattern of poor water clarity at these sites. There were six other sites with one or two water clarity records below the 1.6 m guideline value. The clearest river water in the Takaka catchment is the Te Waikoropupū River (median: 22 m, maximum: 41.5 m, measured at a site 600 m downstream of the main spring) followed by Onekaka at u-s Ironstone (Median: 10 m, Maximum: 15.8 m).

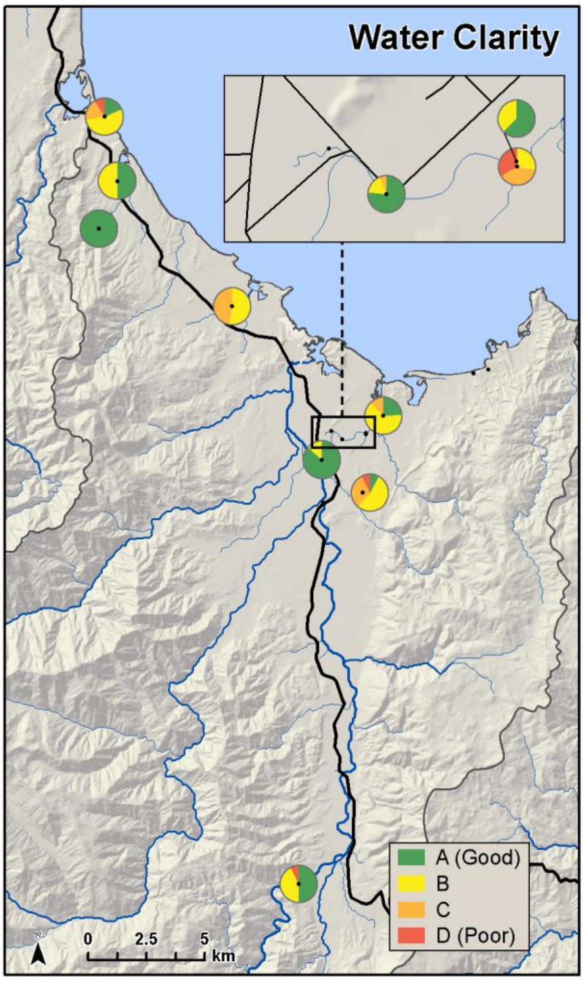


Figure 2. Proportion of water clarity records in each attribute state (A to D) for river water quality sites in the Takaka Water Management Area (sites shown have a minimum of 10 samples).

Disease-causing Organisms

The National Bottom Line annual median *E. coli* concentration (1000 *E. coli*/100 ml) was exceeded at Powell at 40 m u-s Motupipi Rv in 2014 (median value 1080 *E. coli*/100 ml). In the same year, the annual median *E. coli* concentrations for three sites used for contact recreation, or that flow into estuaries or beaches used for contact recreation, exceeded the contact recreation limit (540 *E. coli*/100 ml): Tukurua at Playground, Onahau at Onahau Rd and Motupipi at Abel Tasman Dr.

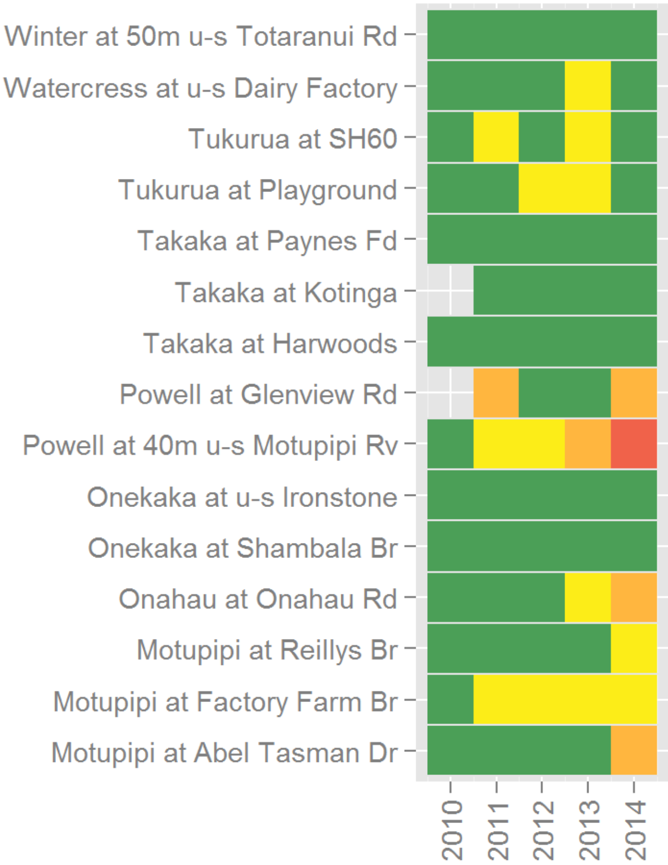


Figure 3. Tile plot of annual median *E. coli* values for sites in the Takaka Water Management Area. Colours indicate attribute states A (green), B (yellow), C (orange) and D (red). Annual median values were calculated for sites with three or more records in a given year.

Filamentous Green Algae Cover & Periphyton Score

The coverage of filamentous green algae in the Takaka Water Management Area was generally low (Figure 4). On two occasions, however, Watercress at u-s Dairy Factory had coverage greater than 50%. High coverage was also recorded on one occasion at Motupipi at Reillys Bridge (during Spring 2014).

Periphyton scores (Rapid Assessment Method 2, NZ Periphyton Monitoring Manual, 2000) were generally good (in the A or B bands). However, both Motupipi sites, both Powell sites and Takaka at Harwoods had at least three periphyton scores less than seven (bands C or D). The cover of *Didymo* is extensive at Harwoods and Paynes Ford, and filamentous green algae seem to grow better on *Didymo* than a clean stream bed.

Macro-algal cover in the Motupipi and Onekaka Inlets is generally low, except in the western arm of the Motupipi Inlet where there are significant areas of localised nuisance algae (Stevens and Robertson, 2007).

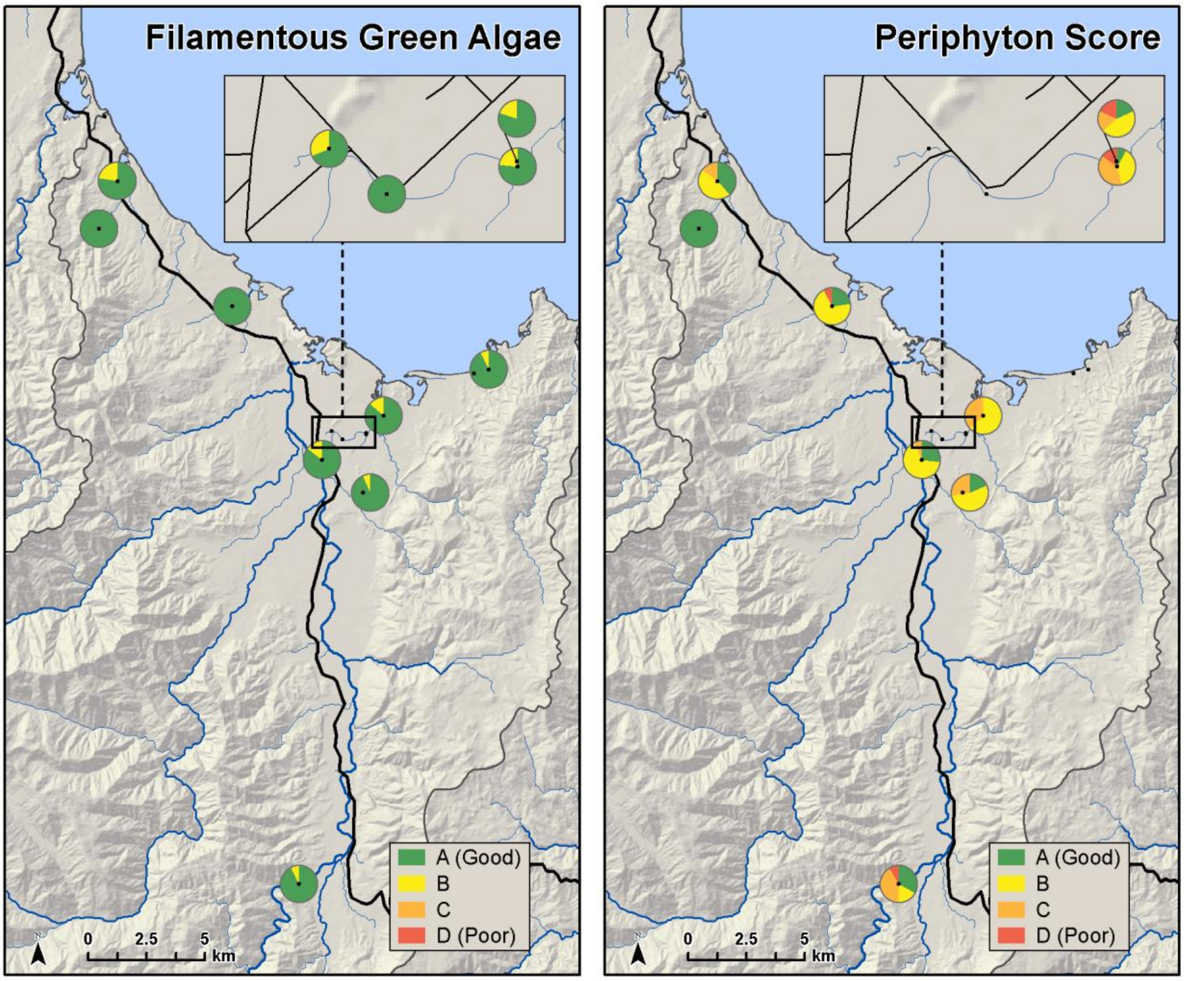


Figure 4. Coverage of filamentous green algae greater than 20 mm in length (left) and periphyton community score (right) for sites in the Takaka Water Management Area. Pie charts show the proportion of estimates in each attribute state (A to D) for sites with 10 or more observations (2010 to 2014 data).

Nutrients

The annual median **nitrate-N** concentrations in the Takaka Water Management Area were all in the A or B bands (less than 1.0 and 2.4 g/m^3 respectively) (Figure 5). The Motupipi and Powell catchments had higher annual median nitrate-N concentrations than the Takaka or Watercress catchments, though within the acceptable range. These sites have the highest recorded nitrate concentrations in Tasman District after the spring-fed streams of the Waimea plains (near Richmond). Some limited nutrient records for the Waingaro at Hanging Rock and Onekaka and Shambala show very low levels. Nitrate toxicity has recently been found to be mitigated strongly by water hardness (as calcium carbonate). All the waterways with the highest nitrate concentrations also had high hardness, enough that toxicity is unlikely to ever be an issue (Hickey, 2015). This means that nitrate is only an issue with respect to promoting excessive filamentous green algae growth.

Annual median **ammonia** concentrations were within the A band (less than 0.03 g/m^3).

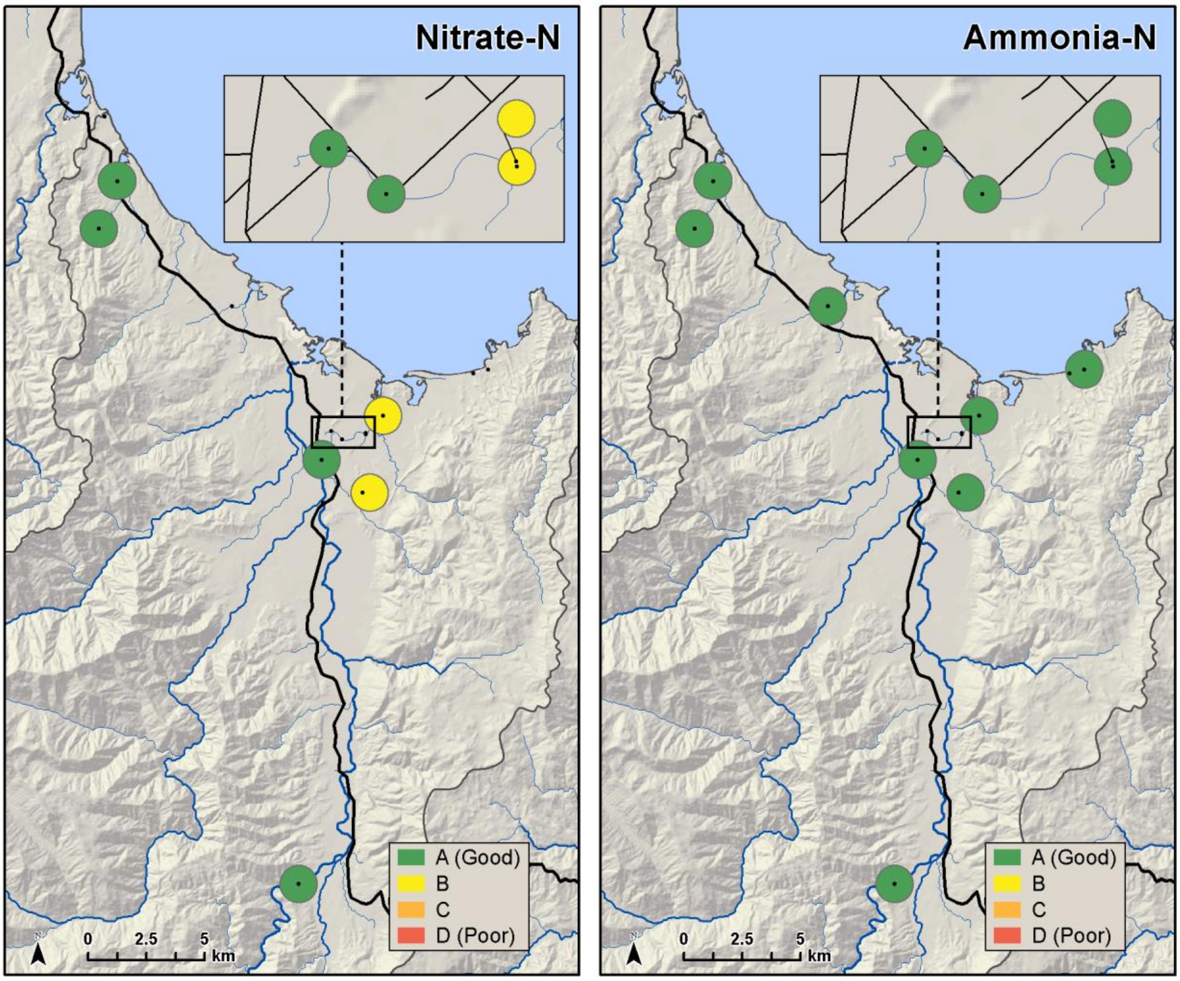


Figure 5. Nitrate (left) and ammonia (right) concentrations for sites in the Takaka Water Management Area. Pie charts show the proportion of annual medians in each attribute state (A to D) for sites with 10 or more observations (2010 to 2014 data).

Most dissolved reactive phosphorus (DRP) concentrations were satisfactory (less than 0.01 g/m^3) (Figure 6). At least three DRP sample concentrations, however were unsatisfactory (above 0.01 g/m^3), at the Motupipi River sites as well as Powell at 40 m u-s Motupipi and Watercress at u-s Dairy Factory.

