Kaituna Catchment Water Quality Monitoring

Results from monitoring October 2014 – October 2015

Summary

The Kaituna community (including local landowners and iwi) indicated a need for improved understanding of surface water quality in the Kaituna River. Arising from this, a one-year study of combined water quality and cultural monitoring was co-ordinated by Environment Canterbury. The purpose of this study was to gain a better understanding of the catchment and identify where hotspots are located in order to allow informed and targeted responses.

This short report summaries the results from one-year of monitoring and identifies key water quality issues arising from this study.
Faecal contamination is elevated for much of Kaituna River, and does not meet recreational water quality standards. Sediment deposition on the bed of the Kaituna River is evident (from visual observations). This sediment accumulation acts as a reservoir for nutrients and bacteria. Nutrient enrichment can promote excessive growths of aquatic plants (macrophytes) and algae, of which macrophytes are abundant in the lower reaches. The accumulation of sediment and excessive growth of macrophytes can have detrimental effects on the ecosystem, such as flow impediment, oxygen consumption via respiration or the breakdown of trapped and accumulated organic matter, and generally smothering of the benthic habitat.

Overall, water quality of the Kaituna River indicates that some parameters are elevated in terms of meeting relevant guidelines and objectives. Future efforts are required to ensure the water resource can be restored to a healthy aquatic state, and enjoyed for recreational and cultural purposes.

1. Introduction

Kaituna River is located in the Kaituna Valley on Banks Peninsula and is greatly characterised by the volcanic geology of the area. The catchment extends 15km through the valley from Mt Herbert (928m) down to near sea level where is flows into Te Waihora. The river flows down a steep sided valley that contains some remnant native vegetation cover, providing an area of high quality habitat for native flora and fauna/aquatic species.

Banks Peninsula streams are generally steep and are short in distance from the headwaters to the outlet. This means that these streams can experience high flows during rainfall events, causing erosion of the banks and allowing sediment to enter the stream. The steep catchment and erosion is a contributing factor to the state of water quality in the Kaituna Valley. Contaminants of concern to these areas are phosphorus, fine sediment and faecal matter. Typically these contaminants are mobile in runoff through overland flow. Dissolved phosphorus has a high affinity for particulate matter such as soils and clay, and will readily bind to these particles. Riparian planting and fencing programmes have already been carried out along the Kaituna River for aesthetics and as a preventative measure for overland flow contamination to the stream in places.

A long term water quality monitoring record exists for one site on the river (recorder) dating back to 1992. Monitoring at this site indicates that E.coli and sedimentation levels are elevated. However, more intensive monitoring was required for identification of areas in which to focus management.

This valley, although located on Banks Peninsula, is located within the Selwyn-Waihora water management zone. Management activities aim to maintain and improve the ecological values of the Kaituna Catchment, including Kaituna River, its tributaries, associated catchment activities and Te Waihora. This area is very important to Ngāi Tahu, particularly for the Koukourārata hapu of Banks Peninsula who used the Kaituna Valley as their traditional pathway to Te Waihora to gather mahinga kai.

This report aims to inform on the current state of water quality in Kaituna River. A greater understanding of this catchment will allow for effective future management of the water resource.

2. Methods

Water quality was sampled monthly at six sites along the mainstem of Kaituna River and one site on a tributary, Okana Stream (Figure 1). This was carried out in conjunction with a COMAR (Cultural Opportunity Mapping Assessment and Response) assessment. Results from the COMAR monitoring are not presented in this report.

Samples were analysed for:

- Dissolved Reactive Phosphorus (DRP)
- Total Phosphorus (TP)
- Total Suspended Solids (TSS)
- Nitrate + Nitrite Nitrogen (NNN)
- Escherichia coli (E.coli)
- Ammoniacal Nitrogen (NH_4N) from April 2015
- Total Nitrogen (TN) from June 2015

Ammoniacal nitrogen was introduced to the sample regime in April 2015 to investigate if there were any issues arising from possible leakages from outdated septic tanks. Total Nitrogen was subsequently added in June 2015.

When the concentration of these parameters were below laboratory detection limits, they were converted to a value equal to half the detection limit (i.e. <0.08 = 0.04). Where parameter concentrations were greater than the laboratory detection limits the results were given a value equal to the upper detection limit.

