Waimakariri Zone water quality and ecology: State and trend

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Executive summary

Background

The National Policy Statement (NPS) for Freshwater Management (MfE, 2014) dictates that regional councils must set limits for water quality and water quantity in every catchment. To that end, Environment Canterbury is working with the Waimakariri Canterbury Water Management Strategy (CWMS) zone committee to set nutrient limits and develop a non-statutory framework that protects ecological health in the zones rivers and streams, while providing for the social and economic needs of the community. There is increasing competition for water and nutrient allocations to facilitate more intensive land use in some parts of the Waimakariri CWMS Zone. However, there is evidence to suggest that current land use is having a negative effect on water quality and aquatic ecosystem health in the zone, and these effects must be managed, particularly in lowland streams. In this report the current state of the zones waterways in terms of ecology and habitat values are summarised, and state and trends in water quality discussed. This report is not only intended to inform the zone committee of current state, but also of the key drivers of ecosystem health in the zone so that that these factors can be managed appropriately through the sub-regional planning process.

What was done

Available water quality and ecology data for the Waimakariri CWMS zone were collated, and the results compared with current regional plan limits and objectives, and established guideline values from the literature. Current state was assessed from data collected over the past five years and trend analyses were undertaken across the entire data set where more than five years of data were available.

What was found and what it means

Many of the rivers in the Waimakariri CWMS Zone, particularly spring-fed streams, exhibit unhealthy ecological communities, poor habitat conditions and degraded water quality. This condition reflects the high intensity land use in many parts of the zone. Without appropriate catchment scale management of nutrient losses and sediment inputs these impacted streams will continue to exhibit unhealthy aquatic communities.

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1 Introduction

Environment Canterbury is working with the Waimakariri Water Zone Committee to set nutrient limits and develop a non-statutory framework that protects ecological health in the zones rivers and streams, while providing for the social, cultural, and economic needs of the community. In this report the current state of the zones waterways in terms of ecology and habitat values are summarised, and state and trends in water quality discussed. This report is not only intended to inform the zone committee of current state, but also of the key drivers of ecosystem health in the zone so that that these factors can be managed appropriately through the sub-regional planning process.

The Waimakariri CWMS zone encompasses the area between the Waimakariri River and the northern most extent of the Ashley River catchment, and extends from the Puketeraki Range in the west to Pegasus bay in the east. The main river catchments in the zone are the Ashley River/Rakahuri catchment and the Kaiapoi River catchment (Figure 2-1).

The upper Ashley River flows through Lees Valley, and, along with its tributaries the Lillburn River, the Whistler River, the Townshend River, and Duck Creek drains the Puketeraki and Pancake ranges (Boyle and Surman, 2013). The Ashley River exits Lees valley by a deep narrow gorge, and then braids into two or more channels (Glova, 1988). Between the gorge and its confluence with its major tributary, the Okuku River, the Ashley is joined by the Glentui River, the Garry River, and Bullock Creek. Further downstream, the Ashley receives hill-fed and spring-fed flows from the Makerikeri River and spring-fed flows from Waikuku stream. The Ashley River terminates in Ashley Estuary, which also receives flow from two spring-fed streams, Taranaki Creek and Saltwater Creek.

The Kaiapoi River is a spring-fed stream that arises on the northern side of the Waimakariri River stop bank, approximately two kilometres east of where the Eyre Diversion discharges to the Waimakariri. The upper Kaiapoi River receives flow from the Eyre Main Drain and Englefield Stream before meeting the Cust River/Main Drain and Ohoka River at the three streams confluence, just west of Kaiapoi township. Although the Cust River receives some run off from the eastern faces of the hills between Ashley Gorge and Oxford township, and has a hill-fed form throughout its length (broad, gravel bed), including the channelized section of the lower river known as the Cust Main Drain, it is predominately a spring-fed river. The Ohoka River is also spring-fed and has a catchment that drains the area east of Mandeville North between Tram and Mill Roads. Below the three streams confluence, the Kaiapoi is met by the Cam River/ Ruataniwha, which receives spring-fed flows from the North, Middle and South Brooks. Downstream of the confluence with the Cam River the Kaiapoi River has a tidal influence.

The Waimakariri CWMS zone is significant to Ngāi Tahu as a mahinga kai resource. The Ashley River was the “food basket of Kaiapoi Pa”, and the lowland streams, such as the Cam River, were, and still are, very important whitebait fisheries: The Cust River and the Kaiapoi River are also important to the recreational fishery and contain valuable spawning habitat for brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*).

This report takes a top down approach in assessing the current state of the zones rivers and streams by first assessing ecological health, then considering how this is being impacted by various habitat and water quality parameters. The key habitat and water quality indicators assessed in this report are outlined in the following section.

1.1 Key drivers and indicators

1.1.1 Invertebrate health

The aquatic macroinvertebrate community is an important component of the stream ecosystem. Sensitivity to pollution and other physico-chemical stressors differs between macroinvertebrate taxa, thus the composition of the invertebrate community in a stream can provide valuable information about how the state and trends in water quality and habitat are impacting ecosystem function. Indices such as the Macroinvertebrate Community Index (MCI) and its derivative the Quantitative MCI (QMCI) can capture the macroinvertebrate community response to stressors such as organic material and nutrients.

Generally, the higher the QMCI score the better the water and habitat quality. Invertebrate communities with a QMCI score below 4 are indicative of poor water quality, communities with a score between 4 and 5 are indicative of fair water quality, communities with a score between 5 and 6 are indicative of good water quality, and communities with a score above 6 are indicative of excellent water quality (Stark and Maxted, 2007). When these grades were established the key concern of the time was point source discharges of agricultural, industrial and urban wastes, and the grades were used as indicators of the level of organic pollution. Nowadays, point source discharges are less common in Canterbury, and the predominant drivers of stream heath are diffuse nutrient discharges, habitat degradation and abstraction for irrigation. Consequently, when considering the drivers behind low QMCI scores consideration must be given to a range of habitat and water quality parameters, not just traditional metrics of pollution such as nutrient and toxicant concentrations. .

1.1.2 Habitat as a driver of ecosystem health

Periphyton and macrophyte coverage

Periphyton is an important component of the aquatic food web, but xcessive growths of periphyton can have a range of negative effects on aquatic ecosystems. Large standing crops of periphyton can smother stream-bed substrate, thereby reducing the amount of suitable habitat available for fish and invertebrates. High densities of periphyton can also cause large diurnal (daily) fluctuations in dissolved oxygen concentrations and pH. Biggs et al. (2000) recommended provisional guideline values of 15% and 30% long (>2 cm) filamentous algae cover for the protection of benthic biodiversity and trout habitat and angling values respectively.

Prolific macrophyte growths are also detrimental to ecosystem function. At high densities, macrophytes, like periphyton, can reduce habitat availability for fish and invertebrates. Large macrophyte stands also reduce stream hydraulic capacity, increase sediment deposition (Hearne and Armitage, 1993; Kaenel and Uehlinger, 1998) and alter daily oxygen patterns (Wilcock et al., 1999; Wilcock and Nagels, 2001). Due to a lack of empirical data, robust macrophyte cover and volume thresholds for the onset of detrimental effects on ecological condition, hydrology and aesthetics do not currently exist (Matheson et al., 2012). However, Matheson et al. (2012) recommended a provisional macrophyte volume guideline of less 50% of the channel for the protection of instream ecological condition, flow conveyance and recreation and a cover guideline of less than 50% for the protection of aesthetics and recreation.

How about a para explaining WCC?

Sedimentation

Deposited fine sediment has a range of negative effects on stream ecosystems. Excessive fine sediment deposition reduces food and benthic habitat availability to invertebrates (Kemp *et al.,* 2011) by smothering periphyton and macrophytes (Brookes, 1986; Graham, 1990; Ryan, 1991; Yamada and Nakamura, 2002) and infilling interstitial spaces (Walton, Reice and Andrews, 1977; Kemp *et al.,* 2011). In addition sediment deposition can affect benthic invertebrates by reducing dissolved oxygen near the substrate (Sear and DeVries, 2008). Consequently, benthic sediment cover is an important regulator of invertebrate communities. Indeed, Greenwood et al. (2012) found that sedimentation was the single most important predictor of invertebrate community composition in some Canterbury streams, and Burdon *et al.* (2013) determined that above 20% fine sediment cover invertebrate community health declines markedly.