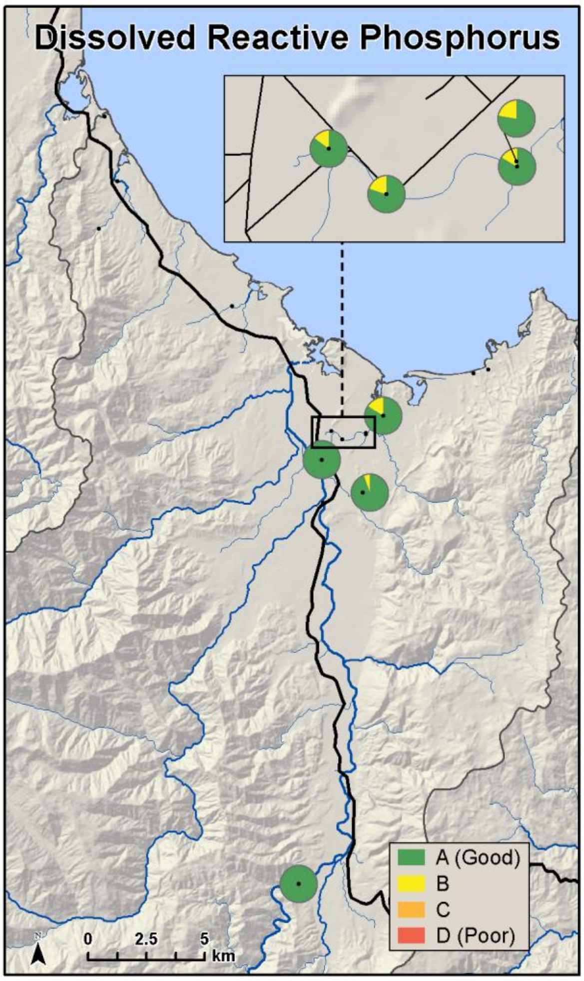


Figure 6. Dissolved reactive phosphorus concentrations for sites in the Takaka Water Management Area. Pie charts show the proportion of records in each attribute state (A to D) for sites with 10 or more observations (2010 to 2014 data).

Resuspendable Sediment

Volumetric SBSV were examined for three high risk sites on smaller waterways in the Takaka catchment and found to be relatively high compared to others across the district. There were no differences found between the sampling years (2012 to 2015) at these sites (Figure 7).

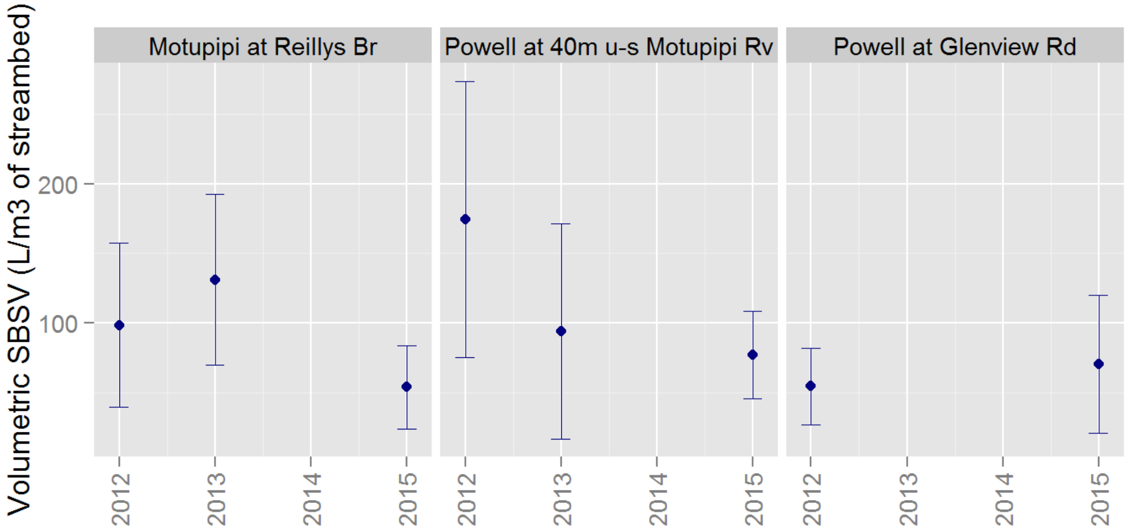


Figure 7. Mean volumetric suspendable benthic sediment volume (SBSV) from 2012 to 2015 (sampled during Summer). The error bars show 95% confidence intervals.

Of the three sites in the Motupipi catchment (Motupipi at Reillys Br, Motupipi at Factory Farm Br and Powell at 40 m u-s Motupipi Rv) where resuspendable solids were measured, all recorded a score of poor at least once and greater than 10 % of records have a 'C' (fair) score (Figure 8).The depth of fine sediment measured at about 100 m intervals in the bed of the Motupipi from Watercress Creek to Able Tasman Drive showed a maximum dept of over 1 m in some pools downstream of the Powell Creek confluence) and 300 mm depth on average over this 3 km reach. Sites on the Takaka, Onekaka and Onahau rivers had much better resuspendable solids score with the Takaka at Harwoods site recording 100% of samples in the 'A' band.

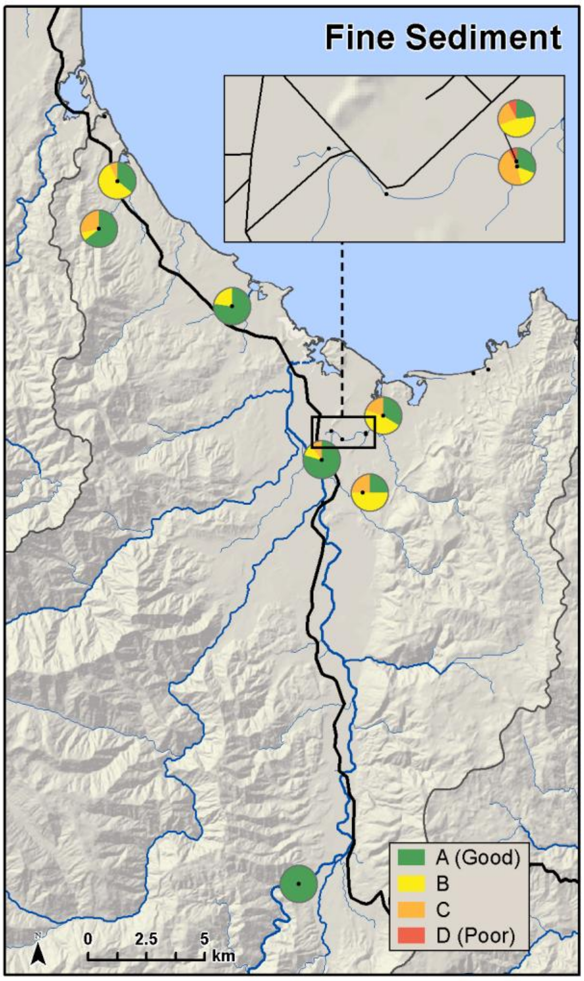


Figure 8. Proportion of resuspendable solids scores in each attribute state (A to D) for sites in the Takaka Water Management Area.

Macroinvertebrate Community

There was a wide range of MCI results in the Takaka Water Management Area over the last five years (Figure 9). Onahau at Onahau Rd and Onekaka at Shambala Br had MCI values in the good to excellent range. In contrast, Watercress at u-s Dairy Factory had poor MCI values and Motupipi at Reillys Br was poor/fair.

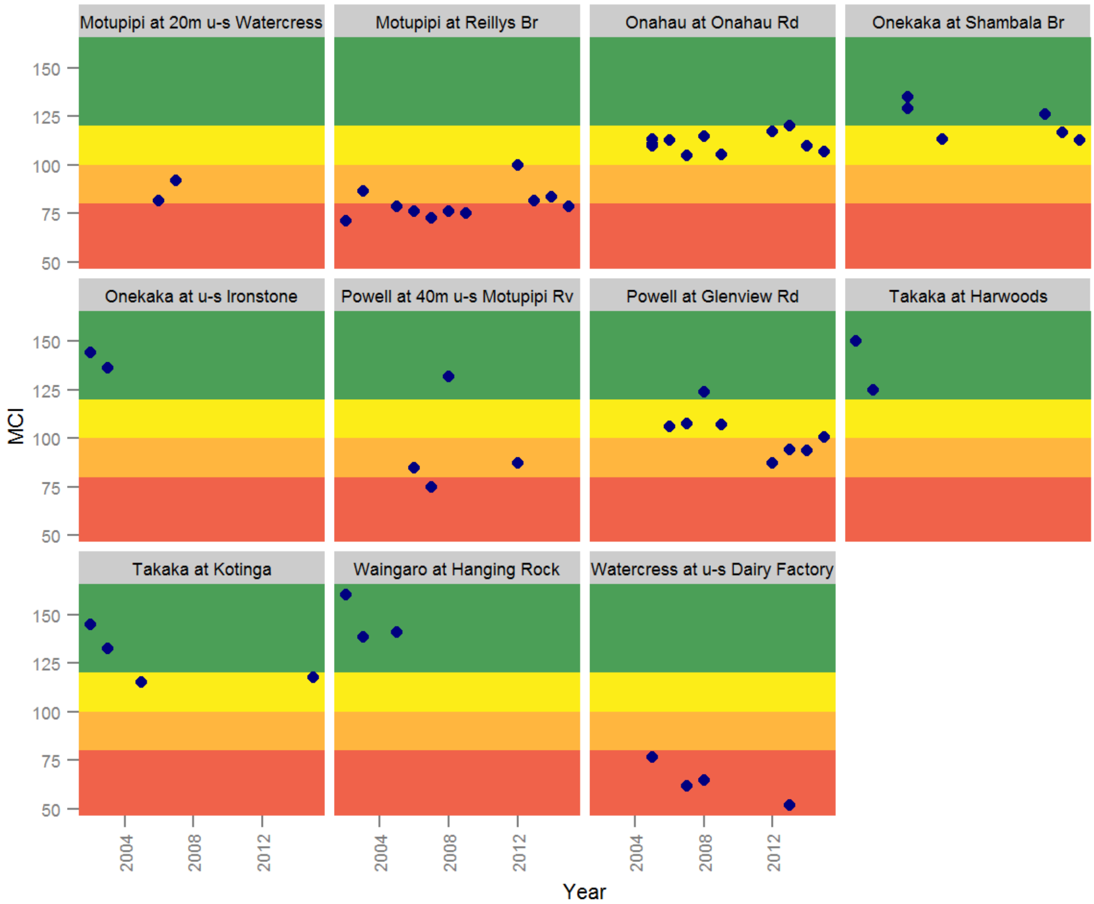


Figure 9. Macroinvertebrate community index (MCI) scores between 2001 and March 2015 for sites in the Takaka Water Management Area (blue dots). The background colours indicate these quality classes: excellent (green), good (yellow), fair (orange) and poor (red).

Paired Site Differences – Takaka River

This section compares the difference (increase or decrease) between two sites on a particular waterway on a particular day. The differences are then averaged to get the "mean difference". It is not the difference of the mean from each site calculated from the whole record for one site with the mean from the whole record from other site.

When comparing the records from Takaka at Kotinga with the reference site at Takaka at Harwoods, there were **relatively large differences in nutrient concentrations** (Figure 10). Takaka at Kotinga had Nitrate-N records more than 200 times higher 0.193 g/m^3, SD = 0.10, n = 18) than the reference site. However, nitrate is still at very low levels. For **dissolved inorganic nitrogen** there was a similar pattern (mean increase 0.192 g/m^3, SD = 0.10, n = 18).

Interestingly, the coverage of *Didymo* at Kotinga was consistently lower than at the reference site (mean decrease 32%, SD = 31%, n = 10). A further difference between Takaka at Kotinga and the reference site was in the concentration of ***E. coli*.** At Kotinga, *E. coli* concentrations were up to 40 times higher (mean increase 47 *E. coli*/100 ml, Figure 10). Water clarity was higher downstream, probably due to clear water from the Waingaro River and sediment getting trapped in the Takaka River drying zone.

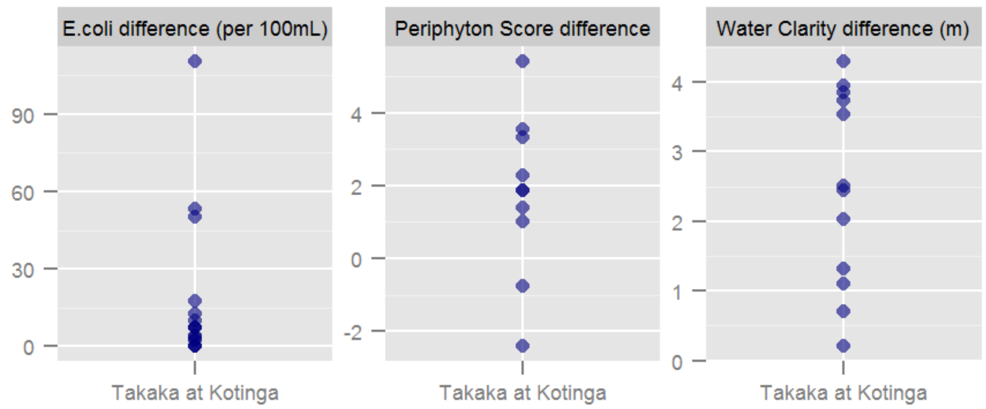


Figure 10. Difference between Takaka at Harwoods (upstream) and Takaka at Kotinga (downstream) for water quality data collected at both sites on the same day. A positive difference means the downstream site had a higher value than the upstream site.

Trends in the Takaka WMA

The analysis of trends in the Takaka Water Management Area revealed several improvements over the past 10 years (Table 2). Dissolved reactive phosphorus concentrations improved in the Motupipi and Powell catchments. For nitrate-N concentrations, there were improving trends in the Takaka river sites but degradation in Powell at Glenview Rd, Watercress at u-s Dairy Factory and Te Waikoropupū Springs.

Table 2. Water quality trend results for sites in the Takaka Water Management Area over the 10-year period 2005 to 2014 (highlighted in blue) and over the full record (from 15 to 45 years depending on the site). Seasonal Kendall trend tests were used for *E. coli* concentrations, water clarity measurements and nutrient concentrations (Ammonia-N, Nitrate-N and DRP). The trends shown are significant ($p < 0.05$), meaningful (RSKSE > 1% per year) and the change in value between the start and end of the trend line is greater than the detection limit for the attribute (refer to the Methods sections for the detection limits). Statistics are shown in the Appendices.