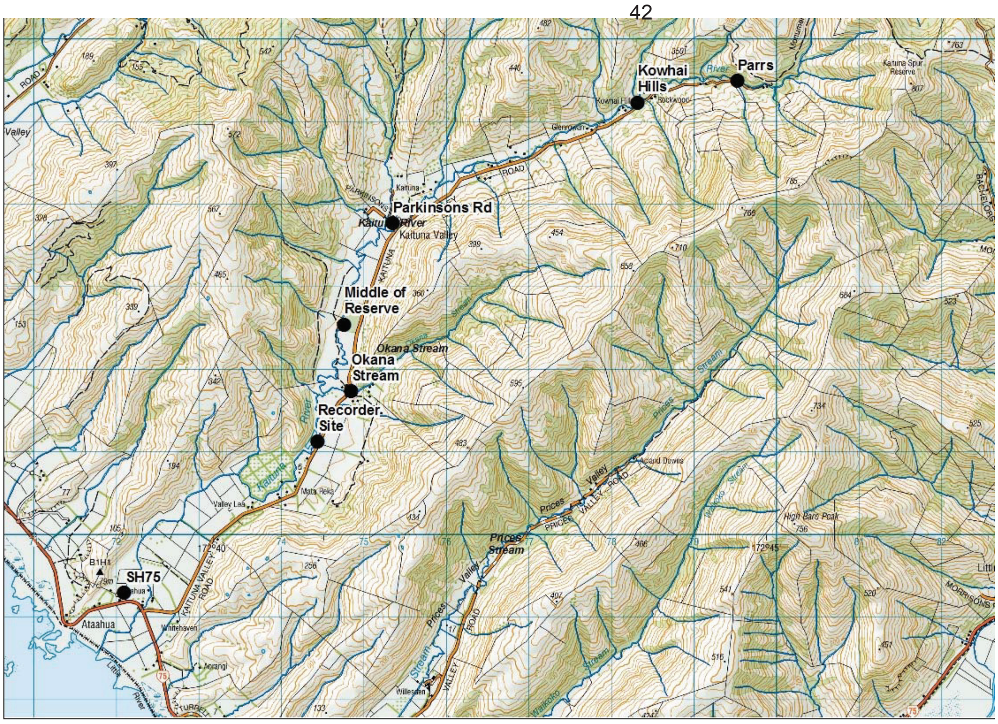


Figure 1. Map of the Kaituna catchment water quality investigation sampling sites

3. Results

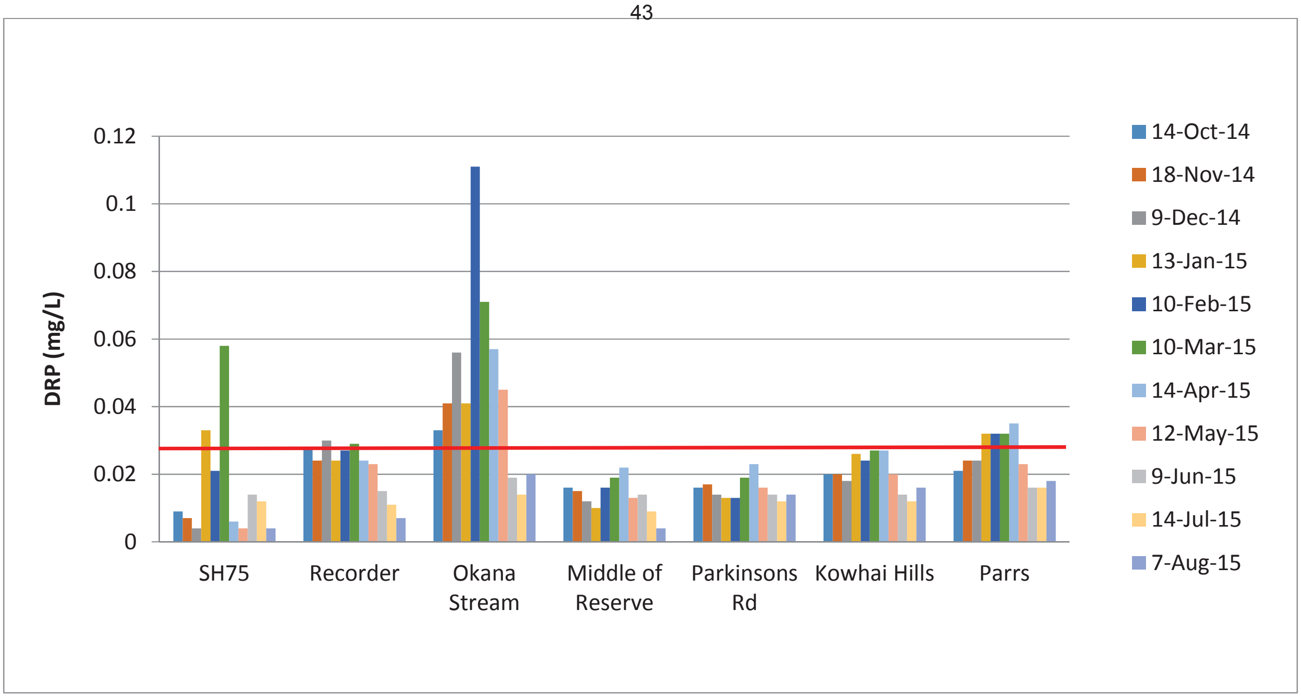
3.1 Nutrients

Nutrients (such as nitrogen and phosphorus in their dissolved form) are major controlling factors in the proliferation of algae and aquatic plant communities. At high concentrations, algae and plants can grow in such large quantities that they become a nuisance, smothering or choking waterways which can cause flooding and a reduction of instream habitats for fish and aquatic invertebrates. These excessive growths can cause large fluctuations in dissolved oxygen concentrations in the water, causing a range of detrimental effects including death in fish and invertebrate populations. Some forms of nitrogen in elevated concentrations, such as ammonia and nitrate, become toxic to aquatic life and can pose a public health risk in drinking water.