The effects of sediment deposition on macroinvertebrates can alter food availability to the fish species that prey upon them (Wood and Armitage, 1999; Matthaei *et al.,* 2006), which can affect growth rates and community structure (Henley *et al*., 2000; Kemp *et al.,* 2011). Deposited sediment can also affect the reproductive performance of freshwater fish species. The availability of spawning habitat is a major determinant in the success or failure of fish populations, and large amounts of deposited sediment can have significant impacts on fish species that spawn in or on the bed substrate. Clapcott et al. (2011) recommended a guideline value of <20% fine sediment cover to protect stream biodiversity and fish (both native and exotic).

1.1.3 Water quality as an indirect driver of ecosystem health

Plant available nutrients

Dissolved inorganic nitrogen (DIN) is composed of nitrate-nitrite nitrogen (NNN), and ammoniacal nitrogen (NH_4N), and is the component of nitrogen that is readily available for plant uptake. As concentrations of DIN increase so too does the risk of nuisance periphyton growths in hill-fed systems and nuisance macrophyte growths in spring-fed systems. Dissolved reactive phosphorus (DRP) is the readily available component of phosphorus for plant uptake, and, as with DIN, the higher the DRP concentration the greater the risk of nuisance periphyton and macrophyte growths. Biggs (2000) developed an empirical relationship between periphyton growth and DIN and DRP concentrations to establish thresholds for the protection of benthic biodiversity and trout habitat and angling values from nuisance periphyton growths. Similarly, for the purpose of developing a Bayesian Belief Network model, Matheson et al. (2012) defined the DIN and DRP concentrations at which there is a 90%, 70% and 30% probability of nuisance macrophyte in spring-fed streams. There is, however, a high level of uncertainty around these thresholds as nutrient availability is just one of a number of factors that influence macrophyte growth. Light availability, flow conditions and rooting substrate also have a strong influence over macrophyte densities and growth rates.

The response of benthic cyanobacteria (blue-green algae), such as *Phormidium*, to nutrient enrichment has been investigated recently in New Zealand. Sustained low flows and high water temperatures are thought to be key drivers in cyanobacteria blooms (Heath et al., 2011; Quiblier et al., 2013), and Wood and Young (2012) and Heath *et al.* (2011) found a positive relationship between cyanobacteria coverage and high ratios of total nitrogen to total phosphorus.

Suspended solids

At high concentrations, suspended sediments can have a range of direct and indirect negative ecological effects. Physical abrasion and reduced light penetration at high suspended sediment concentrations can reduce periphyton and macrophyte abundance (Bruton, 1985; Van Nieuwenhuyse and LaPerriere, 1986; Graham, 1990; Davies-Colley et al., 1992), thereby limiting food availability to macroinvertebrates (Henley et al., 2000; Kemp et al., 2011). This, combined with increased drift as invertebrates are dislodged by sediment, can reduce abundance (Quinn et al., 1992; Wood and Armitage, 1999; Kemp et al., 2011). Fish can also be impacted by high suspended sediment concentrations by reduced recruitment of migrating juveniles, clogged gills, reduced feeding performance, and reduced food availability (Boubée et al., 1997; Greer et al., 2015a; Kemp et al., 2011; Lake and Hinch, 1999; Rowe and Dean, 1998; Sutherland and Meyer, 2007). Total suspended solids (TSS) is the measure of the mass concentration of sediments suspended in the water column used in this report.

1.1.4 Water quality as an direct driver of ecosystem health

Toxicity

In addition to promoting plant growth, high concentrations of nitrate nitrogen and ammonia can be toxic to aquatic fauna. Nitrate is toxic to invertebrates and fish in high concentrations, as it interferes with oxygen transport in the blood, and consequently, metabolic function (Camargo and Alonso, 2006). In humans this effect is known as methemoglobinemia, and is often referred to as blue baby syndrome, due to the cyanosis (blue skin colouration) commonly observed in affected children (Knobeloch et al., 2000). Susceptibility to nitrate toxicity varies between species and even different life stages of a particular species (Camargo and Alonso, 2006). Ammonia toxicity occurs when accumulations inside the body interfere with metabolic processes and increase body pH (Camargo and Alonso, 2006; Randall and Tsui, 2002). Fish are particularly susceptible to ammonia toxicity and elevated levels can cause a loss of equilibrium, increased respiration, and increased heart rate (Camargo and Alonso, 2006; Randall and Tsui, 2002). When exposed to extreme concentrations of ammonia, fish go into convulsions followed by coma, and death (Randall and Tsui, 2002). As with nitrate, susceptibility to ammonia toxicity is species and life stage dependent (Randall and Tsui, 2002).

1.1.5 Water quality and plants as a determinant of recreation value

Faecal contamination

Faecal matter can contain a range of bacteria, viruses and other pathogens that may present a risk to the health of people and animals. For people, the risk is highest when ingesting water, or when undertaking recreational activities that put them in direct contact with the water. *Escherichia coli i*s the bacteria commonly used in New Zealand to indicate the degree to which a freshwater body has been recently contaminated by faecal matter. Higher *E. coli* concentrations indicate a higher risk of illness to water users, due to established relationships *with E. coli* counts, and pathogens, bacteria and viruses.

Toxic cyanobacteria

Benthic cyanobacteria such as *Phormidium* can have a range of deleterious impacts on stream values. It produces toxins that cause detrimental health effects including nausea, skin rashes and abdominal pain, cramps and diarrhoea. Dogs are particularly susceptible to the toxins produced, with death occurring in as little as 30 minutes in some cases (Wood et al., 2007). Cyanobacteria can also produce odorous compounds that taint fish flesh, making it unpalatable.

Figure 1-1 Typical *Phormidium* bloom on the surface of a cobble

2 Methods

2.1 Data sources

This assessment incorporates invertebrate data collected as part of Environment Canterbury's Aquatic Ecosystem Health (AEH) programme. For this programme, Environment Canterbury conducts annual monitoring of macroinvertebrate communities and habitat quality at a large number of sites thoughout Canterbury, in order to monitor the health of aquatic ecosystems in wadeable rivers and streams in the region (Meredith et al., 2003). The programme is conducted across a range of river types with different catchment land use, source of flow, vegetation types and geographical spread, and fortunately there are 20 AEH sites in the Waimakariri CWMS zone that have been sampled in the last five years (Table 2-1 and Figure 2-1). Briefly, each site is visited annually between spring and early summer and a composite kick net invertebrate sample is collected. Invertebrates are then identified and counted by Environment Canterbury staff to calculate a QMCI score for the site which can be compared with the freshwater outcomes set out in the Land and Water Regional Plan (LWRP).

Data related to fish distributions were accessed through the New Zealand Freshwater Fish Database (NZFFD). The NZFFD is maintained by NIWA and provides a depository in which researchers and members of the public can record data pertaining to fish sampling. The database provides information about the location of previously sampled areas, the physical condition of sampled sites, the fish species present and their abundance. The database does not provide definitive presence absence data, in that if a species is not recorded, this does not mean that it is not present. However, in well sampled areas, such as the Waimakariri CWMS zone, the NZFFD does provide an indicative range of the species present. Fish are naturally transient which makes them ill-suited to use as a biological indicator of stream health compared to metrics such as invertebrate community structure and plant cover. Consequently, native fish distributions are not treated as a key indicator of ecological health in this report, and no attempt was made to collate fish records not entered on the NZFFD as it was considered that there would be little benefit in collecting these data.

Inanga (*Galaxias maculatus*) are a culturally and recreationally important species of native galaxiid, the juveniles of which make up a large proportion of the whitebait catch (McDowall, 1990). The complex life cycle of inanga has put them under pressure from multiple sources, and the species is now classified as "declining". Overall, the biggest threat to the species is considered to be the destruction and restriction of spawning habitats (Hickford and Schiel, 2011). Information relating to inanga spawning habitat in the Waimakariri CWMS zone was sourced from a recent Environment Canterbury technical report (Greer et al., 2015b) in which potential inanga spawning habitat in Canterbury's rivers was modelled and mapped (Greer et al., 2015b), and the schedule of known inanga spawning sites presented in the notified version of Plan Change 4 of the LWRP.

Periphyton, macrophyte, cyanobacteria and fine sediment cover data were sourced from Environment Canterbury's State of the Environment (SoE) water quality monitoring programme and targeted investigations designed to fill knowledge gaps about water quality in the zone. As part of these programmes, Environment Canterbury staff made monthly or quarterly observations of these parameters at each site. Prior to July 2015 staff would make an estimate of the percentage of the visible stream bed covered by each of the aforementioned plants, or fine sediment from the stream bank. Since July 2015 a more quantitative approach has been employed. At each site the bed of a 25 to 30m long representative reach is surveyed using a stream viewer to determine the percentage of the visible bed covered by plants and fine sediment. The survey is carried out in such a way that all points within the representative reach are within three metres of an area of bed that has been viewed by the surveyor.