Site name	Attribute	Effect ☺ ☹	N obs	N years
Motupipi at Factory Farm Br	Ammonia-N	☺	39	10
Motupipi at Reillys Br	Ammonia-N	☺	39	10
Motupipi at Reillys Br	Ammonia-N	☺	58	15
Motupipi at Reillys Br	DRP	☺	40	10
Motupipi at Reillys Br	DRP	☺	58	17
Motupipi at Reillys Br	*E. coli*	☺	60	17
Onahau at Onahau Rd	Water Clarity	☺	36	10
Onekaka at Shambala Br	Water Clarity	☺	36	10
Powell at 40 m u-s Motupipi Rv	Ammonia-N	☺	43	10
Powell at 40 m u-s Motupipi Rv	DRP	☺	45	10
Powell at Glenview Rd	Ammonia-N	☺	43	10
Powell at Glenview Rd	Nitrate-N	☹	45	10
Takaka at Harwoods	Nitrate-N	☺	63	17
Takaka at Kotinga	Nitrate-N	☺	42	10
Te Waikoropupū Springs	Nitrate-N	☹	40	10
Te Waikoropupū Springs	Nitrate-N	☹	103	45
Te Waikoropupū Springs	Water Clarity	☹	107	18
Watercress at u-s Dairy Factory	Ammonia-N	☺	37	10
Watercress at u-s Dairy Factory	Nitrate-N	☹	38	10

Takaka Catchment

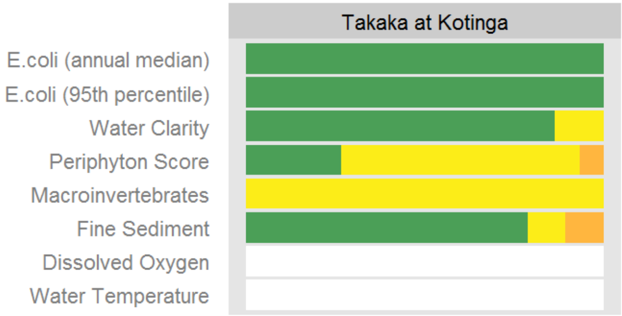
Above: Takaka River at Paynes Ford looking downstream to SH60 (December 2010)

The Takaka catchment area is 940km^2 with land cover dominated by native forest and subalpine tussock land. The Takaka River is a regionally important trout fishery and demand for water for irrigation is high. On average about 8,000 l/sec from the river downstream of Lindsay's Bridge (about 7km downstream of the Takaka at Harwoods site) is lost through the gravel river bed. When the flows at Harwood site fall below 7,000 l/sec the Takaka River can be anticipated to dry from 0.5-1km downstream of Lindsay's Bridge (upper crossing of SH60) for a stretch of several kilometres downstream through to about 1 km upstream of Paynes Ford bridge (SH60).

The Waingaro, Anatoki and Takaka rivers have excellent or good base flow water clarity. However, the Takaka River is one of the few rivers in the district which has much lower water clarity in its headwaters compared to the lower reaches (median at Harwoods is 5.1 m compared to 7.7 m at Kotinga over the period of 2010-2015). This is probably due to one or more of the following factors:

- the impounded water released into the Takaka River from the Cobb reservoir, via the Cobb hydro-electric power scheme, upstream of the Harwoods site (at low lake levels and windy conditions the fine sediment on the bed of the lake gets re-suspended)
- the input of very clear water, from the Waingaro (12.1 m median, 30.5 m maximum) above the Takaka Rv at the Kotinga site
- greater settling of fine sediment in the area of the river that loses water to ground (mid reaches downstream of Lindsay's Bridge).

While median water clarity has remained about the same at Harwoods and Kotinga sites.
The power scheme is not managed to reduce the discharge of fine sediment to the Takaka River and the relationship between water clarity or turbidity of Takaka downstream of the Cobb discharge with lake level and wind has not been looked at (Lilley,P: pers.comm.). However, it is in the interest of the power scheme to limit the fine sediment input due to the erosive force on the plant e.g. pelton wheel abrasion. Metals such as iron and manganese in solution from the sediments of Lake Cobb can also cause decreased water clarity.



Site data summary plot. Colours indicate attribute states from A (good) to D (poor).
Refer to the interpretation guide for full details.

Average levels of faecal indicator bacteria at base-flows are low at both the Takaka Rv sites (Kotinga median *E. coli*/100 ml: 15, Harwoods median *E. coli*/100 ml: 2 (below detection) with occasional high readings in the lower reaches. The results for weekly sampling during the summer bathing season (2010-15 only) at Paynes Ford show it is safe for contact recreation for the vast majority of the time (median: 20 *E. coli*/100 ml; 260 *E. coli*/100 ml alert guideline met more than 92% of the time and the 550 *E. coli*/100 ml alarm guideline met 98% of the time).

Nutrient concentrations are low at Harwoods and Kotinga as well as the Waingaro River at Hanging Rock (Median NO_3-N in g/m^3: 0.009, 0.01 and 0.01 respectively, Median DRP in g/m^3: 0.001, 0.002 and 0.032). Nitrate-N concentrations are also decreasing at the Harwoods site (Figure 11). The reason for this trend is unclear at this stage.

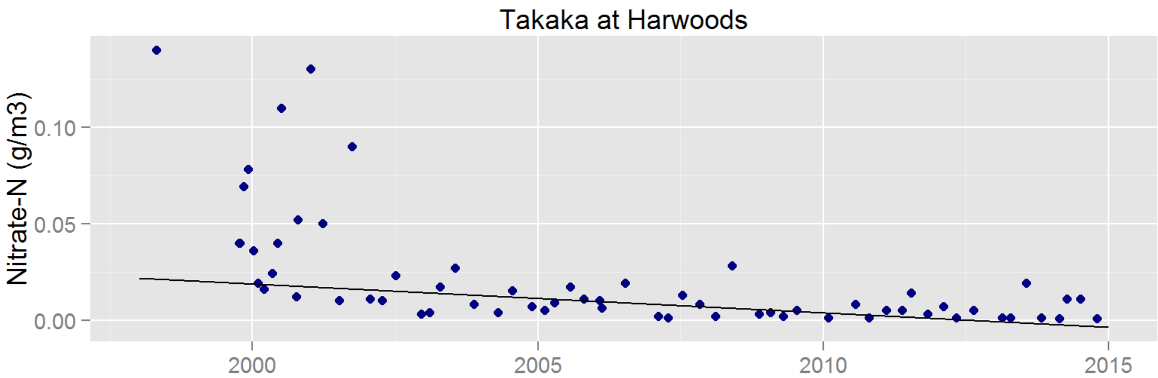


Figure 11. Takaka at Harwoods Nitrate-N concentration data with 17-year trend line ($p < 0.0001$, RSKSE = -15% per year). No significant meaningful trend was detected over the most recent 10 years of the record.

However, the coverage of filamentous green algae Takaka River upstream of Paynes Ford can be high in summer (see photo below). This is partly due to the presence of *Didymo* (first discovered in Dec 2007) which protects the filamentous green algae from sheer stress allowing it to grow back faster after floods.

There are several intensive dairy farms in this catchment with sophisticated monitoring systems for soil moisture associated with their irrigation systems to avoid leaching of nutrients.

1

2

3

4

From left to right:

1 - Takaka Rv at Kotinga (January 2005).
2 - Takaka Rv upstream Paynes Ford (November 2007). Showing heavy filamentous algae growth.
3 - Waingaro Rv at Hanging Rock (January 2009). Water clarity maximum 30.5 m.
4 - Takaka Rv at Harwoods (February 2005).

Table 3. Summary statistics for sites in the Takaka catchment

	Takaka at Harwoods	Takaka at Kotinga	Waingaro at Hanging Rock
River Environment Class	Cool Extremely Wet Volcanic basic Mountain-fed Low gradient	Cool Extremely Wet Hard sedimentary Hill-fed Low gradient	Cool Extremely Wet Hard sedimentary Mountain-fed Low gradient
Catchment area (km^2)$^+$	259	714	
Predominant land use upstream	98% native forest and tussock	Upstream of Mouth: Indigenous Forest: 78.4% or 785km^2 (635km^2 in National Park) Exotic pasture: 14.9% or 151km^2 of which dairying makes up 49.68 km^2 (14,465 cows)	100% native forest or alpine tussock
Mean annual rainfall (mm)	2,230	1,980	3110
Mean annual flow (l/sec)	14,425	37,664	18,298
Median annual flow (l/sec)	10,084	17,439	10,517
7-Day Mean Annual Low Flow (l/sec)	2,380	3,310	3,685
Lowest recorded flow (l/sec)	483	1,668	2,226
Water quality record	2000-present	Quarterly: 2000-present Monthly: 2013-present	Quarterly: 2000-2010

Te Waikoropupū River

This river is fed by one of the largest springs in the Southern Hemisphere (mean flow in main spring is almost 10 m^3/sec (8.5-15 m^3/s range), with Fish Creek Springs contributing 3.3 m^3/sec (Thomas and Harvey, 2013). The waters emanating from the spring arise from the Arthur Marble Aquifer, karst system that takes leaked water from rivers such as the Takaka (below Lindsay's Bridge) and lower Waingaro and many tributaries in the mid and upper Takaka Valley.

Te Waikoropupū Main Spring (March 2004)

Te Waikoropupū Main Spring has the **second-highest clarity of freshwater in New Zealand** (after Blue Lake and the Sabine River in Nelson Lakes National Park) and amongst the highest in the world at over 60 m. At a monitoring site on Te Waikoropupū River about 600 m downstream of the spring (upstream of a salmon farm discharge) the median is 22 m, but is decreasing (Figure 12). This natural reduction is from a number of sources such as: dissolved organic carbon (colour) from soil leaching (mostly from the Fish Creek catchment) and exudates from the aquatic plants that have extensive coverage of the bed in the spring and river. The higher the clarity the more reduction you get in clarity for a given amount of dissolved or particulate material in the water. The water clarity median downstream of the salmon farm discharge from 2012 to 2015 is 18.5 m.

The **water temperature** in Te Waikoropupū Springs is very constant (around 11.7^{o}C), but since 1994 they are often over 12.1^{o}C during the summer season, but this is well below the level when any adverse ecological effects occur.

A statistically significant **increase in Nitrate-N concentration** is evident in the **main spring** water over the period from 1970 to 2014 (Figure 13) (Stark, 2015; Mead, 2015). On average, nitrate-N values have increased by about 40 to 50% in 44 years (Stark, 2015). It seems as if nitrate concentrations are levelling off. . It is highly unlikely that nitrate concentrations in Te Waikoropupū Springs will ever get to toxic levels. Nitrate-N in the Fish Creek spring is about 20% higher than the main spring. This reflects the higher proportion of younger (average of one year) and more shallow groundwater feeding the Fish Creek springs. The recharge for the Fish Creek springs has been estimated to be about 50% from the Takaka River and 25% from the karst uplands, whereas for the main spring the proportions are 18.5% and 74% respectively (Thomas and Harvey, 2013).

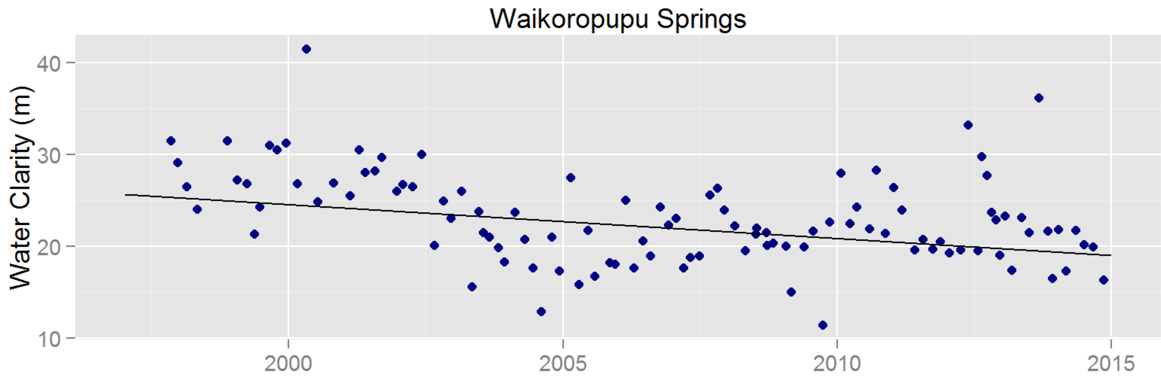


Figure 12. Water Clarity at Te Waikoropupū River 600 m downstream main spring and upstream NZ King Salmon Discharge with 18-year trend line ($p = 0.0001$, RSKSE = -1.7% per year). No significant meaningful trend was detected over the most recent 10 years of the record. Data from NZ King Salmon (2015).

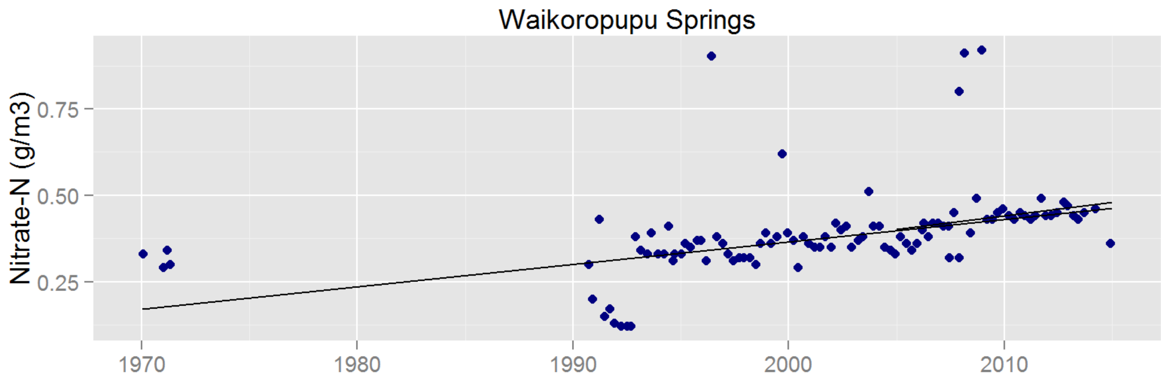


Figure 13. Trend in nitrate-N concentrations in Te Waikoropupū Springs from Michaelis (1974) for 1970-71 and TDC/GNS data from 1990 to 2014. The trend lines are for 10 years ($p = 0.0002$, RSKSE = 1.8% per year) and 45 years ($p < 0.0001$, RSKSE = 1.7% per year).

Ammonia-N concentrations in the main spring are **very low** (median 0.005 g/m^3).

While the **total phosphorus** concentration has increased over the period from 1994 to 2004, **dissolved reactive phosphorus concentrations have not changed from 1990** (median for March: 0.005 g/m^3). While base flow total phosphorus concentrations in the Takaka River are low, they can be very high in floods.

It is important to manage both nitrate and phosphorus to ensure that filamentous green algae growth is not excessive. In spring-fed rivers with very stable flow, phosphorus is particularly important as once it enters the system it usually remains in the sediment where is it available for plant growth. Phosphorus is usually strongly bound to sediment and so managing sediment inputs to the catchment is probably one of the most important management methods.

While the cover of filamentous green algae in the Te Waikoropupū Catchment is very limited, in the Fish Creek springs it is usually very high (often >90% except for winter when it is light limited) (Murray, *pers.com*.). Such algae coverage in the main spring is very low. The potential for flushing flows in the main spring basin are very low given that there are no streams flowing into it. This means that this site is vulnerable to increased nutrient concentrations and stimulation of plant and algal growth. In the Te Waikoropupū River there is potential for some flushing flows from floods in the Fish Creek catchment. However, this is limited by the relatively small size of the catchment (216 ha) compared to the flow in all the springs.

Annual monitoring of macroinvertebrates in the Te Waikoropupū River as part of NZ King Salmon's resource consent has been ongoing since 1988. Overall there has been no statistically significant trend in MCI values in Springs River upstream of the salmon farm outflow channel (Site 3/3a sampled as part of RM110270) (Stark, 2015) (Figure 14). The low MCI in 2001 was considered to be due to a prolonged period of low flows prior to sampling. The increased nutrient content of the waters of the Springs River does not seem to have had any noticeable effect on macroinvertebrate communities or river 'health' as determined by the MCI.