3.1.1 Phosphorus

Phosphorus sources include:

- wastewater
- animal effluent
- phosphatic fertilizers
- volcanic rock/soils.



Lake <--< Headwaters

Figure 2. Dissolved Reactive Phosphorus concentrations in Kaituna River. Note the red line represents the regional median of 0.027mg/L for Banks Peninsula streams (Robinson & Barbour, unpublished)

Dissolved Reactive Phosphorus (DRP) is the amount of phosphorus available for uptake by aquatic plants and algae to use for growth. At most sites, there has been little variation in DRP concentrations over the one year monitoring period (Figure 2). SH75 and Okana Stream are the only sites where we see varying concentrations that are above the median value for Banks Peninsula streams. The SH75 site is close to the river outlet into Lake Ellesmere/Te Waihora therefore water quality is most likely influenced by lake water, more so when it is pushed upstream into the river during southerly/westerly winds.

Phosphorus readily attaches to soil and primarily enters waterways from over land flow or bank erosion. During the peak in February at Okana Stream, it was noted that over a hundred cattle had access to the stream. In March there was still evidence of stock access. During these two sampling periods, the water was noted to be turbid. This indicates that phosphorus-rich sediment had possibly been trampled into the stream. Due to the dry summer and subsequent low flow, it would have taken some time (or until the next significant rainfall event) for the sediment to be flushed downstream away from the sampling point.

The middles sites, Parkinsons and Middle of Reserve, exhibited a decrease in concentration due to the aquatic macrophytes and algae taking up the nutrient and converting it into plant biomass.

It is unlikely the upper reaches are influenced by artificial forms of phosphorus (fertiliser) due to the low intensity land use. Phosphorus sources are most likely from the natural concentrations in the volcanic soils.