Water quality data (i.e. temperature, and concentrations of dissolved oxygen, nutrients,, faecal contaminants, and total suspended solids) were also sourced from Environment Canterbury's SoE programme, and targeted investigations designed to fill knowledge gaps about water quality in the zone. Not all sites have had data collected for the same length of time, or at the same frequency. Table 2-1 provides a summary of where water quality data are available, how long sites have been monitored for, and how frequently monitoring has been conducted. Figure 2-1 depicts the where sites are located in the Waimakariri CWMS Zone.

Environment Canterbury also conducts weekly *E.coli* and cyanobacteria monitoring at popular bathing sites over summer to determine their suitability for contact recreation. Although these data were not used in the body of this report, as frequent monitoring of one season biases results, they are presented in Appendix 2 and referred to where necessary.

Flow data used in trend analysis were provided by the Environment Canterbury hydrology team. Simultaneous gauging data were used to derive relationships between flows at study sites without long-term flow records and the Environment Canterbury's flow recorders on the Cam, Cust, and Ashley rivers and Fox Creek. Synthetic flow records were created using these relationships where appropriate. Sites where a long-term flow record exists or can be synthesised from a nearby flow reorder are listed below.

- Ashley River at Ashley Gorge Road
- Ashley River at SH1
- Waikuku Stream at SH1
- Cam River at Bramleys Road
- North Brook at Marsh Road
- Cust River at Skewbridge Road
- Ohoka River at Island Road
- Kaiapoi River at Island Road

Table 2-1 Water quality and AEH monitoring sites in the Waimakariri CWMS zone

Site ID	Site	NZTMX	NZTMY	Catchment	River type	Since	Monitored	Invert data
SQ30184	Ashley River @ Ashley Gorge Rd	1537355	5213583	Ashley River	Hill-fed lower	2004	Quarterly	Yes
SQ36040	Ashley River 2km u/s of Okuku confl.	1554530	5211021			2014	Monthly	Yes
SQ30179	Ashley River @ Rangiora/Loburn Rd	1566099	5207809			2007	Sporadically	Yes
SQ30175	Ashley River @ SH1	1574736	5208399			1992	Quarterly	Yes
SQ36034	Glentui River @ Ashley Gorge Road	1542320	5213970			2014	Monthly	Yes
SQ36033	Garry River @ Garrymere Road	1550274	5210855			2014	Monthly	Yes
SQ30231	Bullock Creek @ Birch Hill Rd	1553789	5211670			2014	Monthly	Yes
SQ36032	Grey River @ Mt Grey Road	1558434	5220058			2014	Monthly	Yes
SQ30229	Grey River @ Whiterock Rd	1556839	5216926			2014	Monthly	Yes
SQ36039	Okuku River near Fox Peak recorder	1551030	5222598			2014	Monthly	Yes
SQ30226	Okuku River @ Birch Hill Rd	1556815	5211589			2014	Monthly	Yes
SQ36031	Makerikeri River @ Dixons Road	1563540	5209604			2014	Monthly	No
SQ00028	Saltwater Creek @ Toppings Rd	1573142	5210689		Spring-fed plains	1999	Annually	Only
SQ34646	Saltwater Creek @ Factory Rd	1574730	5210832			2004	Quarterly	Yes
SQ30215	Taranaki Creek @ Gressons Rd	1570981	5205254			2000	Quarterly	Yes
SQ34191	Taranaki Creek @ Preeces Rd	1574757	5205291			2000	Quarterly	Yes
SQ30211	Taranaki Creek @ Kings Ave	1576655	5207858			2000	Sporadically	Yes
SQ30222	Waikuku Stream @ SH1	1574465	5206975			2000	Quarterly	Yes
SQ30221	Waikuku Stream above Ashley confl.	1575792	5208066			2014	Monthly	No
SQ32943	Kaiapoi River @ Harpers Road	1564806	5191961	Kaiapoi River	Spring-fed plains	2006	Sporadically,	Yes
SQ30340	Kaiapoi River @ Heywards Rd	1566309	5193008			2006	Sporadically,	Yes
SQ30332	Kaiapoi River @ Island Rd	1570316	5197413			1999	Monthly	Yes
SQ30406	Cust River @ Tippings Rd	1547647	5205419			1999	Annually	Only
SQ30400	Cust River @ Skewbridge Rd	1569938	5197879			1999	1/4ly	Yes
SQ00027	Ohoka River @ Bradley's Rd	1565253	5199080			1999	Annually	Only
SQ30426	Ohoka River @ Island Rd	1570219	5197465			1999	quarterly	No
SQ34905	Cam River @ Marsh Rd	1570017	5203344			2006	1/4terly	No
SQ30369	Cam River @ Bramleys Road	1570577	5200988			1999	1/4terly	Yes
SQ34903	North Brook @ Marsh Rd	1569444	5203314			2005	quarterly	No
SQ30390	South Brook @ Marsh Rd	1567756	5203007			2006	1/4terly	Yes

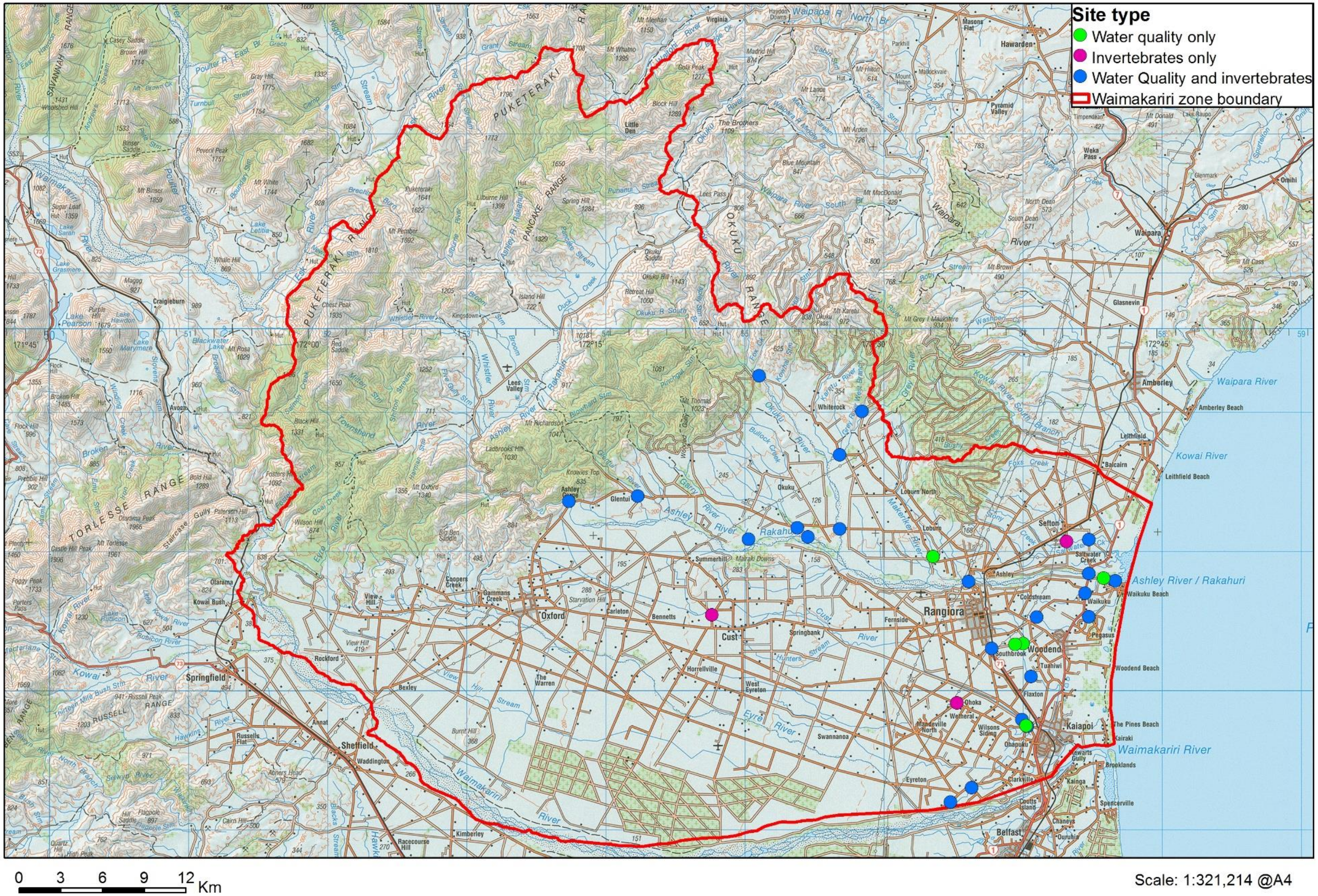

Figure 2-1 Map of the Waimakariri CWMS zone and the location of monitoring sites

2.2 Analysis

The current state of ecosystem health, habitat and water quality at each monitoring site was assessed using data from the past five water years (July to June, 2011-2016). Five years is the minimum length of time to assess normal state in sites that are sampled on a quarterly basis. In some sites there is only two years of data available, and the decision to include these sites in this assessment was made based on the high sampling frequency at these sites (monthly) and the fact that their exclusion would result in a large area of the Ashley River catchment going unassessed. Nevertheless these data were collected during a period of drought, and may reflect a worse case situation rather than normal state.