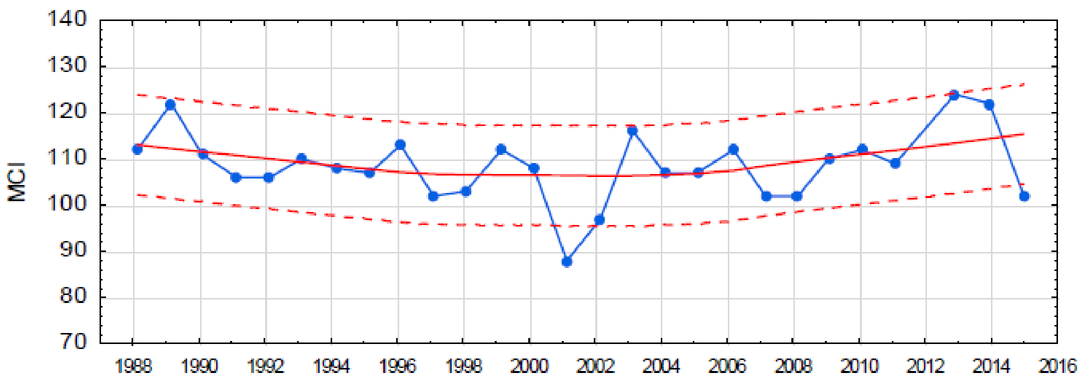


Figure 14. MCI versus time (23 February 1988 – 29 December 2014) for Site 3/3a in the Springs River upstream of the NZKS discharge. Data from August – September collected prior to 2000 have been excluded. The fitted line is a LOWESS trend (tension = 0.7) with dashed red lines indicated error of ±10.83 MCI units (Stark, 2015).

No *E.coli* has been detected in the main spring of this river showing that this water is suitable for drinking (although the main spring water is not accessible, and drinking from the river is not recommended due to wildfowl influence). However, sampling in Fish Creek and the Fish Creek spring consistently detect faecal indicator bacteria in the range of 5-30 *E.coli*/100 ml (N.Murray, 2014, unpublished). A drinking water supply from the river was set up at Te Waikoropupū Springs car park, but later removed as the Department of Conservation could not guarantee that the water would contain no *E.coli*.

The water quality at the Te Waikoropupū Spring has limited vulnerability to discharges to the unconfined aquifer of the Takaka Valley floor. Despite pastoral farming having increased in intensity there is no evidence of a subsequent change in water quality at the spring. Dairy farming in 2014 covered 24km^2 of the recharge area of the spring. The number of dairy cows having increased from an estimated 5500 to 6700 between 2005 and 2014 (density 2.3 to 2.8 cows/Ha) (Mead, 2015). The area irrigated has increased from 2-10 km^2 from 2003 to 2012 (Mead, 2015).

Te Waikoropupū River at biomonitoring Site 3a upstream of the NZ King Salmon discharge. Top: January 2009, Bottom: February 2010. Photos: Courtesy John Stark. Note the variability in aquatic plant growth.

Table 4. Flow Statistics in l/sec for the Te Waikoropupū River (MALF = Mean Annual Low Flow)

Mean	Median	7 day low flow (l/s)			
		MALF	5 yr	10 yr	20 yr
14630	14030	8683	7101	6563	6168

Lake Kilarney

Lake Kilarney is located within Takaka township. It is a sinkhole filled with water from ground water and has occasional surface water entering but no regular streams in or out. There is a steep slope from the bank into the water. *Lagarosiphon* is the dominant aquatic plant with an average height of 4 m within the water column.

Some surface water flows into the lake during rain from two storm water pipes – Commercial Street and Meihana Street that were piped to the lake in 1970. However, in December 2004 a new sump was installed in the paddock on the Fonterra Factory land that allowed runoff from pasture into the pipes that feed into the lake. This has now been removed but it was possible that runoff from this paddock is responsible for an increase in nutrient and sediment discharges to the land. There is often a long lag time until nutrients accumulate in the lake sediments to the point that algal growth becomes prolific. Uncontrolled storm water and paddock discharge to the lake is not desirable as there is limited ability for the lake to flush so it acts as a dead end of inputs. There is some limited potential for bores down gradient of Lake Kilarney to be affected by water in the lake and this is an area to be followed up as part of the lake monitoring recently started.

Left: Looking south over Lake Kilarney on 10 March, 2014 showing an algal bloom. Note that the bloom is not so prevalent near the shaded edge of the lake. Right: Looking west over Lake Kilarney on 19 February, 2015. Whole lake is highly turbid looking due to an algal bloom.

In the past Lake Kilarnery in Takaka was a clear blue colour. In the mid 1950's it was considered very clear by the locals, now it is a murky brown colour due to algal growth and there is concern expressed by many locals. The algal blooms are likely to because of eutrophication (nutrient enrichment). Blue lake in Rototai was formed in similar geological process but has no storm water connections and the colour of the water is still blue.

The brown coloured plume observed on Lake Kilarney on 10/3/2014 was due to the microalgae, *Peridinium*. This is a motile algae and so explains why it was found only in part of the lake (the sunniest part). This is not an uncommon occurrence, but there are no previous records of this microalgae for this lake. *Microcystis* was also found in the sample at lower concentrations. *Microcystis* can be a concern due to its ability to produce toxins and so contact recreation and stock drinking is not recommended if this alga were to build up in the lake. The present concentration of this species was probably not high enough to need to warn the public. There is a need to sample nutrient concentrations in the lake and also any input drains.

Nutrient concentrations appear to be very low in the near surface waters of the lake. Results from a water sample taken on 19 February, 2015, 2 m out from the eastern shore failed to detect any dissolved nutrients (nitrate + nitrite <0.001, dissolved reactive phosphorus <0.001, total ammonia <0.005).

Continuous sampling of dissolved oxygen and temperature during 10-18 March 2015 showed regular diurnal fluctuations of 80-120% saturation and 21-25^{o}C respectively. The dissolved oxygen flux of this order in a lake indicates significant photosynthetic activity, probably from the phytoplankton which may explain why there were very low nutrient concentrations with the surface waters.

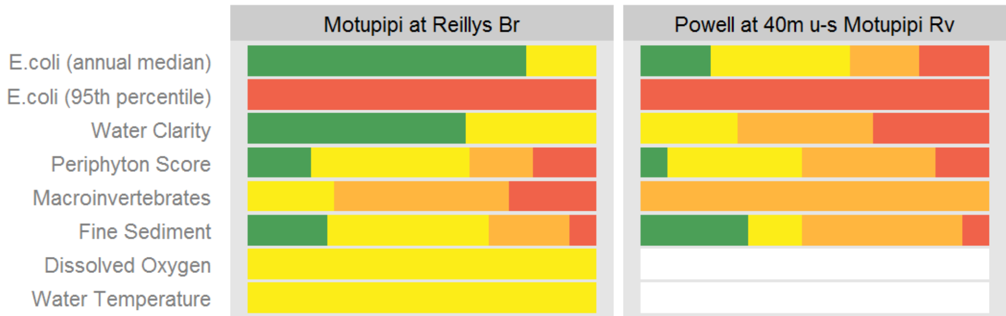
Location map of Lake Kilarney

Motupipi Catchment, near Takaka

The values in the Motupipi waterway are whitebaiting and kayaking in the lower reaches. There is a reasonable abundance of eel and inanga in this river and its tributaries as well as a few redfin bullies in the riffles of the Motupipi River.

Motupipi River at Factory Farm Bridge looking upstream (February 2005)

Land use in this catchment is primarily intensive farming on the flat land with extensive farming on the hill country. The Takaka Dairy Factory ceased its discharge to Watercress Creek after a fire at the plant in June 2005. In addition, the washwater sprayed to land within the catchment is much less concentrated than prior to this period.



Site data summary plot. Colours indicate attribute states from A (good) to D (poor). Refer to the interpretation guide for full details.

The Motupipi, with its tributaries (**Watercress, Powell, McConnon, and Berkett Creeks)**, have consistently elevated **nitrogen concentrations** (James 2007). Nitrate-N is moderately elevated in the lower catchment (Reilly Bridge site median 1.53 g/m^3-NO_3). This, combined with stable flows, is why **filamentous green algae form such extensive growths** (particularly upstream of Powell Creek) and the brown soupy algal blooms (*Cryptomonas*) near the Abel Tasman Drive bridge (the top of the estuary, see photo below). The major source of these nutrients is groundwater that emerges as springs (particularly the karst springs) in the mid-reaches and headwaters of the Motupipi, with pasture run-off also contributing (James & Stevens, 2008). No clear source of the nitrate in these springs has been determined from isotopic analysis, but could be both fertiliser and effluent and from geological sources. The karst spring water feeding the Motupipi near Sunbelt Cres has been aged at 6-7 years (using tritium and sulphur hexafluoride dating methods) (van der Raaj and Baisden, 2011). This suggests either a source relatively remote from the Motupipi River or very low groundwater permeability slowing down travel times. Nitrate concentrations have increased at both the Powell Creek upstream site at Glenview Rd (Figure 16) and at Watercress Creek at the dairy factory (Figure 17). Neither of these sites are far from the spring source of each of these creeks.

Dissolved (soluble) **phosphorus** concentrations in the Motupipi (including Watercress Creek) were found to be **relatively low at all sites** (medians in g/m^3: Watercress Ck 0.008, Factory Farm Br 0.006, Reilly Br 0.013 and Abel Tasman Dr 0.008) (Figure 15). It is pleasing to see that dissolved reactive phosphorus concentrations have **declined** at the Motupipi at Reilly's site (almost 10% per year over the whole 17-year record (1999-2015). This result led this river to become a finalist in the "River of the Year Award, 2014" (http://nzriverawards.org.nz/2014-new-zealand-river-awards/). This decline is likely to be related to the discharge of washwater and whey from the Takaka dairy factory to pasture on farms in the catchment in the 1970's and 80's. Olsen P levels in soils in paddocks in the upper Motupipi River and Watercress Creek catchments were routinely very high (about 200-300 g/m^3) in the 1990's but have been reducing ever since (range 44-121 g/m^3 in 2011) (data supplied by Jeff Riordan, Fonterra Glendale Farm). Olsen-P concentrations of about 25 mg/kg are ample for good plant growth. No phosphate fertiliser has been used on this farm (and probably others in the catchment) since that time.

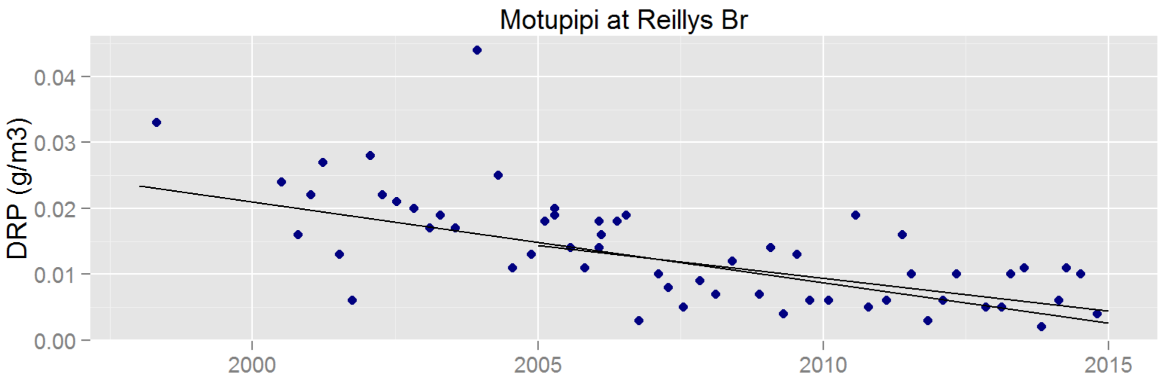


Figure 15. Motupipi at Reillys Br dissolved reactive phosphorus (DRP) concentration data with 10-year ($p < 0.0001$, RSKSE = -10% per year) and 17-year trend lines ($p < 0.0001$, RSKSE = -9.8% per year).

A programme sampling water quality, monthly, for a year (2006-2007 over all flows) in the **Powell Creek** Catchment showed soluble nitrogen concentrations were also high, with 90% of samples across all sites being above guidelines. It is likely that groundwater feeding upper Powell Creek is the cause (the source of this groundwater could be the same as the Motupipi). Soluble phosphorus concentrations were found to be relatively low at all sites (medians in g/m^3: Powell at Glenview Rd 0.002, Powell at Reilly Br 0.006, Berkett u-s Powell 0.005, McConnon u-s Powell 0.007).

Filamentous green algae cover in the lower Powell is often over 30% in summer.

A **wetland was constructed** and fenced over the period of a few years from 2009 in the upper part of this catchment.

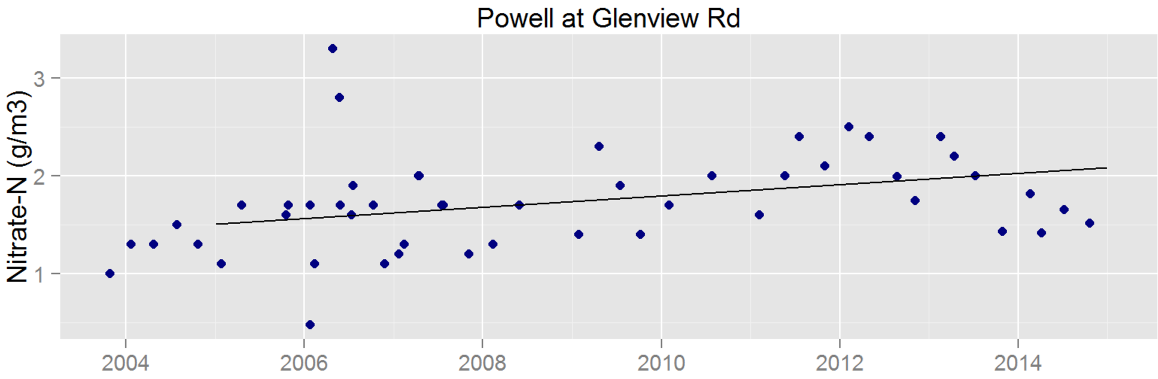


Figure 16. Powell at Glenview Rd Nitrate-N concentration data with 10-year trend line (p = 0.013, RSKSE = 3.4% per year).

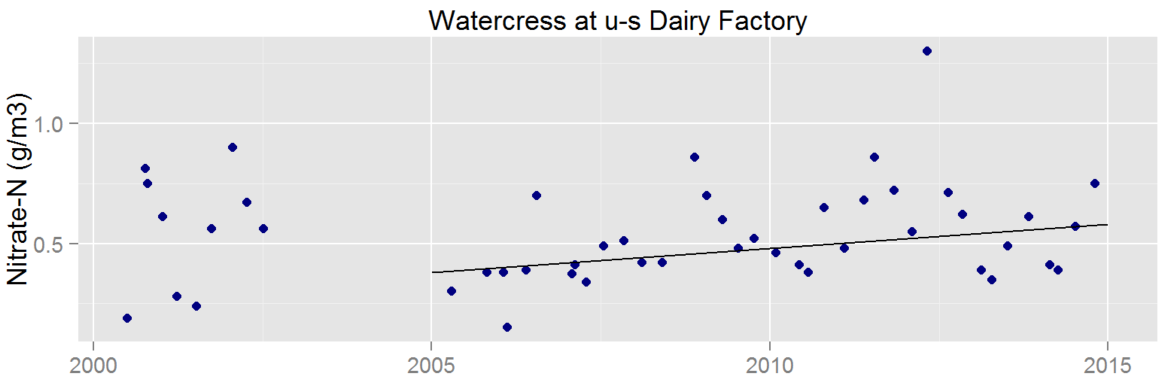


Figure 17. Watercress at u-s Dairy Factory Nitrate-N concentration data with 10-year trend line (p = 0.013, RSKSE = 4.1% per year). There was no significant meaningful trend over the full record (15 years).