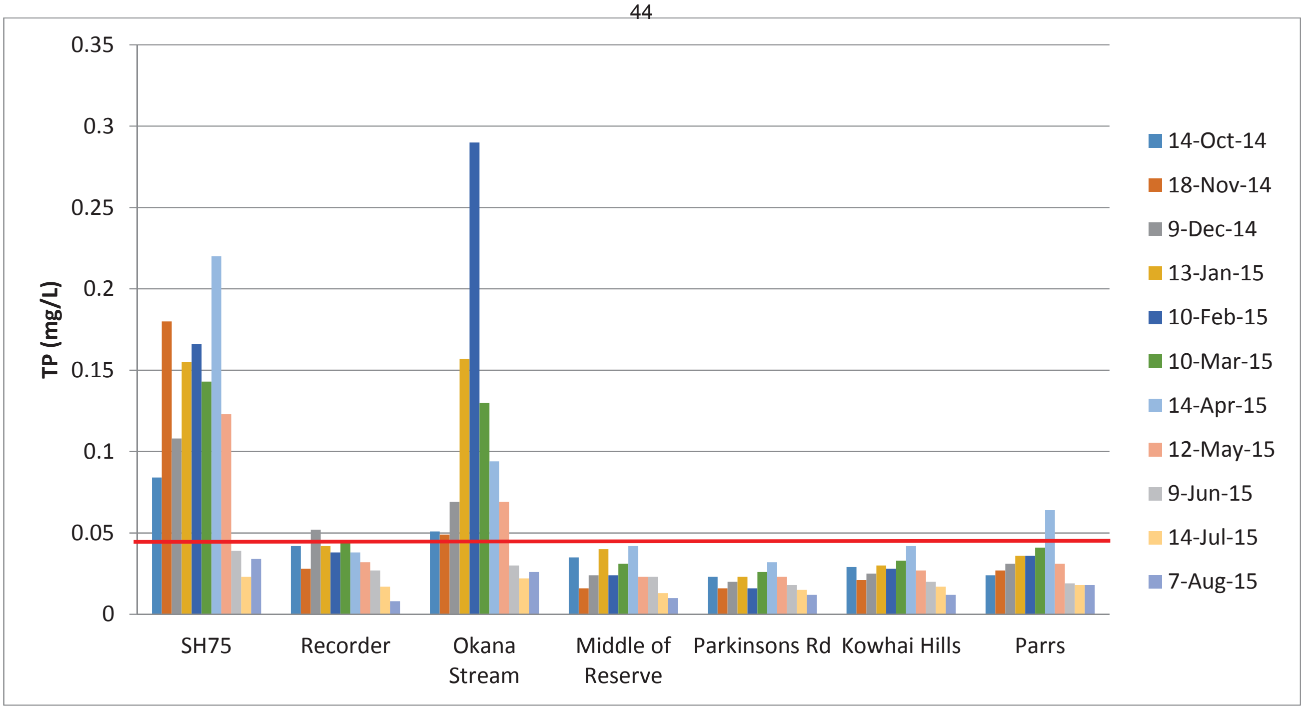


Figure 3. Total Phosphorus concentrations in Kaituna River. Note the red line represents the regional median of 0.048 mg/L for Banks Peninsula streams (Robinson & Barbour, unpublished)

Total Phosphorus (TP) is the measure of both inorganic (dissolved) and organic (insoluble minerals or biological tissue) phosphorus. Elevated concentrations occur at both the SH75 and Okana Stream sites (Figure 3). Concentrations of TP are much more elevated at the SH75 site compared to DRP. At all of the other sites, patterns of TP are similar to DRP (the proportion of inorganic to organic nitrogen is about the same).

The greater concentrations of Total Phosphorus at SH75 compared to concentrations of DRP indicate that much of the phosphorus at this site is locked up in either biological tissue or insoluble mineral particles, and thus unavailable for uptake by macrophytes and algae. The influence of lake water at SH75 indicates that sediment and algae from the lake is present and contributing to elevated phosphorous concentrations. The green colouration of the water at this site indicates that some phosphorus could be bound up as phytoplankton originating from the lake. Phytoplankton are free floating algae that inhabit the upper sunlit layer of the water column. When present in high enough numbers, they may cause a green discoloration to the water due to the presence of chlorophyll within their cells. This is what gives Lake Ellesmere its green tinge.

3.1.2 Nitrogen

Nitrogen sources include:

- fertiliser
- effluent disposal
- urine patches in paddocks
- the breakdown of dead plant matter (including grass or straw and instream plant matter),
- seasonal die-off of legumes (clovers, lucerne, etc.)
- animal or human faeces

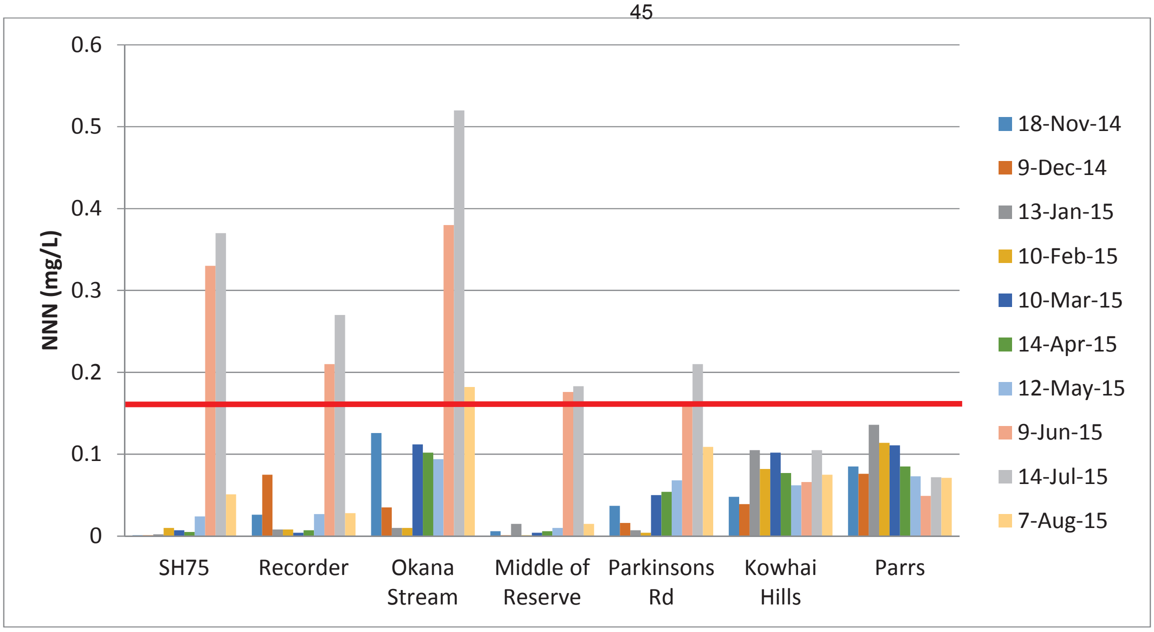


Figure 4. Nitrate-and-Nitrite Nitrogen concentrations in Kaituna River. Note the red line represents the regional median of 0.164mg/L for Banks Peninsula streams (Robinson & Barbour, unpublished)

Nitrate-and-Nitrite Nitrogen (NNN) concentrations were elevated in the upper sites compared to those downstream (Figure 4). Peaks are observed in June and July, particularly in the lower reaches.