2.2.1 Current state of invertebrate communities

Yearly minimum QMCI results have been compared to the LWRP QMCI Table 1a outcomes for each river type (Table 2-2). The rationale for the selection of these objectives is covered in Hayward *et al.* (2009).

2.2.2 Current state of cyanobacteria, periphyton and macrophyte coverage

The LWRP sets river-type specific outcomes for long filamentous periphyton, total macrophyte, emergent macrophyte and benthic cyanobacteria coverage (Table 2-2). A description of how these outcomes were set can be found in Hayward *et al.* (2009). Briefly these outcomes were developed for the maintenance of aesthetic, recreational and ecosystem values.

In this assessment, annual maximums of recorded observations of long filamentous periphyton cover and benthic cyanobacteria cover at each site were compared against the freshwater outcomes set out in the LWRP, the periphyton guidelines presented in Biggs (2000) and the cyanobacteria guidelines presented in Mfe/MoH (2009). The provisional macrophyte guidelines presented in Matheson et al. (2012) for the protection of ecosystem condition refer to macrophyte volume, which is currently not measured by Environment Canterbury. As such, annual maximums of total and emergent macrophyte cover since July 2011 were only compared with relevant LWRP outcomes. The use of agrichemicals and mechanical excavators to intentionally remove macrophytes that pose a threat to drainage means that coverage in some waterways may have been underestimated.

2.2.3 Current degree of bed sedimentation

Box and whisker plots were used to present the distribution of fine sediment cover values recorded at each site over the past five water years. The box and whisker plots depict the median, the 10^{th}, 25^{th}, 75^{th} and 90^{th} percentiles of recorded values. Figure 2-2 describes how these box and whisker graphs should be interpreted. The distribution of fine sediment cover values recorded at each site were compared to the guideline value of 20% cover designed to protect stream biodiversity and fish (Clapcott et al., 2011). Annual maximum values recorded at each site since July 2011 were also compared against the freshwater outcomes set out in the LWRP (Table 2-2).

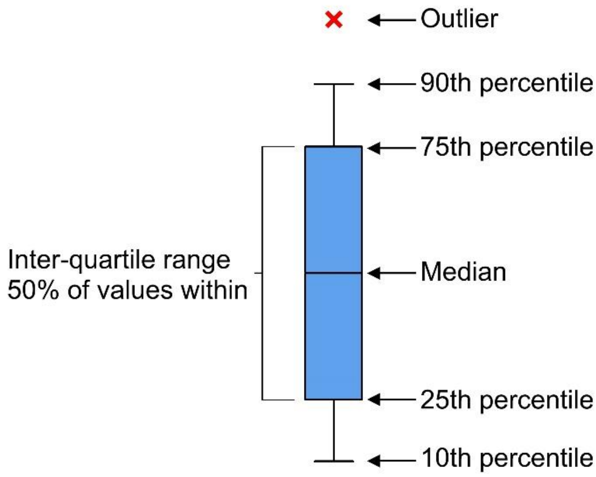

Figure 2-2 Box and whisker plot interpretation

2.2.4 Current state and trends in dissolved oxygen (DO) and temperature

Annual minimums of recorded DO saturations and annual maximums of recorded temperatures at each site were compared to the LWRP table 1a outcomes for these parameters (Table 2-2). The rationale for the selection of these objectives is covered in Hayward et al. (2009). Temperature and dissolved oxygen can fluctuate dramatically between and within days. Therefore, the single monthly measurements of temperature and DO saturation presented in this report are not representative samples and can only be used to identify where outcomes have definitely been breached. That recorded observations of DO and temperature do not exceed LWRP outcomes does not mean that these thresholds are not regularly being breached at a site.

Table 2-2 Summary of relevant LWRP Table 1a outcomes for the assessed river types

	Ecological health			Macrophytes		Periphyton			Siltation
River type	QMCI (Min)	DO (min sat. %)	Temp. (Max °C)	Emergent (max cover %)	Total (Max cover %)	Chl *a* (max mg/m²)	Filamentous algae >20 mm (max cover %)	Cyanobacteria mat (max cover %)	Fine sediment (max cover %)
Hill-fed lower	6	90	20	N/A	N/A	200	30	50	15
Spring-fed plains	5	70	20	30	50	30	50	50	20

2.2.5 State and trends in nutrient concentrations in terms of plant growth and toxicity

State

Box and whisker plots were used to present the distribution of DIN and DRP concentrations recorded at each site since July 2011. Comparisons of the median values of those nutrients with established thresholds for periphyton and macrophyte growth allowed for a relative assessment of risk of nuisance plant growths. For hill-fed rivers, all of which are in the Ashley River catchment, the results have been compared to guidelines set to protect benthic biodiversity and trout habitat and angling values from nuisance periphyton growths in rivers with a 30 day accrual period (Biggs, 2000). This accrual period was decided based on the information presented in Boyle and Surman (2013), who reported that there are, on average, 10 flood events a year in the Ashley River of sufficient magnitude to mobilise bed substrate and periphyton. DIN and DRP concentrations in spring-fed streams were compared to the thresholds at which there is a 90%, 70% and 30% probability of nuisance macrophyte growths (Matheson et al., 2012). As previously stated there is a high level of uncertainty around these thresholds

Box and whisker plots were also used compare nitrate-nitrite nitrogen (NNN) (Table 2-3) and total ammoniacal nitrogen (NH_4N) concentrations (Table 2-2) at each site with guidelines designed to prevent chronic nitrate and ammonia toxicity (Hickey, 2014, 2013). In line with recommendations in Hickey (2013), these are presented as median values, 95th percentiles (NNN) and maximums (NH_4N). However, as 95th percentiles and maximum values are not depicted in the box and whisker plots, these are presented in the narrative. NNN concentrations have been used, as nitrate nitrogen results were not collected, and the proportion of nitrite nitrogen in the oxygenated waters across Canterbury tends to be very low (Stevenson et al., 2010)

Table 2-3 Thresholds for the protection of biodiversity from nitrate toxicity (Hickey, 2013) and the NPS (2014) bands for nitrate toxicity

Protection level for biodiversity	NPS (2014) band	Median NNN concentration*	95th percentile NNN concentration
99%	A	<1 mg/L	<1.5
95%	B	<2.4 mg/L	<3.5
90%		<3.8 mg/L	<5.6
80%	C	<6.9 mg/L	<9.8
<80%	D	>6.9 mg/L	>9.8

Table 2-4 Thresholds for the protection of biodiversity from ammonia toxicity (Hickey, 2014) and the NPS (2014) bands for ammonia toxicity

Protection level for biodiversity	NPS (2014) band*	Median NH_4N concentration	Maximum NH_4N concentration
99%	A	<0.03 mg/L	<0.05
95%	B	<0.24 mg/L	<0.40
80%	C	<1.3 mg/L	<2.20
<80%	D	>1.3 mg/L	>2.20

*ammonia biodiversity protection thresholds and NPS (2014) attribute state boundaries calculated at pH 8 and 20˚C. Site specific boundaries not calculated

Trends

Trends in DIN, DRP, NH_4N and NNN were analysed using the non-parametric Seasonal Kendall test in the Time Trends software package (version 5.0). Where flow data were available, flow adjustment was applied using LOWESS smoothing (30% span). Both unadjusted and flow adjusted values are presented in this report, but where available flow adjusted trends are the primary focus of the narrative. All trend statistics are reported at the 95% confidence level (P<0.05), and trends are reported as environmentally meaningful when the Relative Sen Slope Estimator [RSSE (median annual Sen slope divided by median result)] indicates an annual change of more than 1% per year. These same categories have been used extensively when analysing trends in water quality data (e.g., Ballantine and Davies-Colley, 2009; Stevenson et al., 2010). When the concentrations of the analysed 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 upper value limits the results were given a value equal to the upper value limit.