If there is sufficient light algae can grow to nuisance levels it has sufficient quantities of both nitrogen and phosphorus in soluble form, as well as stable flows and warmer water temperatures. **Filamentous green algae** cover exceeded nuisance levels (30%) for about 20% of the records for Motupipi at Reilly Br and 25% of records for Powell at Reilly Br (spring-autumn records only; no excessive algal growth has been observed in winter). It appears that the level of cover is decreasing, maybe in relation to the decrease in dissolved reactive phosphorus.

Above: *Cryptomonas* algae bloom in the lower Motupipi. Left: April 2007; Right: February 2014

The concentrations of **faecal indicator bacteria** in smaller tributaries (Berkett, McConnon and Powell) are amongst the highest in the District at low flows. Over the 2006-07 period the stream water was unsuitable for stock drinking for just under half the time (James 2008, reported under the Dairying and Clean Streams Accord Tier II monitoring programme). In the base flows of May 2011 the source faecal bacteria in the lower catchment were identified as being from ruminants (such as cows and goats) and wildfowl, without any trace of human genetic material. At Watercress Creek the source was only ruminant. It is disappointing that there has not been a significant improvement in faecal indicator bacteria in Powell or Motupipi Rivers given the amount of fencing in the catchment. However, some large areas have only recently been fenced and some are still to be fenced. It may be that the thick sediment deposits known to occupy the bed of these waterways is a significant reservoir of these disease-causing organisms and the stability of the sediments due to aquatic plants rooted in the bed means that they do not get flushed out.

During each of two flood events in August 2010 lower Powell Creek and Motupipi at Reilly Bridge were estimated to discharge 10^{11}-10^{13} *E. coli* /100 ml. This combined load is high for a small catchment, considering that the Aorere River was estimated to discharge 10^{16} *E. coli* /100 ml over a whole year and over a much bigger catchment. In 2008 the tributary Berkett Creek, consistently had the highest concentrations of faecal bacteria. It would be interesting to resample this creek following fencing in 2009.

Summer-time **dissolved oxygen levels are very low** in the lower and upper reaches of the Motupipi River (daily minima averaging 45-50% but going as low as 35% saturation at times) (Figure 105) at the Motupipi Water Quality Monitoring Station. This does not appear to have changed (Figure 23). Aquatic plant growth rates and oxygen uptake rates are much higher than many other streams draining intensive agriculture in New Zealand and internationally (Young 2006). Daily minimum dissolved oxygen does not correlate well with flow (r^2=0.0396), so flow is not the main driver of dissolved oxygen in this river (Allen and Young 2012). The seasonal increase in respiration caused by the increased biomass of aquatic macrophytes during summer often has a strong influence on dissolved oxygen in spring-fed streams. This is likely to be the case in the Motupipi River, as ecological monitoring in the upper reach (approximately 1.3 km upstream from the affected reach) has shown that the median summer coverage of macrophytes was 80%. Reduced flow in the river has the potential to reduce dissolved oxygen concentrations. The environmental effects of removing 51 L/s from groundwater from a point about 50 m from the stream upstream of Reilly Bridge (began in 2014) was predicted to have minimal effect on water level, habitat availability and water quality, especially in reaches dominated by macrophyte beds (Allen and Young 2012). Monitoring data before and after confirms that this take is not having an effect. However, there will be a point at which flow reductions will affect dissolved oxygen levels.

Water clarity in the Motupipi River is moderately high (median 5.45 m, 95th percentile 9.8 m) but expected to be higher given that the source is mostly alluvial spring water. Water clarity appears to have changed little from 2000 to 2015. Median water clarity was low at the bottom of Powell Catchment (1.6 m), but was even lower in Berkett Creek (1.2 m).

Fine sediment deposits in this stream are relatively thick, with an average of 200-300 mm over the original cobble bed and a layer over 1.2 m thick for a 450 m reach downstream of Powell Creek. Aquatic plants in the stream cause the build up of large amounts of fine sediment both by increasing the retention and settling of sediment washed into the stream and from dead plant matter. Shading the stream using riparian trees is recommended as the best method to manage this issue. While this is of concern in the shallow areas of the waterway, it must be expected that sediment will build up naturally in the deeper pools as these were created when this river was part of the Takaka River about 200-300 years ago when stream power and velocities would have been much greater. As velocities are now much lower, these pools are unlikely to be flushed unless the river returns through this previous course. Sediment sampling in this drain was also above guidelines for zinc and chromium indicating that runoff from roads is entering the drain.

Sediment in a stormwater drain near Orange Engineering on the edge of the Takaka township was found to be contaminated with **high concentrations of copper, chromium, and zinc** (all over an order of magnitude higher than ANZECC guidelines for 90% level of protection (ANZECC & ARMCANZ 2000)).

Macroinvertebrate condition was mostly **poor or very poor in the lower parts of this catchment, including lower Powell Creek**, except for upper Powell Creek, which was good in 2004 but has declined since. The excessive levels of fine sediment and elevated nitrate (median 1.5 g/m^3) are probably the reason for this. Powell Creek at Glenview Rd showed a decline in most macroinvertebrate indices (MCI, % mayflies, stoneflies and caddisflies) which seems to coincide with the removal of a peat bog wetland upstream of this site in September 2008 and a change to cropping maize.

Motupipi Rv at Reilly's Bridge (January 2006, left and November 2004, right).

The ecological health of the upper and mid-western arms of the Motupipi estuary are impaired by high nitrate and sediment from the Motupipi River (Robertson and Stevens 2008). Shellfish collected in these areas are likely to be unsafe to eat most of the time due to the level of disease-causing organisms. The health of the eastern arm of the estuary is generally good.

Due to the high percentage of intensive farming in this catchment (almost 40% of the land area) water quality guidelines will always be difficult to meet, although **considerable improvement is expected** through implementing better environmental practice. Despite some best management practices being employed on several farms, there is still a lot more that could be done to benefit water quality of the stream. An effective method is the **installation of wetlands in key locations** to filter run-off and seepage from the land.

Another factor affecting the state of water quality in the Motupipi River is the **lower frequency of overflows of floodwater** from the Takaka River into the Motupipi compared to 10-20 years ago, most probably due to lower bed levels in the Takaka River. Takaka River currently overflows into the Motupipi at about 1400 m^3/sec, providing flushing of fine sediment deposits and aquatic plants and algae. Anecdotal evidence suggests that the overflow from the Takaka River in 2008 (24 November) resulted in reduced algal blooms for the two years following (reports from whitebaiters). The **lack of flushing flows, over recent years, leads to greater levels of fine sediment** in the bed and more prolific aquatic plant growth. Controlled release of Takaka floodwaters to the Motupipi River through automatically controlled gates could produce a significant gain for water quality and aquatic ecology.

Above: Overflow from the Takaka River to the Motupipi during a flood in November 2008.

Table 5. Summary statistics for sites in the Motupipi catchment.
Note: Flow statistics for the Motupipi River from continuous measurements (November 2006 to May 2015).

	Motupipi (includes Powell Ck)	**Powell Creek**
River Environment Class	Warm Wet Alluvial Spring-fed - alluvial	Warm Wet Soft sedimentary Lowland-fed (spring-fed upstream Glenview Rd)
Catchment area (km^2)$^+$	2856 (based on mouth at Rototai)	560
Predominant land use upstream	Dairy 36% (over 200 cows)	Dairy 56.6% Sheep and beef ~30%
Mean annual rainfall (mm)	1840	1500
Mean annual flow (l/sec)	466	-
Median flow (l/sec)	385	-
Mean annual low flow (MALF) (l/sec)	210 approx	-
Lowest recorded flow	126	
Water quality record	Quarterly: 2000-present Continuous dissolved oxygen, conductivity, temperature, rainfall and flow from 2007-present (dissolved oxygen Dec-Mar only from 2014).	2005-present

Motupipi River Water Quality Monitoring Station

To be able to continuously monitor water quality in the Motupipi River, Council installed a permanent monitoring station at the Motupipi at Reilly's Bridge site in December 2006. This station records dissolved oxygen saturation, conductivity, temperature, air temperature, flow, turbidity, and rainfall at 15-minute intervals, thus providing useful continuous water quality data over the three years and ten months of operation. This monitoring station was set up because of the very poor water quality and in conjunction with dairy industry clean streams monitoring programme. Data for 2010-2015 is available but not shown as it is almost identical to the pattern shown in the early period of the data..
Between December 2006 and August 2010, **temperature** records showed clear seasonal patterns, with warmer temperatures in summer and cooler ones in winter (Figure 19A). The highest temperature halfway between the daily mean and maximum recorded was 18.8 °C (15/01/2008) and the lowest 10.25 °C (06/07/08) with an average of 13.85 °C. Therefore, the site never exceeded the recommended guidelines for aquatic ecosystem protection of 20°C.

Turbidity analyses showed that recommended guidelines for contact recreation (i.e. 5.6 NTU) were only exceeded for 2.5 % of the time, with the majority of the records (97.5%) being between 1 and 5 NTU (Figure 18). The lowest daily average turbidity recorded was 0.11 NTU (12/08/2010) and the highest 36.5 NTU (23/07/2009). **Time trend analyses** showed a statistically (P=0.02) and ecologically significant (RSKSE = -13.82%) **decrease in turbidity** at the site over the monitoring period (Figure 19B). Average monthly turbidity was highest in July and November 2008, following major floods and lowest in September 2010 (Figure 19B).

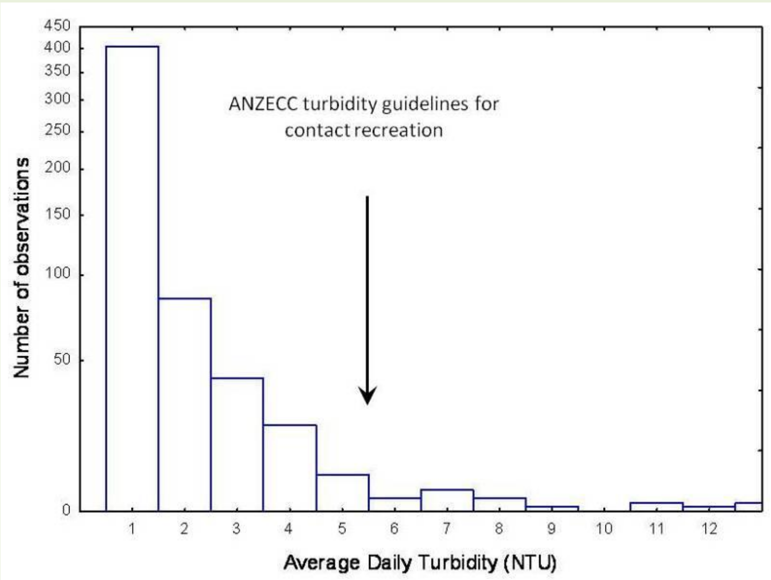


Figure 18.Frequency of average daily turbidity recorded between December 2006 and August 2010.
Note: The X-axis is on a log scale.

Flow ranged from 0.2 m^3/sec (26/04/2007) to 7.2 m^3/sec (24/11/08) with an average of 0.45 m^3/sec (Figure 19). Turbidity was positively correlated with flow (Figure 20), although the

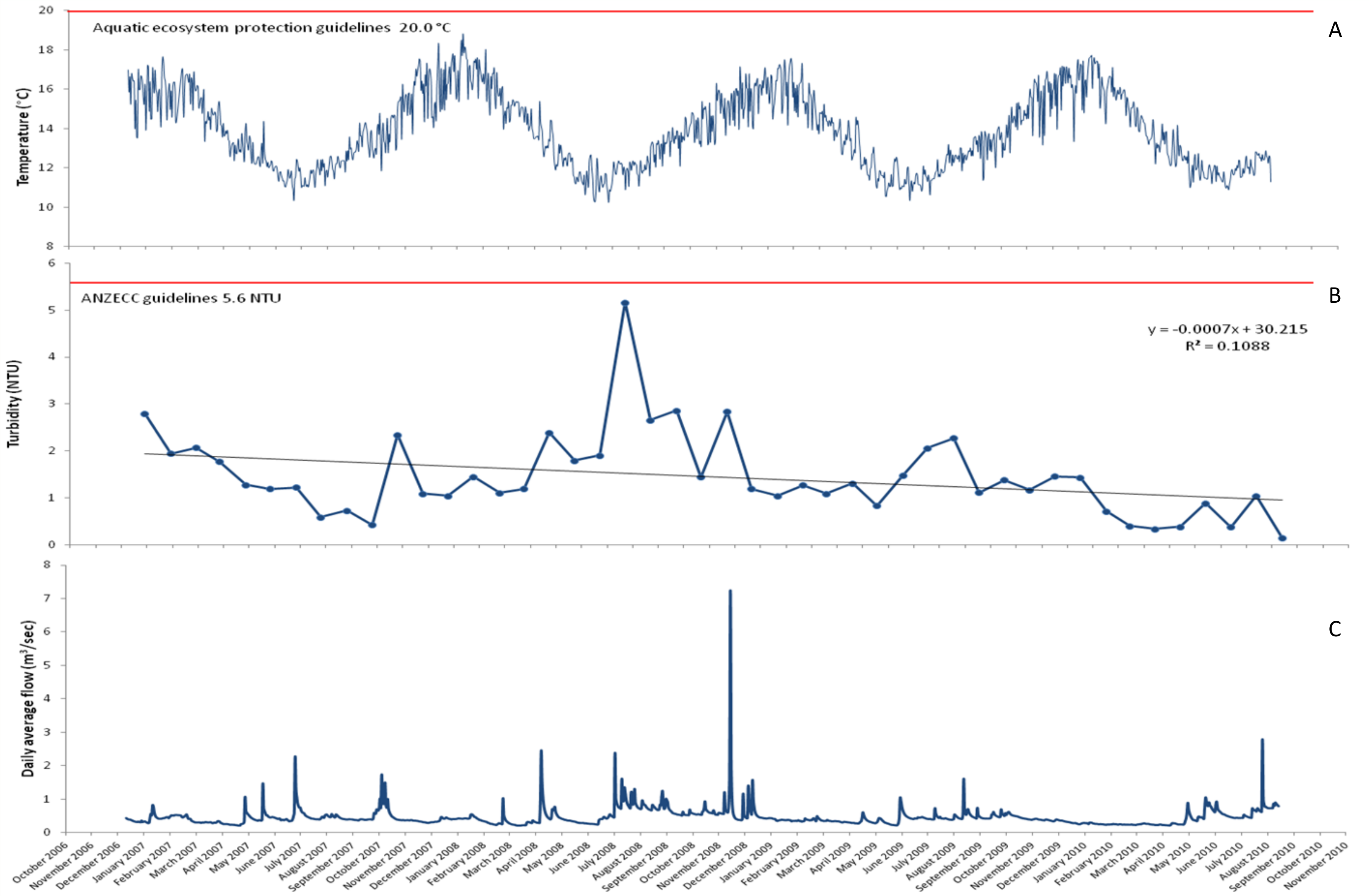


Figure 19. A) Average daily temperature records halfway between the daily mean and daily maximum, B) monthly average turbidity and C) daily average flow recorded between December 2006 and August 2010 at Motupipi at Reilly's Bridge.