Nitrite is an unstable form that is rapidly oxidised to nitrate in oxygenated conditions. Therefore the majority of NNN is present as nitrate. Nitrate can be toxic to aquatic species above certain concentrations (>1mg/L) (Hickey, 2013). All NNN concentrations recorded at the study sites were below this level. This suggests that nitrate toxicity is unlikely to affect biodiversity values in any of the study sites.

NNN in this catchment is contributing to soluble nutrient concentrations and thus a controlling factor of macrophyte and algae growth. This is observed in the decrease of NNN from the headwaters down to the outlet at the lake. The upper catchment is characterised by a clear and fast flowing habitat whereas in the lower reaches, macrophyte growth is more prominent. These macrophytes take up the soluble nutrients and convert NNN into plant biomass.

As mentioned previously, the SH75 site is influenced by lake water. NNN concentrations are relatively low in the lake because all the soluble nitrogen is used up by the algae (phytoplankton) and so we see very low concentrations at SH75.

Spikes of NNN occurred in both June and July for many sites. This is during the wetter months of the year, and water testing had occurred just after rainfall (Appendix 1). Plants (both on land and instream) grow slowly over winter so do not require as much nutrient uptake. This results in increased overland flow of excess nutrients from land into the waterway.

Although spikes do occur, the concentrations of nitrogen at the headwaters are not in excess and concentrations presented here sit within the regional median values for Banks Peninsula Streams.

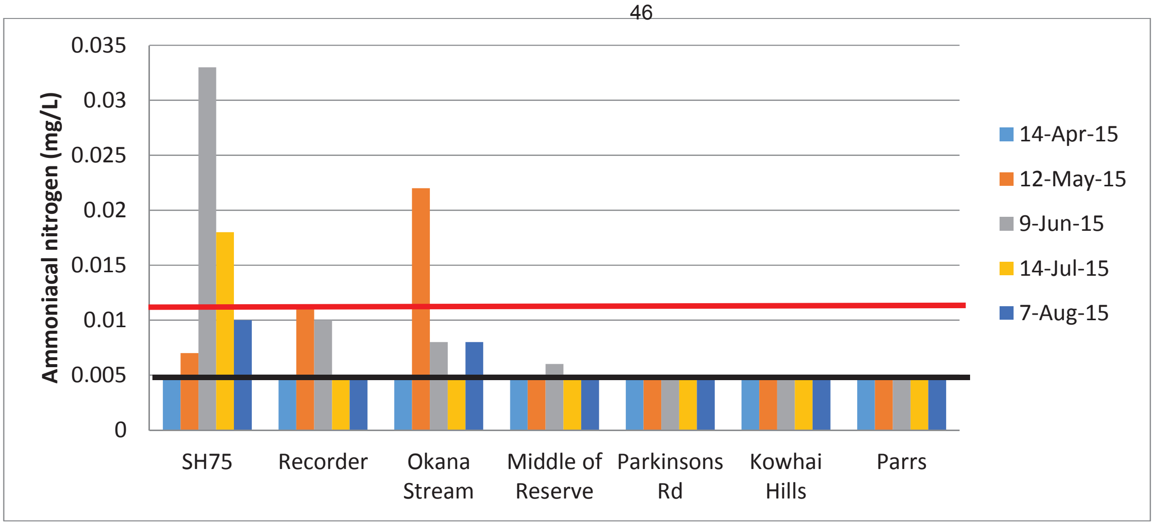


Figure 5. Ammoniacal Nitrogen concentrations in Kaituna River. Note the red line represents the regional median of 0.011 mg/L for Banks Peninsula streams: black line represents the lab detection limit (Robinson & Barbour, unpublished)

To investigate possible sources of nitrogen in the catchment, ammoniacal nitrogen was added into the sampling regime in April. There were questions raised in previous community meetings that old leaking septic tanks may have been influencing water quality in the Kaituna catchment.

Ammoniacal nitrogen (NH_4-N), also often called 'ammonium', covers two forms of nitrogen; ammonia (NH_3) and ammonium (NH_4). Ammoniacal nitrogen is a very important plant fertiliser but is less mobile in the soil than nitrate-nitrogen. It enters waterways primarily through point source discharges, such as raw sewage or dairy shed effluent. The concentration of ammoniacal nitrogen at the upper sites (Parkinsons, Kowhai and Parrs) rarely exceeded laboratory detection limits (Figure 5). These sites are relatively un-impacted and not subject to intensive land use. These results do not indicate any septic tank leakages, particularly in the upper catchment of Kaituna Valley.