2.2.6 Current state and trends in total suspended solids concentrations

State

Box and whisker plots were used to present the distribution of total suspended solids (TSS) concentrations recorded at each site. The median TSS concentrations were compared with the commonly cited threshold of 25 mg/L for the onset of detrimental effects (APEM, 2007; Rowe et al., 2003; Singleton, 2001). TSS can change significantly with flow, and the available data does not allow for definitive conclusions regarding the effects of suspended sediment in the Waimakariri CWMS zone.

Trends

Trends in TSS concentrations were analysed using the same methodology as was used to analyse nutrient data.

2.2.7 Current state and trends in faecal contamination

State

Box and whisker plots were used to compare the distribution of *E.coli* levels recorded at each site with MfE/MoH (2003) alert [550 most probable number per 100 mL (MPN/100mL)] and action (260 MPN/100mL) levels.

Trends

Trends in *E.coli* were analysed using the same methodology as was used to analyse nutrient data.

2.2.8 Comparison with National Policy Statement (2014) attribute states

The National Policy Statement for Freshwater Management (NPS) was released in July 2014, and contains a number of national water quality objectives and policies. The NPS also includes a number of water quality attribute (or parameter) tables, which are designed to help guide decisions related to the protection of particular values. Water quality sites in the Waimakariri CWMS zone that are currently monitored (as of June 2016) were compared against the NPS attribute state categories.

3 Results

3.1 Ashley River catchment - hill-fed streams

3.1.1 Ecology and habitat

Invertebrates

Long-term invertebrate data exists for three hill-fed sites in the Ashley River catchment; Ashley River at Ashley Gorge Road, Ashley River a SH1 and Grey River at Mt Grey Road. Of these sites the Ashley River at SH1 has met LWRP outcomes most frequently since 2011. Invertebrate community composition at this site was indicative of excellent water quality (QMCI >6) between 2011 and 2013 (Stark and Maxted, 2007). However, LWRP QMCI outcomes were not met in the 2014 and 2015 water years, during which time invertebrate community composition was indicative of poor water quality (QMCI <4). In contrast to the patterns observed at the SH1 site, the invertebrate community in the Ashley River at Ashley Gorge Road was healthiest in 2014 and 2015, and these were the only years on which QMCI scores at the site met LWRP outcomes and signalled excellent water quality (Stark and Maxted, 2007). Between 2011 and 2013 invertebrate community composition at the Ashley Gorge site was indicative of only poor to fair water quality. LWRP QMCI outcomes have only been met once in the past five years in the Grey River at Mt Grey Road. In 2012 the QMCI score recorded at the site was 6, which suggests that water quality was excellent at this time. However, on all other years QMCI scores have ranged between 2.7 and 5.3 and are indicative of only poor to good water quality.

Only one year (2015) of invertebrate sampling was conducted in the remaining hill-fed sites in the Ashley River catchment. These data, therefore, cannot be used to make categorical conclusions about the state or drivers of ecological health at these sites, especially considering that sampling was conducted during a significant drought. Four sites, Okuku River at Birch Hill Road, Ashley River two km upstream of the Okuku confluence, Garry River at Garrymere Road and Glentui River at Ashley Gorge Road, met the LWRP QMCI outcomes in 2015, and invertebrate community composition at these sites was indicative of excellent water quality [QMCI >6 (Stark and Maxted, 2007)]. Invertebrate communities at the remaining sites did not meet the LWRP QMCI outcomes in 2015, and were indicative of only poor to good water quality (Stark and Maxted, 2007).

Table 3-1 Minimum QMCI scores recorded in hill-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Ashley River @ Ashley Gorge Rd	6	4.2	4.3	3.7	6.9	6.3	5.1
Ashley River 2km u/s of Okuku confl.		N/A	N/A	N/A	N/A	6.8	6.8
Ashley River @ Rangiora/Loburn Rd		N/A	N/A	N/A	N/A	6.4	6.4
Ashley River @ SH1		6.3	7.4	7.4	2.0	3.7	5.4
Glentui River @ Ashley Gorge Rd		N/A	N/A	N/A	N/A	6.2	6.2
Garry River @ Garrymere Rd		N/A	N/A	N/A	N/A	6.0	6.0
Bullock Creek @ Birch Hill Rd		N/A	N/A	N/A	N/A	2.6	2.6
Grey River @ Mt Grey Rd		5.7	6.0	4.8	2.5	5.3	4.9
Grey River @ Whiterock Rd		N/A	N/A	N/A	N/A	3.3	3.3
Okuku River near Fox Peak recorder		N/A	N/A	N/A	N/A	5.6	5.6
Okuku River @ Birch Hill Rd		N/A	N/A	N/A	N/A	6.3	6.3

Fish

Native species found in the Upper Ashley River catchment (ie Hill fed streams) between 2000 and 2016 were shortfin eel (*Anguilla australis*), longfin eel (*A. diefenbachii*), upland bully (*Gobiomorphus* *breviceps*), torrentfish (*Cheimarrichthys fosteri*) and Canterbury galaxias (*Galaxias vulgaris*). Of these species Canterbury galaxias, torrentfish, and longfin eels all have an "At Risk - Declining" conservation status (Goodman et al., 2014). Brown trout is the only introduced species recorded in the upper Ashley catchment since 2000.

Periphyton and cyanobacteria

With the exception of at the Ashley River at Ashley Gorge Road and Ashley River at SH1 sites, regular periphyton monitoring has only been conducted in hill-fed rivers in the Ashley River catchment since 2014. Nevertheless, given the drought over this period, these data still provide valuable insight into periphyton communities at these sites.

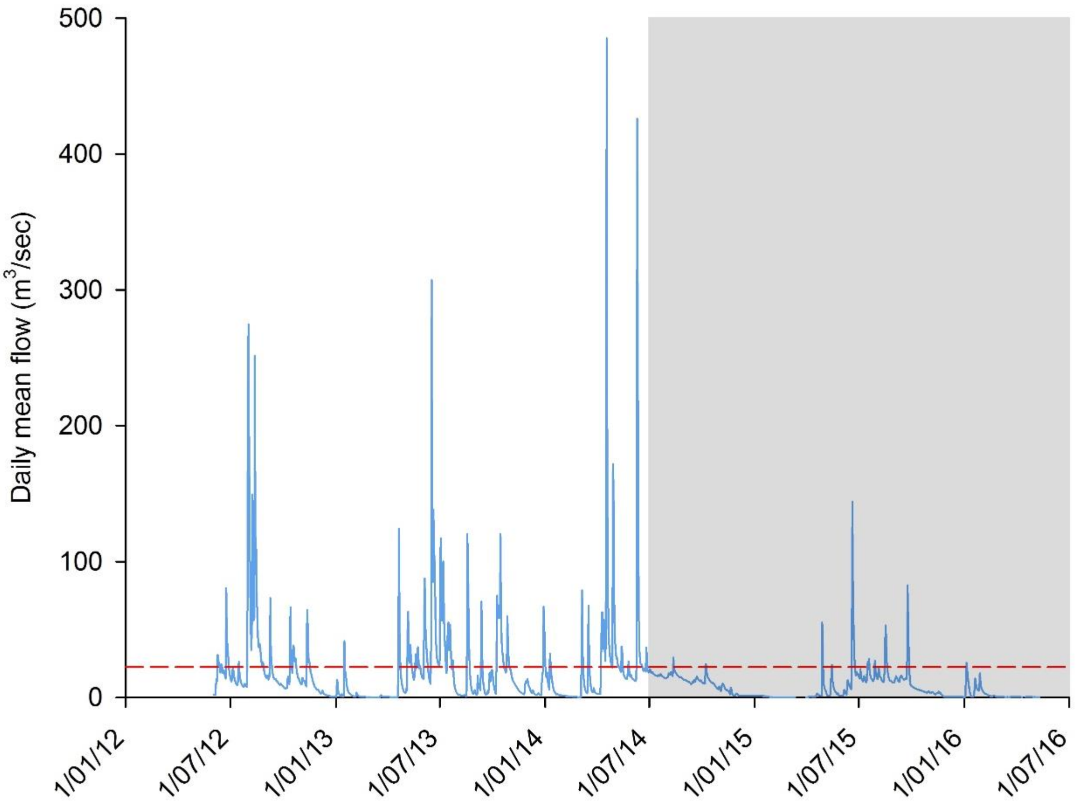

Figure 3-1 Mean daily flows in the Ashley River at SH1. The shaded area represents the period which periphyton monitoring in ten of twelve sites was limited to. The red line represents the flow required to reset periphyton accrual.