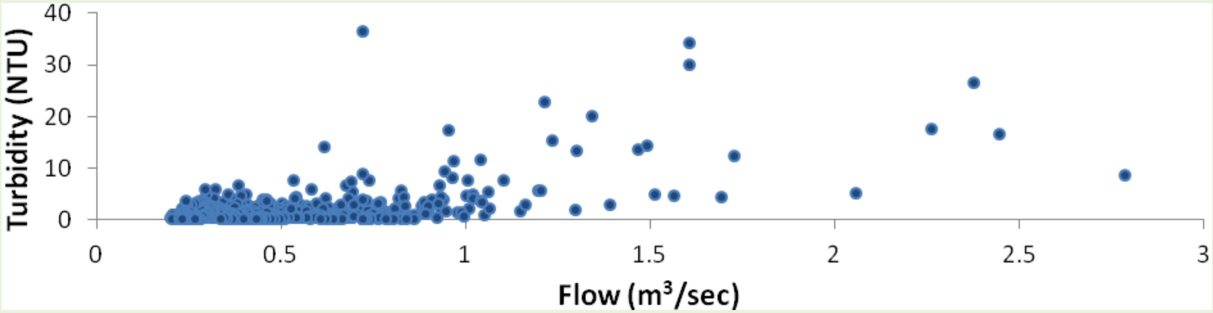


Figure 20. Relationship between average daily turbidity and average daily flow in the Motupipi River at Reilly's Bridge.

Dissolved oxygen saturation records showed characteristic annual patterns **(Figure 21**). DO saturation ranged from a minimum of 36% (02/03/2008) to a maximum of 168% (19/09/2007) with an average of 90.9% between December 2006 and August 2010. Daily fluctuations in DO saturation were greatest in summer and smallest in winter (Figure 21). Similar patterns were observed between 2010 and 2014. DO is fundamental to the survival of aquatic life, and the 1992 ANZECC guidelines recommended that DO should not normally be permitted to fall below concentrations of 6 g/m3 or 80-90% saturation (ANZECC 1992). Daily minimum dissolved oxygen saturations were below 60% saturation for 12% of the sampling period, indicating substantial concerns with low dissolved oxygen levels for most of the time that may be affecting aquatic life.

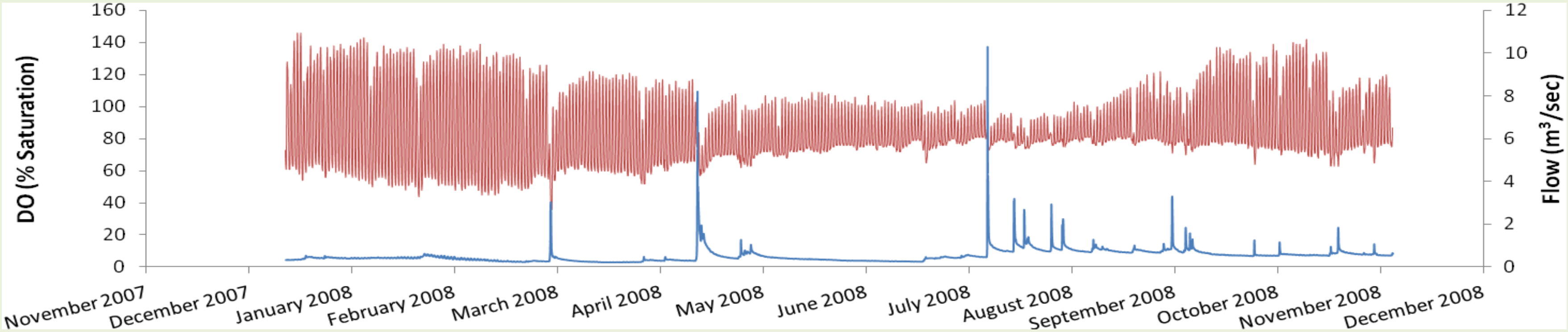


Figure 21. Daily dissolved oxygen and daily flow patterns over a one-year period from December 2007 to November 2008 at Motupipi at Reilly's Bridge.

Ecosystem metabolism was successfully calculated for a five-day period for each season during the earlier sampling period (i.e. 15 seasons between December 2006 and August 2010) (Figure 22). Daily ecosystem respiration (ER) rates ranged from 4.2 $gO_2/m^2/day$ (winter 2010, 25/08/2010) to 19.2 $gO_2/m^2/day$ (summer 2008, 24/02/2008) with an average of 11.8 $gO_2/m^2/day$, reflecting generally poor ecosystem health. Daily gross primary production (GPP) rates ranged from 2.2 $gO_2/m^2/day$ (25/08/2010, winter 2010) to 15.6 $gO_2/m^2/day$ (summer 2009, 25/02/2010), with an average of 7.9 $gO_2/m^2/day$ (Figure)), reflecting satisfactory to poor ecosystem health.

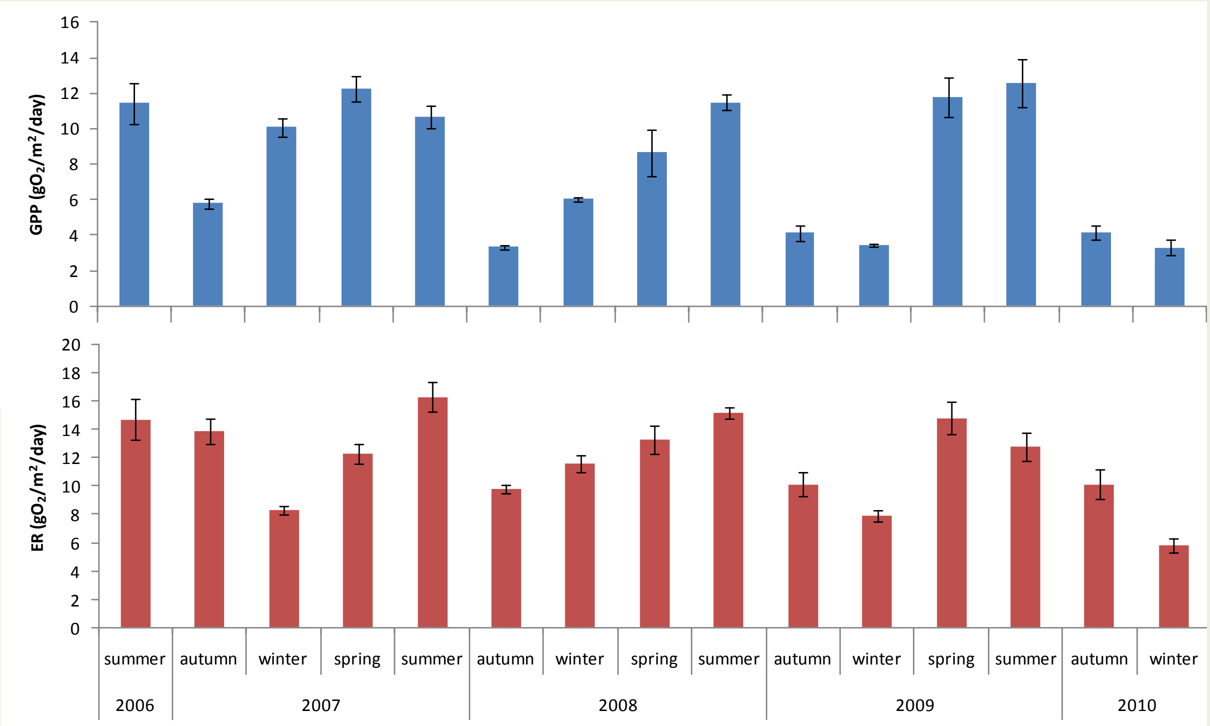


Figure 22. Average seasonal ecosystem respiration (ER) and gross primary production (GPP) rates between December 2006 and August 2010; Note: seasons were categorised as summer = December, January, February; autumn = March, April, May; winter = June, July, August; spring = September, October, November.

Below is a graph of dissolved oxygen over a typical period in summer which has changed little from the decade previous (Figure 23).

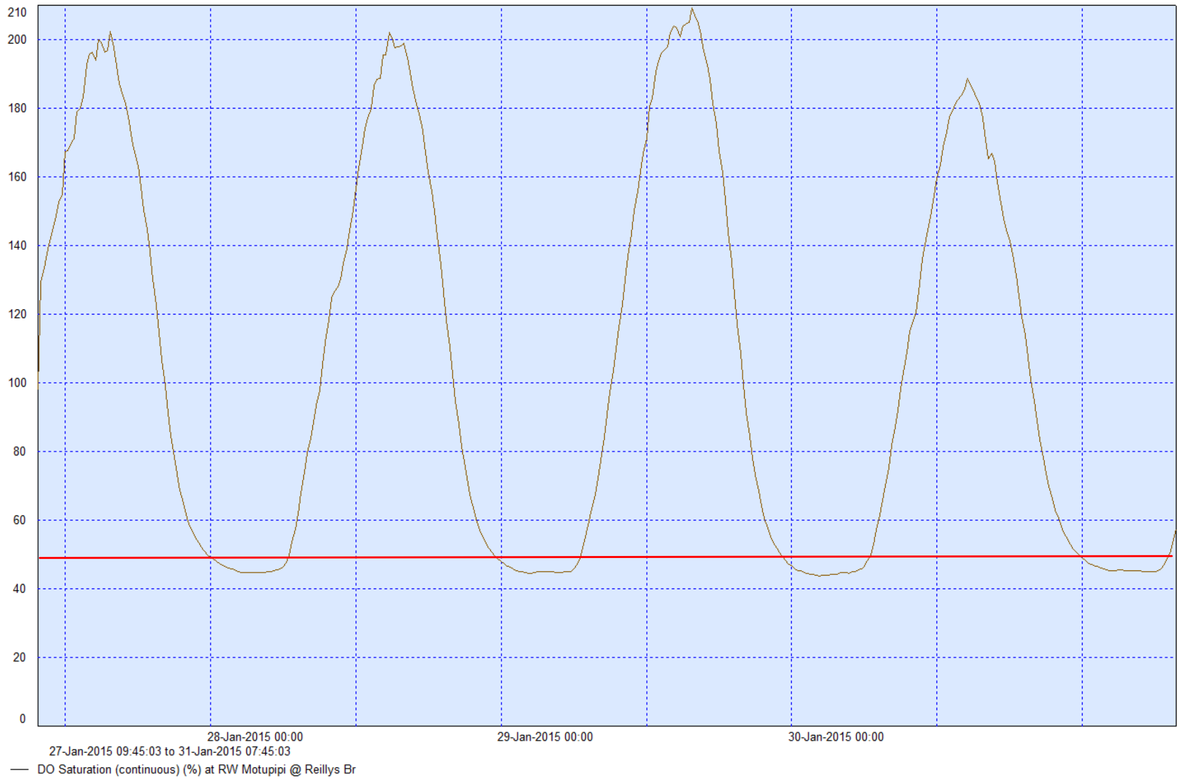


Figure 23. A representative sample of continuous dissolved oxygen saturation data for Motupipi at Reilly Bridge (27-31 January, 2015). Note how similar the patterns are to the earlier part of the record. The national proposed bottom line for the daily 1-day minimum is shown by the red line.

There has been reasonable effort to try and improve the water quality of this river and its tributaries. These include:

- Most streams in the catchment were fenced off from stock progressively between 2000 and 2007 with Berkett Creek being fenced in 2009 and Powell Creek from Glenview Rd to 1.7km downstream Glenview Rd fenced in 2014.
- Much lower loading of nutrients from the Fonterra dairy factory discharge to land and water after June 2005.
- Golden Bay Streamcare Group planted 12,000 plants in riparian zones in this catchment between 2006 and 2014.

Despite these good efforts at this stage the only improving trend is for dissolved reactive phosphorus. Within the next decade it is expected that there will be reduced growth of filamentous green algae in the areas where the plantings have occurred.

Te Kakau Stream, near Takaka

Te Kakau Stream is spring fed and flows along the western edge of Takaka township. The invasive and prolific waterweed *Lagarosiphon major* was accidentally released into the waterway in a flood during the 1960's. To date water quality sampling has only been carried out at this site over the period from 2005-07.

Te Kakau Stm downstream Rose Rd, January 2006

Summer-time minimum **dissolved oxygen levels** were (3-10 February 2006) were found to be **extremely low** (40% saturation for the middle reaches of Te Kakau Stream, as shown in Figure 24, and 0% saturation for the lower reaches of Te Kakau Stream, as shown in Figure 25). Aquatic plant growth rates at the Feary Crescent site are over double the rates for the median for streams draining intensive agriculture in New Zealand and internationally (Young 2006).

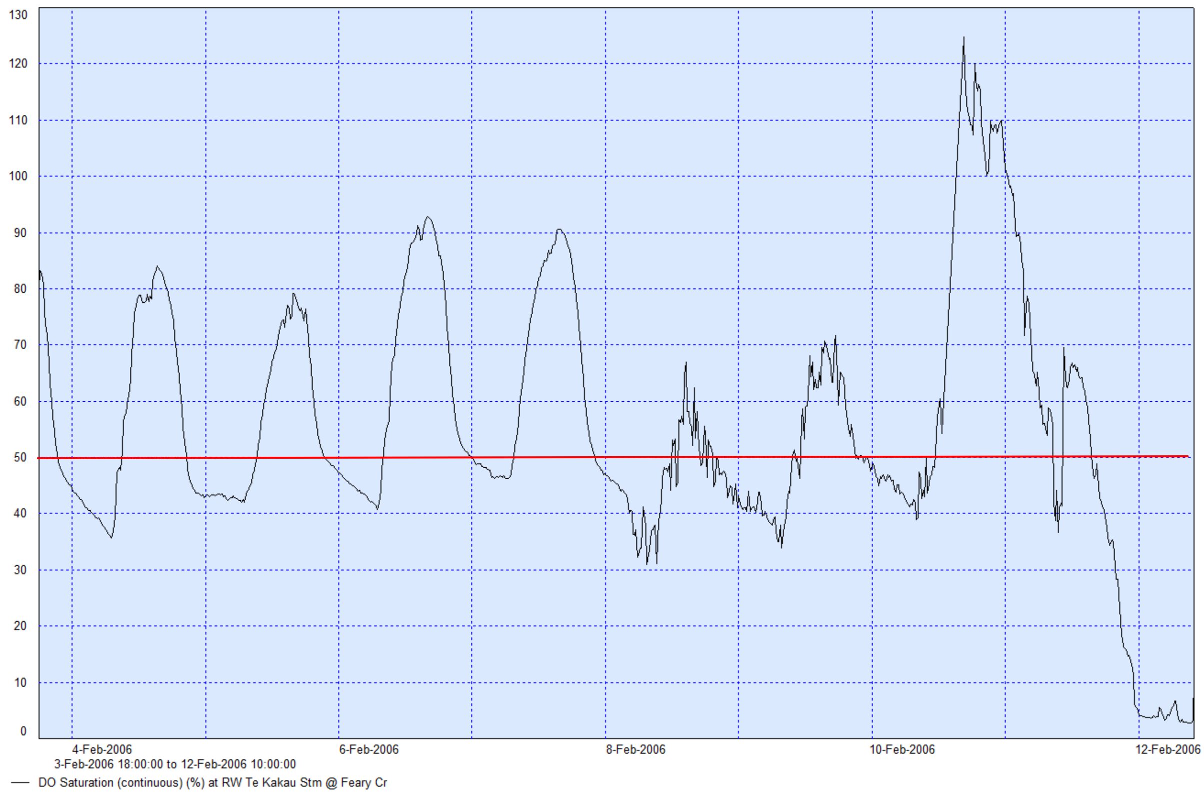


Figure 24 Continuous dissolved oxygen saturation data for Te Kakau Stream at Feary Cres (3-12 February, 2006). The national proposed bottom line for the daily 1-day minimum is shown by the red line.