Ammonia is toxic to aquatic life at high concentrations. These low concentrations suggest that ammonium toxicity is unlikely to affect biodiversity values in any of the study sites.

3.2 Suspended Solids

Total Suspended Solids (TSS) is a measure of the mass of particles suspended in the water column, such as eroded soil or plant matter. Suspended particles affect water clarity and under stable or reduced flow conditions can become deposited on the stream bed and smother benthic environments. Deposited sediment can smother habitats of stream invertebrate and fish, smother clean gravels essential for trout and salmon redds and native fish habitat, and act as a reservoir for bacteria and nutrients such as phosphorus and nitrogen that can be released under anoxic conditions. Excessive sedimentation allows the establishment of macrophytes beds, which then trap more sediment.

Sources of sediment include:

- bank erosion/instability
- earthworks
- vegetation/weed clearance
- cultivation
- stock trampling

This results in mobilisation of sediment from land into surface water, particularly after heavy rainfall.

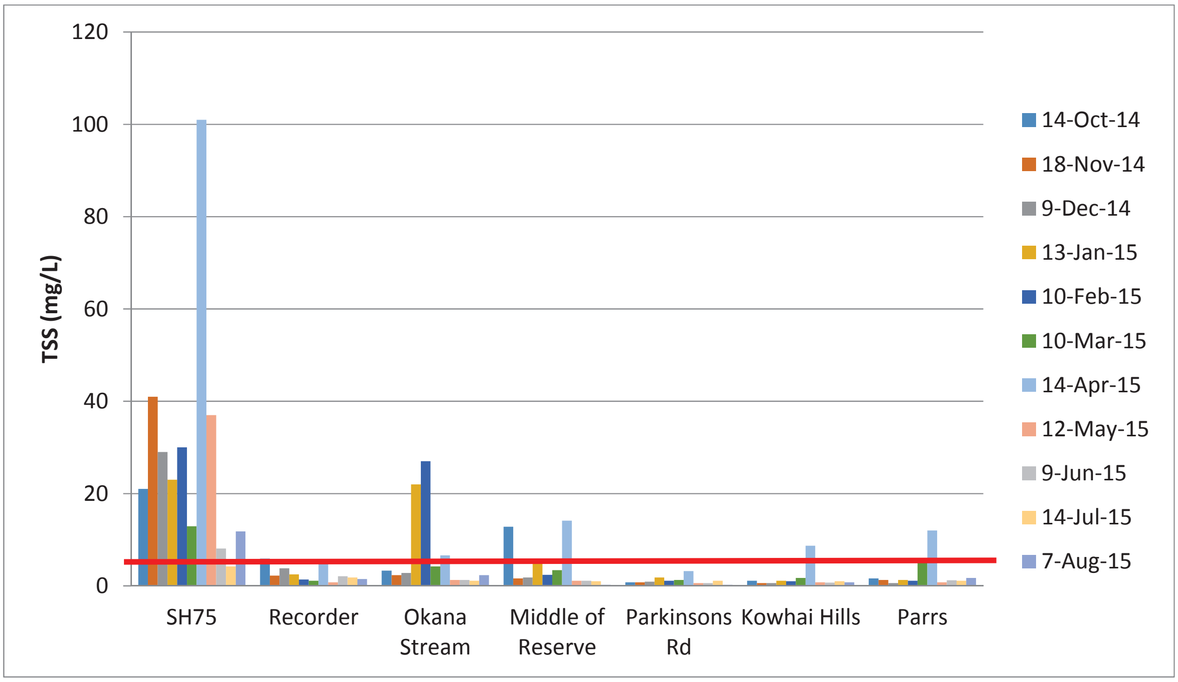


Figure 6. Total Suspended Solid concentrations in Kaituna River. Note the red line represents the regional median of 4 mg/L for Banks Peninsula streams (Robinson & Barbour, unpublished)

Elevated suspended sediments are observed at SH75. Okana Stream also had elevated concentrations in early 2015 (Figure 6). The high concentration of suspended sediment at SH75 is due to the influence of the lake water being pushed upstream. Lake Ellesmere has very high amounts of suspended sediment due to the lack of aquatic macrophytes which bind up the sediment, and to the winds which stir up the sediment from the bed of the lake, resuspending it in the water column. Hamill & Schallenberg (2013) reported that TSS was generally elevated in summer months (January- April) compared to winter months (May to August) which they attributed to the effects of resuspension of lake sediments due to stronger wind and lower water levels during summer.

The elevated concentrations in Okana Stream were most likely a result of bank erosion into the stream. It was noted on a number of sampling occasions that stock either had direct access or there was evidence of recent access. Stock trampling the banks reduces stability and so introducing sediment into the stream.