Flow data from the Ashley River at SH1 recorder sites suggests that since July 2014, the frequency and magnitude of flood events larger than three times the median flow (the required flow to reset periphyton accrual (Biggs, 2000) has been markedly lower than normal in the Ashley River catchment (Figure 3-1). Despite the higher than normal potential for periphyton accrual since 2014, only four sites failed to meet LWRP periphyton outcomes over this time (Table 3-2). Furthermore, exceedances of LWRP outcomes at two sites (Okuku River near Fox Peak Recorder and Makerikeri River at Dixons Road) were minor considering the hydrological conditions during the monitoring period (Figure 3-1). In seven of the eight sites that did not breach LWRP periphyton outcomes, mean annual maximum filamentous periphyton cover was below the threshold recommended by Biggs (2000) for the protection of benthic biodiversity (15%). Overall the limited available data suggests, that with the exception of Bullock Creek and the lower Grey River where recorded periphyton cover exceeded 70% and 90% respectively (Table 3-2), periphyton cover in hill-fed rivers in the Ashley River catchment is generally low and unlikely to contribute to degraded invertebrate communities in many of these rivers.

Table 3-2 Maximum long filamentous periphyton cover (%) recorded in hill-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Ashley River @ Ashley Gorge Rd		20	15	5	5	10	11
Ashley River 2km u/s of Okuku confl.		N/A	N/A	N/A	30	1	16
Ashley River @ Rangiora/Loburn Rd		N/A	N/A	N/A	5	0	3
Ashley River @ SH1		30	0	25	2	5	12
Glentui River @ Ashley Gorge Rd		N/A	N/A	N/A	2	10	6
Garry River @ Garrymere Rd		N/A	N/A	N/A	2	15	9
Bullock Creek @ Birch Hill Rd	**30**	N/A	N/A	N/A	40	73	57
Grey River @ Mt Grey Road		N/A	N/A	N/A	20	5	13
Grey River @ Whiterock Rd		N/A	N/A	N/A	90	15	53
Okuku River near Fox Peak recorder		N/A	N/A	N/A	10	35	23
Okuku River @ Birch Hill Rd		N/A	N/A	N/A	10	10	10
Makerikeri River @ Dixons Rd		N/A	N/A	N/A	10	45	28

From Environment Canterbury's SoE data, cyanobacteria does not appear to be a health risk in hill-fed rivers in the Ashley River catchment. Both the LWRP outcome for benthic cyanobacteria (50% cover) and the MfE and MoH (2009) alert guideline (20% cover) were only breached at one site (Grey River at Mt Grey Road) on one occasion (Table 3-3). However, Environment Canterbury's targeted contact recreation monitoring indicates that since 2010 cyanobacteria has regularly posed a health risk in the Ashley River at Rangiora/Loburn Road and SH1 (Appendix 2)

Table 3-3 Maximum cyanobacterial mat cover (%) recorded in hill-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Ashley River @ Ashley Gorge Rd		1	2	15	5	5	6
Ashley River 2km u/s of Okuku confl.		N/A	N/A	N/A	5	10	8
Ashley River @ Rangiora/Loburn Rd		N/A	N/A	N/A	20	15	18
Ashley River @ SH1		N/A	0	5	10	10	6
Glentui River @ Ashley Gorge Road		N/A	N/A	N/A	1	5	3
Garry River @ Garrymere Road	**50**	N/A	N/A	N/A	2	15	9
Bullock Creek @ Birch Hill Rd		N/A	N/A	N/A	0	3	2
Grey River @ Mt Grey Road		N/A	N/A	N/A	0	60	30
Grey River @ Whiterock Rd		N/A	N/A	N/A	3	10	7
Okuku River near Fox Peak recorder		N/A	N/A	N/A	0	5	3
Okuku River @ Birch Hill Rd		N/A	N/A	N/A	10	15	13
Makerikeri River @ Dixons Road		N/A	N/A	N/A	5	5	5

Fine sediment cover

Deposited fine sediment cover is high in most hill-fed rivers in the Ashley River catchment. The LWRP fine sediment cover outcome of less than 15% has been regularly breached in all but four hill-fed sites in the Ashley River catchment since 2011. Only the Ashley River two km upstream of the Okuku confluence, Ashley River at SH1, Garry River at Garrymere Road and Okuku River at Birch Hill Road sites met the outcome in at least half of the water years in which monitoring was conducted. (Table 3-4). However, of the sites that regularly failed to meet the LWRP fine sediment cover outcome, only the Glentui River at Ashley Gorge Road, Bullock Creek at Birch Hill Road and Grey River at Mt Grey Road failed to meet the guideline value for the protection of biodiversity [<20% cover (Clapcott et al., 2011)] on more than 25% of the recorded observations (Figure 3-2).

It is likely that fine sediment cover is, at least in part, driving the generally degraded sate of invertebrate communities in the hill-fed rivers in Ashley River catchment, even in sites where cover only exceeded the Clapcott et al. (2011) biodiversity protection guideline value sporadically (Figure 3-2). With the exception of Ashley River at SH1, the sites where LWRP sediment outcomes were met, were also the sites that met the LWRP QMCI outcomes (Table 3-1and Table 3-4). Similarly, of the sites that didn't meet the LWRP fine sediment outcomes only the Ashley River at Rangiora/Loburn Rd and Glentui River at Ashley Gorge Road met the LWRP QMCI outcomes on the years sampling was conducted. Unfortunately there is insufficient data to quantify the strength of the relationship between fine sediment cover and QMCI in the Ashley River catchment through statistical analyses. It is also important to remember that invertebrate data only exists for one particularly dry year at most sites. Therefore, the degraded invertebrate communities observed at some sites may be in response to drought effects and may not reflect normal conditions.

Table 3-4 Maximum fine sediment cover (%) recorded in hill-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Ashley River @ Ashley Gorge Rd	**15**	70	20	40	30	20	36
Ashley River 2km u/s of Okuku confl.		N/A	N/A	N/A	5	15	10
Ashley River @ Rangiora/Loburn Rd		N/A	N/A	N/A	70	10	40
Ashley River @ SH1		10	10	70	75	15	36
Glentui River @ Ashley Gorge Rd		N/A	N/A	N/A	30	80	55
Garry River @ Garrymere Rd		N/A	N/A	N/A	10	10	10
Bullock Creek @ Birch Hill Rd		N/A	N/A	N/A	85	40	63
Grey River @ Mt Grey Road		N/A	N/A	N/A	80	80	80
Grey River @ Whiterock Rd		N/A	N/A	N/A	40	55	48
Okuku River near Fox Peak recorder		N/A	N/A	N/A	20	30	25
Okuku River @ Birch Hill Rd		N/A	N/A	N/A	15	10	13
Makerikeri River @ Dixons Rd		N/A	N/A	N/A	20	15	18