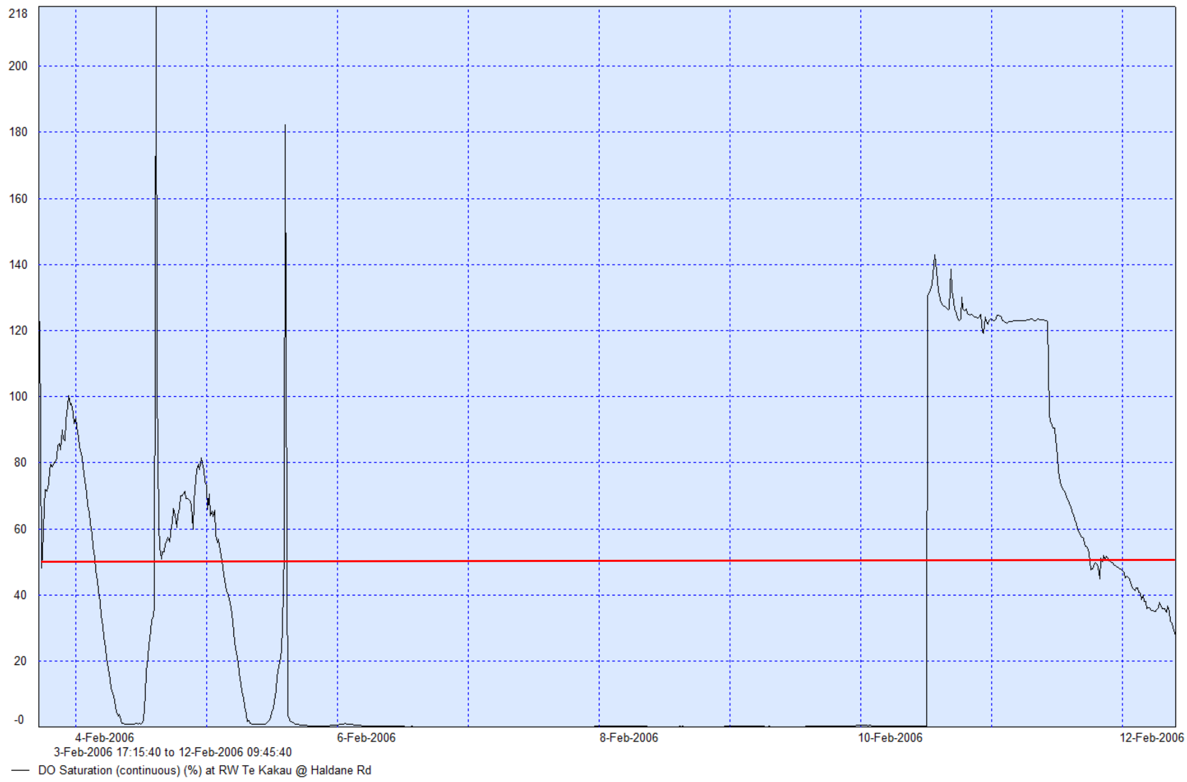


Figure 25 Continuous dissolved oxygen saturation data for Te Kakau Stream at Haldane Rd (3-12 February, 2006). The national proposed bottom line for the daily 1-day minimum is shown by the red line.

Oxygen uptake rates at the Feary Crescent site are among the highest recorded previously. The vigorous growth of the aquatic weed, *Lagarosiphon major* (an oxygen weed), is a major reason for this condition. Of all the methods considered to solve this problem, shading of this stream with overhanging evergreen trees is the most effective and low-cost (James and Clayton 2007). The benefits to fish and invertebrate habitat by using this method are significant and much greater than other methods. Despite riparian planting in all the Council reserve land and some private properties, the offer to have trees planted along the waterway has not been taken up by the majority of landowners with land adjacent to the waterway. The low dissolved oxygen is likely to be little changed from 2007 as the amount of shading of the water needs to increase from the current level of about 20% of the waterway, to >70% to have a reasonable impact.

Fine sediment deposits in this stream are a problem, with an average of 200-300 mm over the original cobble bed. More care needs to be taken right across the district to avoid sediment discharges to spring-fed creeks as they do not get flushed out in floods like hill or mountain-fed rivers.

Like the Motupipi, this waterway would also gain considerably from increased flushing flows from the Takaka River, as happened in the past.

A management plan was drafted in 2004 that aims to facilitate increased public use and enjoyment of the stream environment through a combination of actions, including revegetation, rubbish removal and prevention, minimisation of contaminant run-off, and weed control.

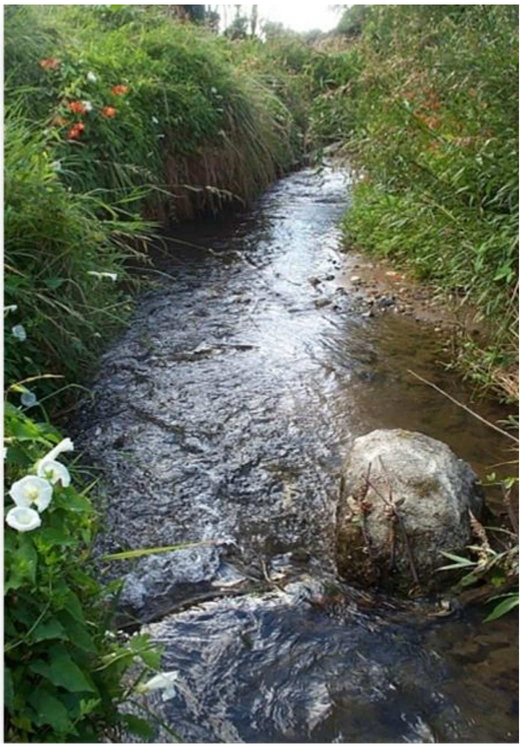
The local community has participated in the management plan process and on-the-ground work. Trials of different methods of aquatic weed control were trialled in 2007-08. While two layers of weed mat was shown to be very effective, the cheapest effective method is shading by streamside plantings. Council reserve land adjacent to the waterway has been largely planted (see photo from 2010 below) as well as several properties. Council has offered native trees for planting along the stream.

Te Kakau Stm at Haldane Rd looking upstream(Top left: October 2005, Top right: September 2005, Bottom Left: July 2010, bottom right: May 2012).

There used to be other spring-fed streams in the Takaka delta. Wigo and Mason Creeks used to flow prior to about 1990, but are now dry and grassed over. These creeks lie to the east of SH60 at the north end of Takaka township and originated from about 2km south-east of the Takaka River. . The reason for this reduced level may be the lower bed level of the Takaka River particularly in the area between south end of Reilly St and 500 m downstream of the Kotinga Bridge. There does appear to be a decline of about 200-300 mm at the Council monitoring bore that would support this theory.

Small coastal streams of Golden Bay

Winter Creek, Pohara

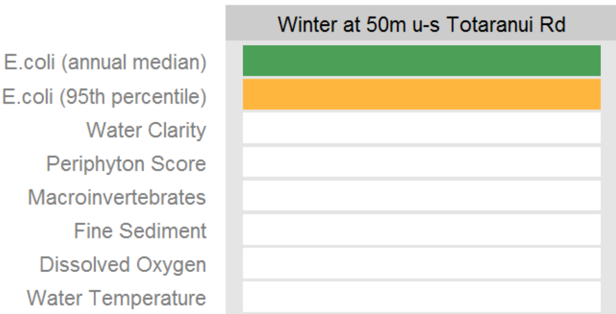


Winter Ck at 500 m upstream Abel Tasman Drive (February 2005).

This creek flows out onto Pohara Beach at its eastern end, and so can potentially affect water quality at this beach.

Winter Creek has generally low to moderate levels of faecal indicator bacteria at base flows (median for 2010-15: 97 *E.coli*/100 ml; compared to median for 2000-2010 of 197 *E.coli*/100 ml), and only about 2% of samples are over the guidelines for stock drinking. While the stream itself is not deep enough to swim in, it flows into a partly enclosed area of a very popular beach.

Conductivity is very high (700-800 µS/cm) in a tributary running out of a limestone cave that joins Winter Creek about 220 m upstream of Abel Tasman Drive, potentially explaining the low macroinvertebrate indices scores. Aluminium and iron concentrations in sediment in this tributary are elevated (10,900 and 33,400 mg/kg dry weight respectively. No other heavy metals were detected. Neither were any hydrocarbons (including poly-aromatic hydrocarbons), volatile organic compounds or semi-volatile organic compounds, or phenols. ketones. This sampling was carried out after allegations that there may be leachate from materials on the former Golden Bay Cement Works site causing the high conductivity.



Site data summary plot. Colours indicate attribute states from A (good) to D (poor).
Refer to the interpretation guide for full details.

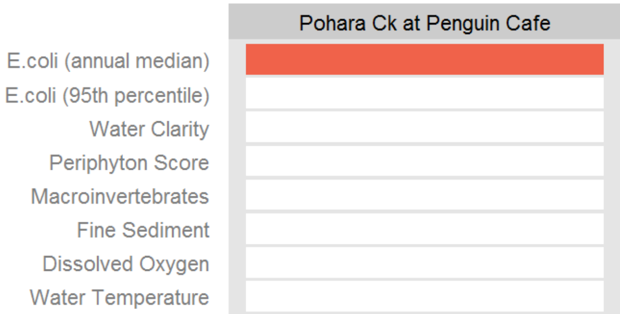
A one-off macroinvertebrate sample (in 2008) showed water quality for Winter Creek was satisfactory to poor (MCI 101, SQMCI 4.1).

In December 2011 the largest ever recorded 48-hour rainfall event in an urban area in New Zealand was recorded in the Pohara-Takaka area (674 mm, when the average rainfall for all of December is 207 mm). This caused wide-scale land slips and heavy silt and sand deposits to the creek and surrounding land. While water quality seems to be little affected, the fish and invertebrate communities are likely to only now be recovering to a state approaching that of prior to this disturbance.

Pohara Creek, Pohara

This small stream also flows out onto Pohara Beach and, being adjacent to a very popular campground (Pohara Beach Holiday Park), it is popular for young children to play in. Land use in the catchment is dominated by sheep and beef farming and residential housing. There are several sink holes and tomos in the limestone that extends for about 500 m upstream from the coast. After a survey in 2009-10 Pohara Beach was found to be one of the most popular in Tasman.

Above: Pohara Beach view ENE (February 2011)



Site data summary plot. Colours indicate attribute states from A (good) to D (poor).
Refer to the interpretation guide for full details.

Since records began in 2003 faecal indicator bacteria concentrations at Pohara Beach over summer have exceeded guidelines about 10% of the whole record (234 samples) and occasionally well over the alarm level. Pohara Creek was confirmed as a potential source of this contamination in 2005-06 and a sanitary survey (intensive investigation to try to find the source(s)) was undertaken over the 2006-07 summer. A significant faecal discharge was discovered and the household's sewerage system was repaired to ensure it connected with the municipal system. After this faecal indicator bacteria results improved for a while, with only 4% of samples exceeding in the period from 2007-2010, but then results worsened again over the last three years (Figure 26). Almost 13% of samples exceeded and the magnitude of the exceedences has increased with many more samples over 1000 *Enterococci*/100 ml. The sampling frequency at Pohara Beach was increased to 20 samples per year in every year (as recommended in the guidelines for a popular site with higher risk) in 2010-11. This precipitated another sanitary survey of the creek in 2014-15 to again attempting to determine the source.

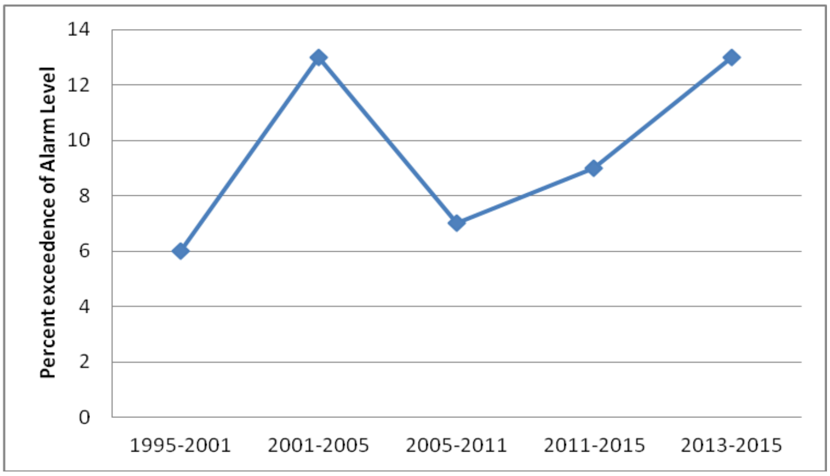


Figure 26. Rate of exceedence of alarm levels at Pohara Beach (Camp East site)

Results of microbial source tracking on 2 February 2015 were inconclusive showing only a weak possum signal and that the source was not bovine, human, dog, sheep, wildfowl, or gull. This is the only such analysis performed to date, but further work will be carried out this coming season.

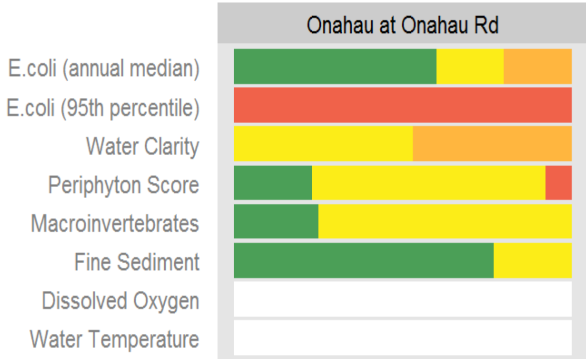
Faecal indicator bacteria (*E.coli* and *Enterococci*) have recently been found to survive in the New Zealand environment outside of the gut of a warm-blooded animal (Devane, 2015). Even more recently it has been found that overseas these bacteria don't just survive in the environment, but can reproduce and support reasonable numbers. These 'naturalised' bacteria are not usually disease-causing and so the faecal indicator bacteria data from these sites may not be useful in managing a public health risk. It has been found overseas that the particular environments they prefer are those with a lot of fine sand, mud, and algal accumulations. These environments are relatively common at Pohara Creek and beach. There are a few of these situations arising around New Zealand and research will be needed to determine if such a 'naturalised' faecal indicator bacteria population exists at Pohara.