Middle of reserve site had earthworks up until May. Heavy rain during the April sampling possibly brought large loads of sediment into the stream from observed stock piles of soil on the river bank. This rainfall would have also caused sediment to be washed overland into the stream at the two upper sites.

Although there are areas of erosion along the banks of the Kaituna River, the results from this study have shown there to be low concentrations of suspended sediment in the water column. Sediment from high flows would be quickly washed downstream into the lake or settle out on the bed of the river and so not be detected in the results from monthly testing of the water column. The summer dry period and subsequent low flows resulted in most suspended sediment being deposited on the stream bed as there would have not been enough flow to flush it downstream. This is evident in visual observations of streambed sedimentation, particularly in the lower reaches. This can act as a reservoir for bacteria and nutrients that have the potential to be released into the water column under anoxic conditions or during wind driven re-suspension of bed sediment.

3.3 Faecal Contamination

The microbial quality of water is important to recreational water users and for drinking-water supplies for humans and livestock. Faecal coliforms are a group of bacteria that usually originate in the gut of warm-blooded animals (birds, mammals and humans) and are present in their faeces. The presence of faecal coliforms in water indicates recent contamination of the water with faecal material, and therefore, bacteria, viruses and other pathogenic (disease-causing) organisms may be present. *Escherichia coli (E. coli)* is a particular type of faecal coliform and is a more specific indicator of recent faecal contamination in freshwater.

For people the risk is highest when ingesting water, or when undertaking recreational activities that put them in direct contact with the water.
Sources of faecal contamination include:

- direct stock access to streams and along the margins
- diffuse surface water run-off containing faecal matter
- direct faecal contamination from large groups of waterfowl
- wastewater (e.g. septic tanks)
- stormwater discharges in urban areas containing animal waste

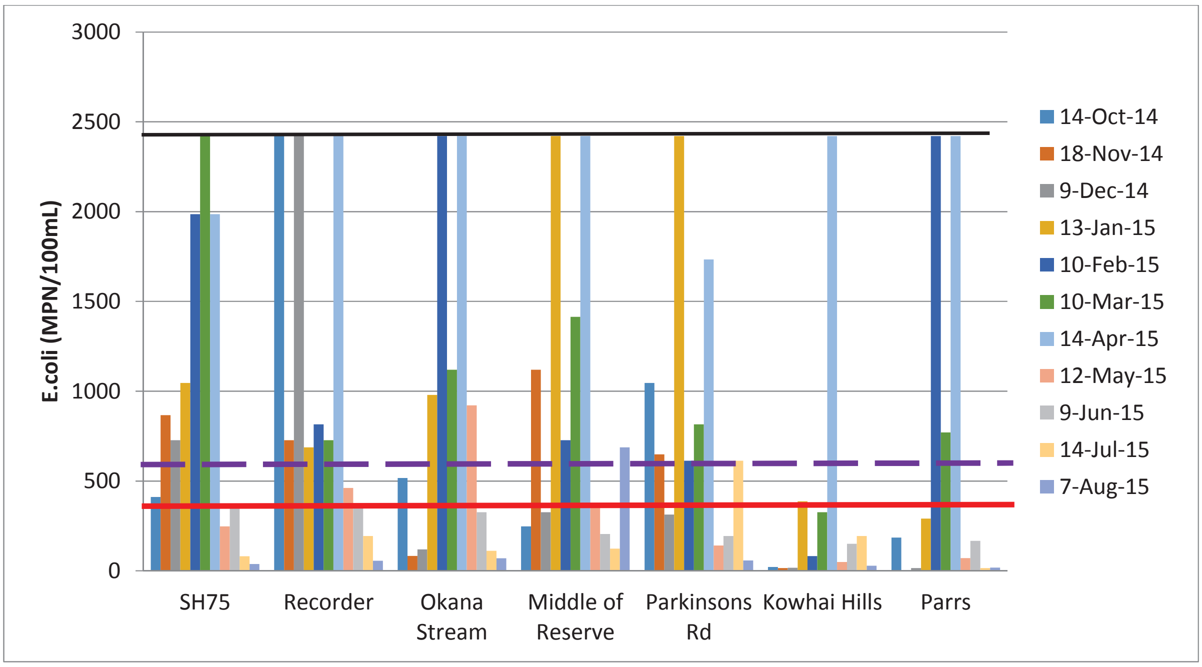


Figure 7. *E.coli* concentrations in Kaituna River. Note the red line represents the regional median of 387 MPN/100mL for Banks Peninsula streams: purple dashed line represents the guideline value of 550MPN/100mL for recreational water quality (MfE/MoH, 2003): black line represents the lab detection limit (Robinson & Barbour, unpublished)

Many of the sites have elevated *E.coli* concentrations, indicating there is a faecal contamination issue in this catchment (Figure 7). Many sites exceed the recommended guideline of 550MPN/100mL* for recreational water quality (MfE/MoH, 2003). Therefore full immersion recreational activities such as swimming can be considered a public health. As contamination is widespread throughout the river, there may be multiple sources of contamination, including livestock or waterfowl. Overland flow from paddocks can entrain faecal matter and associated bacteria, with the resulting drainage during rainfall/irrigation discharging into the stream. Sediment deposited on the stream bed can also entrain faecal matter and be re-suspended during high winds or flow events, re- introducing the bacteria into the water column.