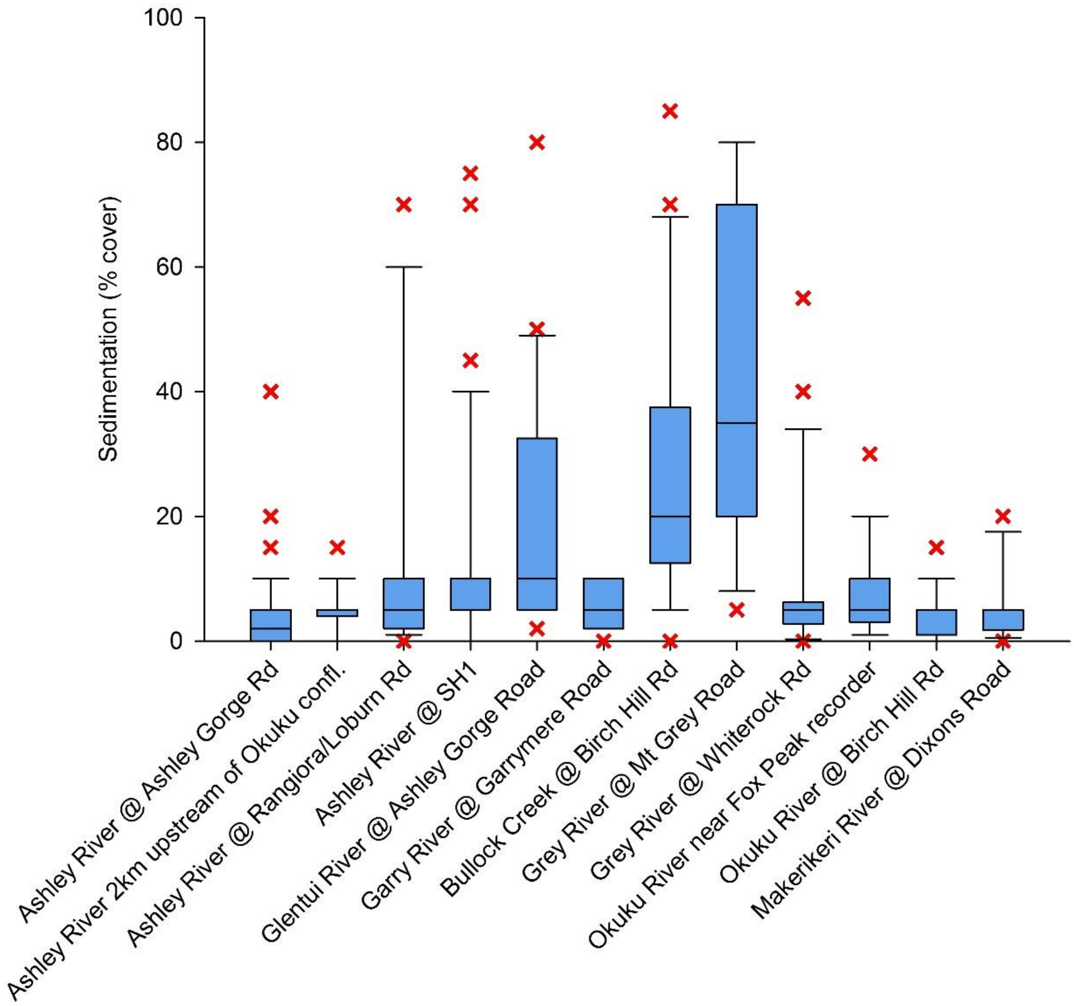

Figure 3-2 Distribution of fine sediment cover data recorded in hill-fed rivers in the Ashley River catchment.

Water temperature and dissolved oxygen

The single monthly measurements of temperature collected for Environment Canterbury's State of the Environment Monitoring Programme are not representative of the full diurnal range of temperatures and can only be used to identify where outcomes have definitely been breached. Annual maximum temperatures recorded in the Ashley River at Ashley Gorge Road, two km upstream of the Okuku confluence, at Rangiora/Loburn Road and at SH1 all failed to meet the LWRP temperature outcomes at least once between 2011 and 2016 (Table 3-5). That the recorded temperatures at the remaining sites did not breach the outcome does not necessarily mean that at some point during this period temperatures did not exceed the 20°C threshold in those rivers.

Table 3-5 Maximum temperature (°C) recorded in hill-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Ashley River @ Ashley Gorge Rd	**20**	18.9	20.5	20.1	20.6	19.8	20.0
Ashley River 2km u/s of Okuku confl.		N/A	N/A	N/A	21.5	21.8	21.7
Ashley River @ Rangiora/Loburn Rd		N/A	N/A	N/A	19.6	22.5	21.1
Ashley River @ SH1		17.2	16.4	19.4	21	21.2	19.0
Glentui River @ Ashley Gorge Rd		N/A	N/A	N/A	17	15.3	16.2
Garry River @ Garrymere Rd		N/A	N/A	N/A	14	15	14.5
Bullock Creek @ Birch Hill Rd		N/A	N/A	N/A	14.1	17.5	15.8
Grey River @ Mt Grey Rd		N/A	N/A	N/A	16.3	15.1	15.7
Grey River @ Whiterock Rd		N/A	N/A	N/A	13.1	16.3	14.7
Okuku River near Fox Peak recorder		N/A	N/A	N/A	18.1	18.6	18.4
Okuku River @ Birch Hill Rd		N/A	N/A	N/A	18.6	18.9	18.8
Makerikeri River @ Dixons Road		N/A	N/A	N/A	16	16.9	16.5

As with temperature, the measurements of DO saturation made by Environment are not representative of the full diurnal range, and can only be used to identify where outcomes have definitely been breached. With the exception of Ashley River at Ashley Gorge Road and two km upstream of Okuku confluence, the Glentui River at Ashley Gorge Road and the Okuku River near Fox Peak Recorder, all sites have failed to meet LWRP dissolved oxygen (DO) saturation thresholds at least once (Table 3-6). These data highlight a significant issue at the Bullock Creek site, where minimum recorded DO saturations in both the 2014 and 2015 water years were exceptionally low. It is possible that this is contributing to the exceptionally poor health of the invertebrate community at this site. However, continual DO monitoring is required to confirm this.

Table 3-6 Minimum DO saturation (%)recorded in hill-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Ashley River @ Ashley Gorge Rd	**90**	74.6	96.2	93.8	94.4	97	78.4
Ashley River 2km u/s of Okuku confl.		N/A	N/A	N/A	93.1	95	94.1
Ashley River @ Rangiora/Loburn Rd		N/A	N/A	N/A	97.8	72.7	85.3
Ashley River @ SH1		97.1	90.3	94.2	83.7	72.9	87.6
Glentui River @ Ashley Gorge Rd		N/A	N/A	N/A	90.4	94.7	92.6
Garry River @ Garrymere Rd		N/A	N/A	N/A	79.9	83.6	81.8
Bullock Creek @ Birch Hill Rd		N/A	N/A	N/A	27.8	39	33.4
Grey River @ Mt Grey Road		N/A	N/A	N/A	77.9	87	82.4
Grey River @ Whiterock Rd		N/A	N/A	N/A	72.5	77.5	75.0
Okuku River near Fox Peak recorder		N/A	N/A	N/A	98	93.4	95.7
Okuku River @ Birch Hill Rd		N/A	N/A	N/A	82.4	92.6	87.5
Makerikeri River @ Dixons Rd		N/A	N/A	N/A	76.4	56	66.2

3.1.2 Current state of water quality

Nutrients as a driver of plant growth

The DIN thresholds for the protection of biodiversity from nuisance periphyton growths are very low in the Canterbury context (0.01 mg/L), and the median concentration at all hill-fed sites in the Ashley River catchment were above this threshold (Figure 3-3). Furthermore the median DIN concentrations in half of hill-fed sites exceeded the threshold for the protection of trout habitat and angling values from nuisance periphyton growths in rivers with a 30 day accrual period. DIN concentrations were greatest in Bullock Creek at Birch Hill Road and Makerikeri at Dixons Road (Figure 3-3).