Pohara Ck upstream Abel Tasman Drive (behind the Penguin Cafe) viewed downstream (January 2007).

Onahau River, Puremahia

About 95% of the 710 Ha catchment upstream of Onahau Road is in native forest with the remaining land use on the flat land in dairy farming. The waterway is incised (cut down through the land with steep banks). Because there is limited mixing of water from this creek with the sea at the mouth, and that since swimming (primary contact recreation) occurs at the mouth, this creek was assessed against contact recreation guidelines. Very good habitat for fish and invertebrates exists in this creek and being close to the coast it is expected to hold high numbers and high diversity of fish.

Onahau River at Onahau Rd (January 2005).



Site data summary plot. Colours indicate attribute states from A (good) to D (poor).
Refer to the interpretation guide for full details.

When monitoring began at this site in 2005 it was evident that water quality was poor in this stream, with high concentrations of faecal indicator bacteria. The average has now halved (median for 2010-15: 250 *E.coli*/100 ml, median for 2005-2009: 500 *E.coli*/100 ml). However, the higher peaks are similar (for 2010-15 and 2005-09 respectively there were 15% and 13% of samples over 1000 *E.coli/*100 ml), high cover of filamentous green algae and poor macroinvertebrate condition. Council received complaints about dairy effluent solids on the beach east of the stream mouth. The effluent treatment systems of the two farms upstream of Onahau Rd were substantially upgraded and a regular stock crossing was bridged in 2010 following court action.

Puremahia Stream, near Paton Rock

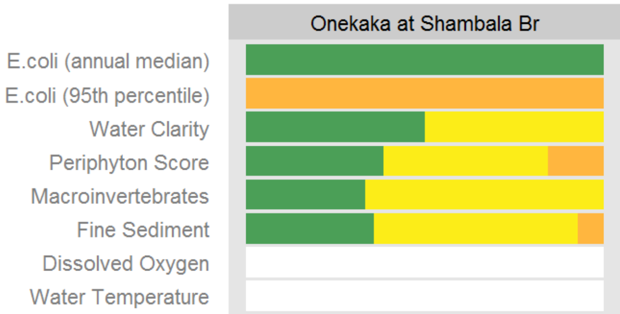
The upper ~20% of this catchment is in native forest, with the remainder in pasture, which is mostly dairy farmland. This stream was found to have high levels of faecal indicator bacteria in two sampling campaigns in 2005 and 2009 (median *E. coli:* 2001/100 ml). Most of the contamination appears to be coming from dairy farmland, both above and below SH60. Since 2005, over 1 km of this waterway has been fenced off upstream of SH60 to exclude stock. This stream is used for contact recreation in the lower reaches.

**Puremahia Rv at 500 m downstream bush line (February 2005, left)
and 50 m upstream Battery Rd (right).**

Onekaka River

This stream has **outstanding native fish values** with the highest species richness for a particular reach known in the district, (one 300 m reach had 12 native fish species plus trout). Most fish species were also abundant. Prolific inanga spawning has been found to occur at a site about 600 m downstream of Shambala Rd. A hydro-electric power scheme operates in the catchment with a 10.7 m high dam (built in 1928) about 4km upstream of the monitoring site at Shambala Road.

Above left: Onekaka Estuary looking to the catchment upstream (June 2010). Above right: Inanga spawning sites on the lower Onekaka River (March 2013).



Site data summary plot. Colours indicate attribute states from A (good) to D (poor).
Refer to the interpretation guide for full details.

The lower section of this river has **moderate concentrations of faecal indicator bacteria** (Median at low flows: 172 *E. coli* /100 ml; ~8% of samples over alarm levels for contact recreation and ~7% over the secondary contact national bottom line). Median *E. coli* loadings in the lower reaches are 100 times higher than the upper reaches (Median low flow load at Shambala: 10^5 *E.coli*/sec). No investigations have been undertaken to date to determine the cause of this issue, which could be dairy farming, or septic tank discharges, or both.

Moderate levels of fine sediments deposited in the bed matrix are found in the lower reaches. Prior to 2005 sediment was dug out and discharged downstream of the dam at low flows resulting in heavy load of fine sediment in the stream bed. This practice is now not permitted under condition of resource consent.

On average, **water clarity is halved in the 2km below Ironstone Creek** (median: 10 m to 5 m; u-s Ironstone to Shambala) (Figure 27). The reasons for this are unclear. It may be the geology, inputs from farmland and roads, or tannins from wetlands or particular forest type.

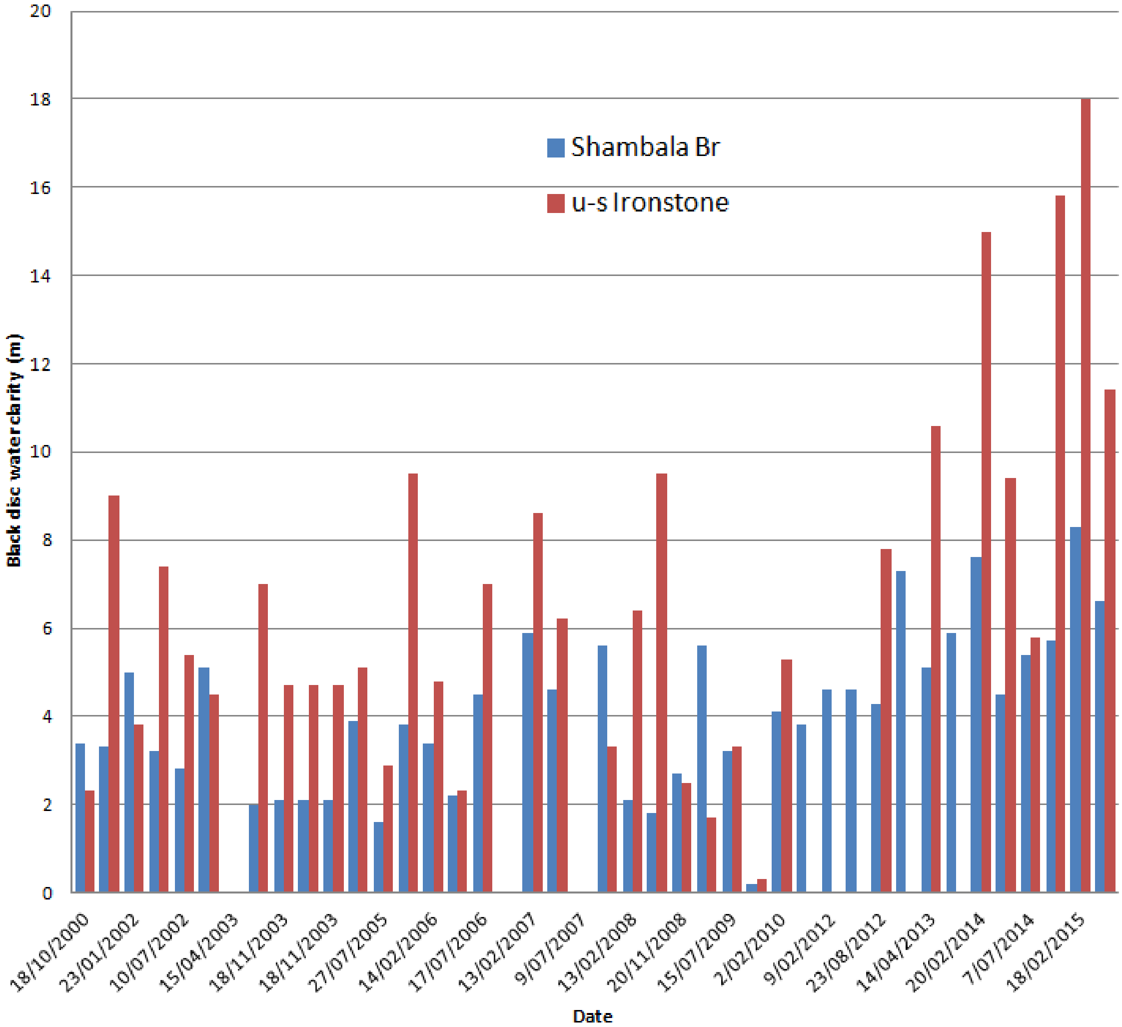


Figure 27. Comparison of water clarity in the Onekaka River between the upstream site (upstream Ironstone Creek) and the downstream site (Shambala).

Above: Electric Waters Dam on the Onekaka River (January 2009)

Onekaka River at the lower site at Shambala ford, November, 2004 (top left) and at the upstream site at Ironstone Ck January 2002 (bottom left), typical sediment plume from kicking in the stream bed at Shambala Rd, November, 2004 (right).

Table 6. Summary statistics for sites in the Onekaka catchment.

	Onekaka u-s Ironstone Ck	Onekaka at Shambala
River Environment Class	Cool Extremely Wet Hard sedimentary Hill-fed Indigenous forest	Cool Extremely Wet Hard sedimentary Lowland-fed Pasture
Catchment area (km^2)	2.3	16
Predominant land use upstream		680 ha (43%) in indigenous forest 800 ha (50%) in dairy farming
Mean annual rainfall (mm)	2,200 est	
Mean flow (l/sec)	345	627*
Median flow (l/sec)	80.6	
7-day Mean Annual Low Flow (l/sec)	44	
Lowest recorded flow	12	112 (Apr 2001)
Water quality record	2000-present	2000-present

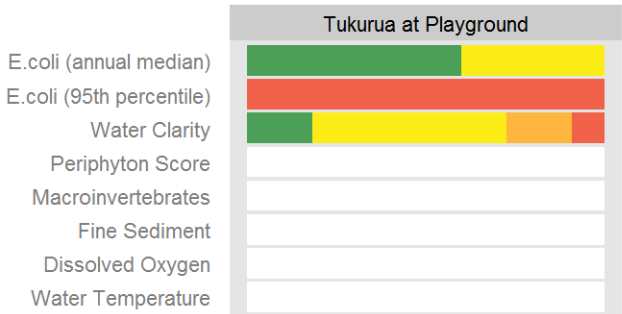
* Estimate from WRENZ 2013. NA = not available

Tukurua Stream

About 85% of the 5.2 km^2 catchment of this hill-fed stream is in native forest with the remainder being a dairy run-off block (0.4km^2), and rural-residential blocks and a campground in the lower catchment (0.4km^2). A pool in the stream near the mouth (adjacent to Golden Bay Holiday Park) is popular for swimming when the tide is half out. Like many small-medium sized streams that drain direct to the coast there is high fish diversity. Importantly the abundance of fish in the stream is also high, particularly for torrentfish.

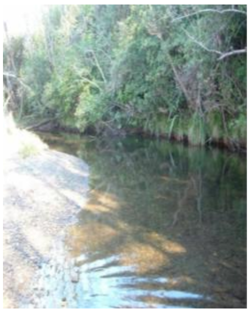
Tukurua Stream approximately 1.5km upstream SH60 (July 2010)

Monitoring in this stream began in 2010 and concentrations of faecal indicator bacteria were found to be moderate-high at SH60 (median: 271 *E.coli* /100 ml) and moderate at the swimming hole near the mouth and adjacent to Tukurua campground (median: 207 *E.coli*/100 ml). Sampling at the beach only about 150 m southeast of the mouth has only recorded five exceedences of alert levels (over 140 *Enterococci*/100 ml) in 129 samples from 1995 to 2014. Several of these exceedences were due to rain events or particularly high tides.



Site data summary plot. Colours indicate attribute states from A (good) to D (poor).
Refer to the interpretation guide for full details.

Four out of five Microbial Source Tracking samples from the stream identified ruminant animals (*e.g.*, cattle, sheep, deer, goat) as a major source, with the last two effective samples showing it was the only source. Wildfowl was found to be a source in 2010-11, but not in the two effective samples since. Wildfowl are considered relatively uncommon in the catchment (Hindmarsh and Bennett pers comm.) they are very unlikely to be a source. A human source was identified in May 2011, but not in the two effective samples since. This shows that the upgrade to the two failing domestic septic tanks discharging to the waterway in 2011-12 has been enduring. Throughout the period the environmental practice at the farm upstream of SH60 was reasonably good with all regular stock crossings fenced and no other less frequently used stock crossings identified. In late summer 2014 a drinking trough located very close to the stream was relocated to a site 50 m away from the stream and fences moved back away from the stream in areas where paddock run-off funnels to the stream allowing for better filtering of contaminants. These latter measures appear to have resulted in an improvement in *E.coli* concentrations (Figure 112 and Figure 113).



Tukurua Stream swimming hole, 50 m upstream mouth (July 2010)
Tukurua Stream approximately 500 m upstream SH60 (January 2012)

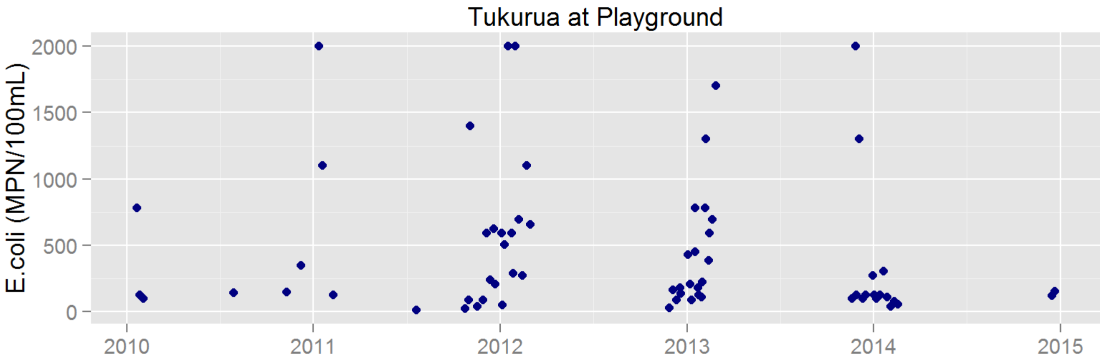


Figure 28. Concentration of *E. coli* at Tukurua at Playground from 2010 to 2015

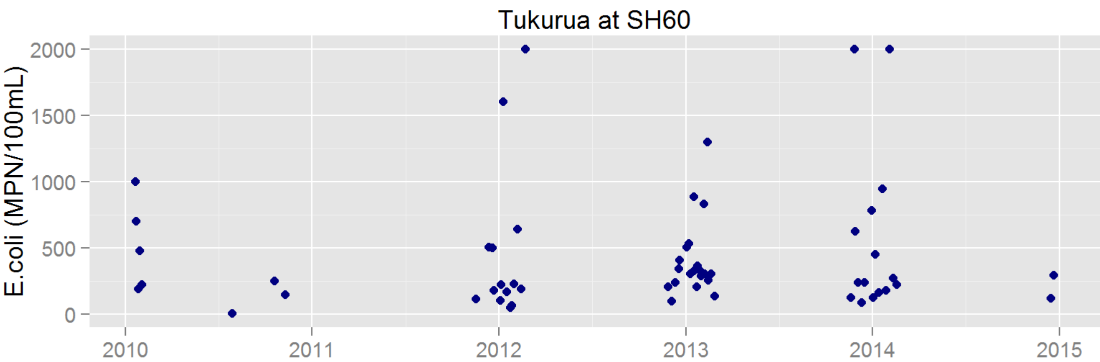


Figure 29. Concentration of *E. coli* at Tukurua at SH60 from 2010 to 2015