In the upper catchment faecal contamination is generally low, however spikes do occur. These spikes indicate contamination events rather than a continuous seepage.

Summer of 2014/2015 has experienced high temperatures and little rainfall resulting in low river flows. These conditions could have exacerbated E.coli concentrations. Most sites exhibited a spike in April as a result of surface runoff during the rainfall event (this is mirrored in the TSS results, Figure 6).

* The Mfe/MoH recreational guidelines are based on the 95%ile of a dataset, whereby only 5% of the sample results can exceed the guideline. Therefore the guidelines presented on this graph are to give an indication of possible exceedances only.

4. Conclusions/Recommendations

In conclusion, this study provides a useful baseline record of current state in the Kaituna catchment. This study could be repeated after remediation works have been completed in order to determine any positive or negative effects on water quality.
Although suspended sediment concentrations are generally low, areas of benthic sedimentation are an issue. Therefore, pathways for sediment to the stream should be restricted, and available stream flow should not be impeded to allow for the flushing of sediment from the stream and minimise nutrient release from sediment to water. Efforts to limit numerous pathways of contaminants to waterways should also focus on smaller tributaries where stock have access, even when dry.
In order to improve Kaituna River, nutrient and sediment inputs to the stream should be managed to control undesirable ecosystem effects from macrophytes and sedimentation. Additionally, faecal contamination should be mitigated in an effort to improve microbiological water quality for recreation and mahinga kai resources.

References

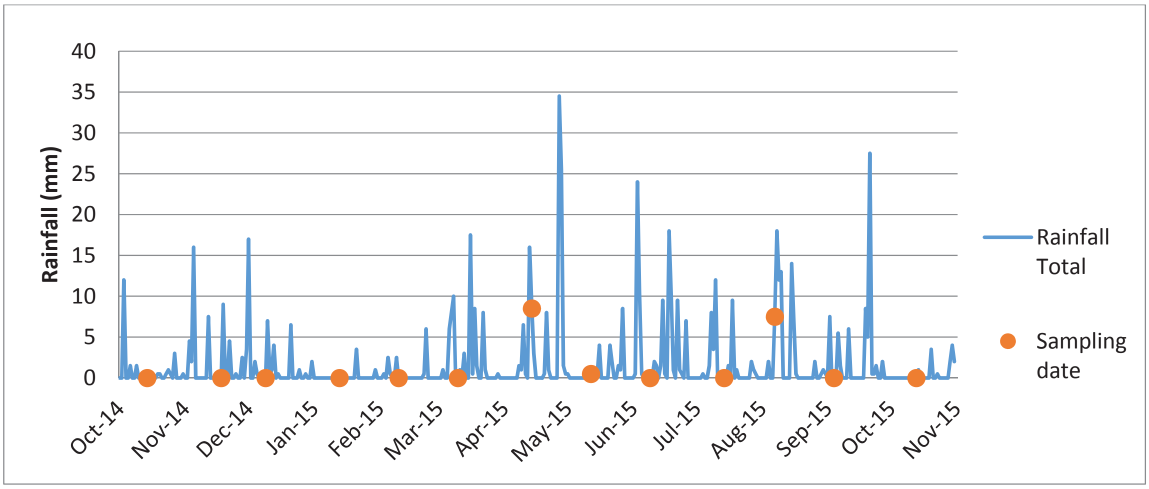
Hamill, K. & Schallenberg, M. (2013). Mechanisms that drive in-lake nutrient processing with Te Waihora/Lake Ellesmere: Inter-annual water quality variability. *River Lake Ltd report prepared for Environment Canterbury*.

Hickey, CW. (2013). Updating nitrate toxicity effects on freshwater aquatic species. *NIWA report prepared for the Ministry of Building, Innovation and Employment.*

Ministry for the Environment & Ministry of Health (MfE/MoH). (2003). Microbiological water quality guidelines for marine and freshwater recreational areas. *Ministry for the Environment, Wellington*.

Robinson & Barbour. (2016). An update of state and trends in surface water quality of Canterbury's rivers and streams. *Environment Canterbury Report unpublished.*

Appendix 1. Rainfall in Kaituna Valley at Recorder



This site is located in the lower reaches of Kaituna River and only gives a fair representation of the lower reaches. Rainfall may have been heavier at the top of the valley.