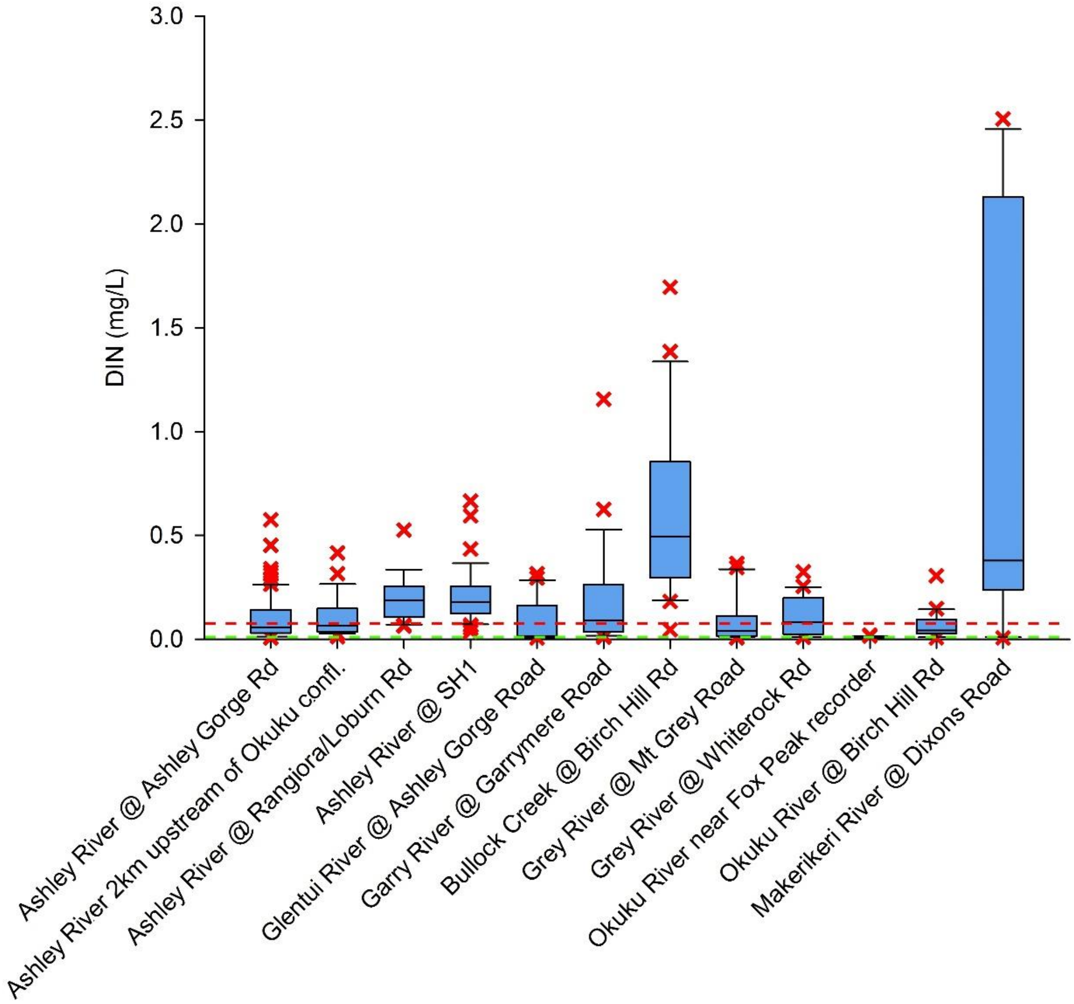

Figure 3-3 Distribution of DIN concentrations recorded in hill-fed rivers in the Ashley River catchment. The red and green lines indicate the recommended thresholds (as annual averages) for the protection of trout habitat and angling values and benthic biodiversity respectively for rivers where accrual time is 30 days

As nuisance periphyton growths have not been observed in most of the hill-fed sites in the Ashley River catchment despite sufficiently high DIN concentrations, there is a temptation to argue for phosphorous limitation. Indeed DRP concentrations are relatively low at all hill-fed sites in the Ashley River catchment when compared to DIN concentrations. Although, median DRP concentrations at all sites exceeded thresholds for the protection of biodiversity from nuisance periphyton growths (Figure 3-4) the threshold for the protection of trout habitat and angling values from nuisance periphyton growths in rivers with a 30 day accrual period was not breached (Figure 3-4). Nitrogen and phosphorous are both fundamental requirements for plant growth, and ecological theory suggests that when the ratio of nitrogen (DIN) to phosphorus (DRP) is highly skewed, plant growth will be limited by a single nutrient. However, recent research suggests that although the N:P ratio influences species composition within plant communities, when the ratio is between 1:1 and 100:1 (applicable to all hill-fed sites except Bullock Creek at Birch Hill Road) the potential for nutrient limitation is difficult to predict and explain (Keck and Lepori, 2012). Therefore, further investigation is required to confirm that phosphorous is limiting periphyton growth in hill-fed rivers in the Ashley River catchment.

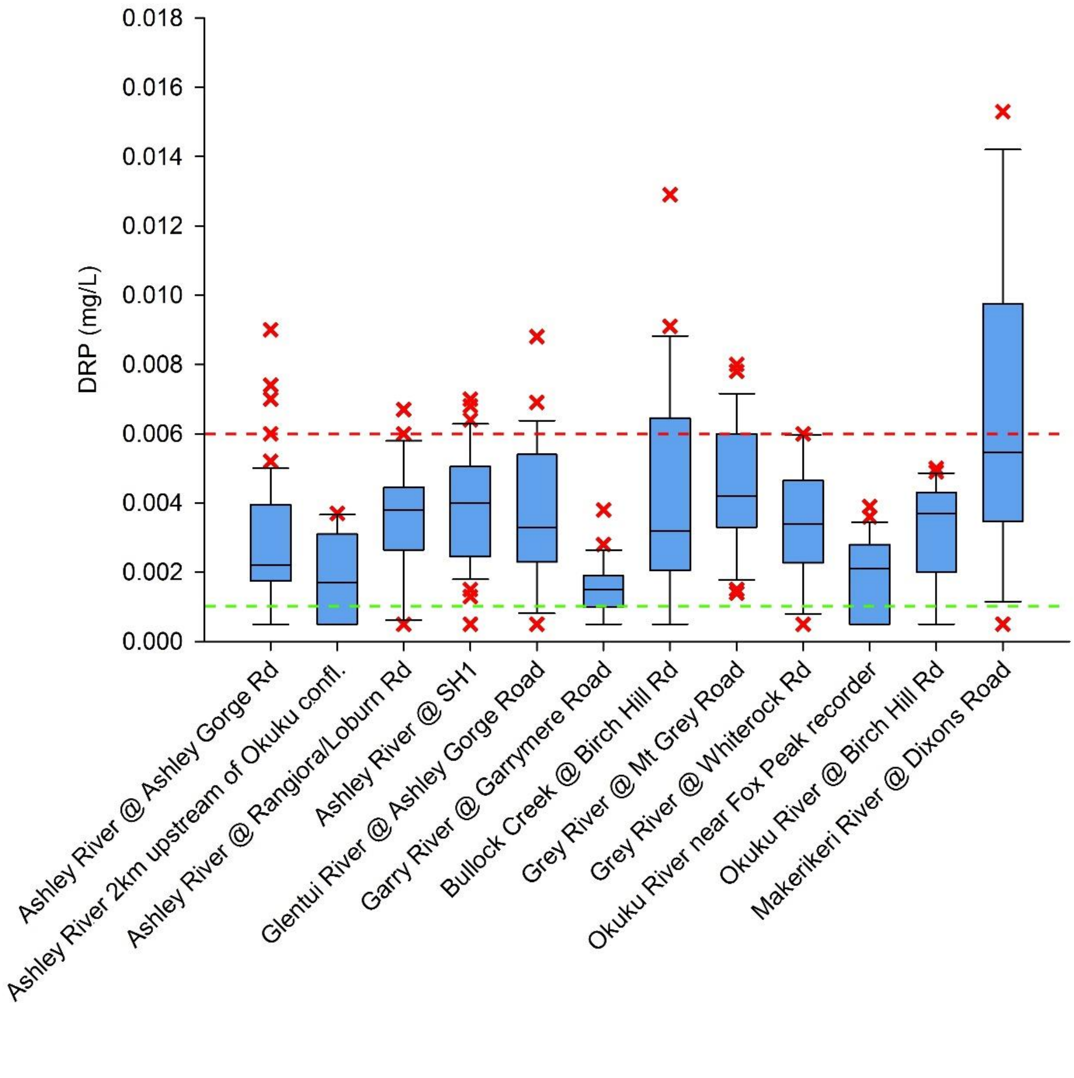

Figure 3-4 Distribution of DRP concentrations recorded in hill-fed rivers in the Ashley River catchment. The red and green lines indicate the recommended thresholds (as annual averages) for the protection of trout habitat and angling values and benthic biodiversity respectively for rivers where accrual time is 30 days.

Nutrients as toxicants

Nitrate toxicity is unlikely to be a key driver of the degraded invertebrate communities observed in many of the hill-fed rivers in the Ashley River catchment. Median NNN concentrations at all sites were below the threshold for the 99% protection of biodiversity from nitrate toxicity (Hickey, 2013) and were in the A-band for nitrate toxicity under the NPS (2014) (Figure 3-5). While not plotted, the 95th percentile NNN concentrations at all sites, except Makerikeri and Dixons Road, were also below the threshold for the 99% protection of biodiversity and in the A band for nitrate toxicity. Although the 95th percentile NNN concentration at Makerikeri at Dixons road (2.48 mg/L) exceeded the threshold for the 99% protection of biodiversity from nitrate toxicity (Table 2-3), it was well below the threshold for 95% protection and only just in the B band under the NPS (2014) (Hickey, 2013). These data suggest that there is only a low risk of nitrate toxicity negatively affecting ecosystem health in hill-fed rivers in the Ashley River catchment.

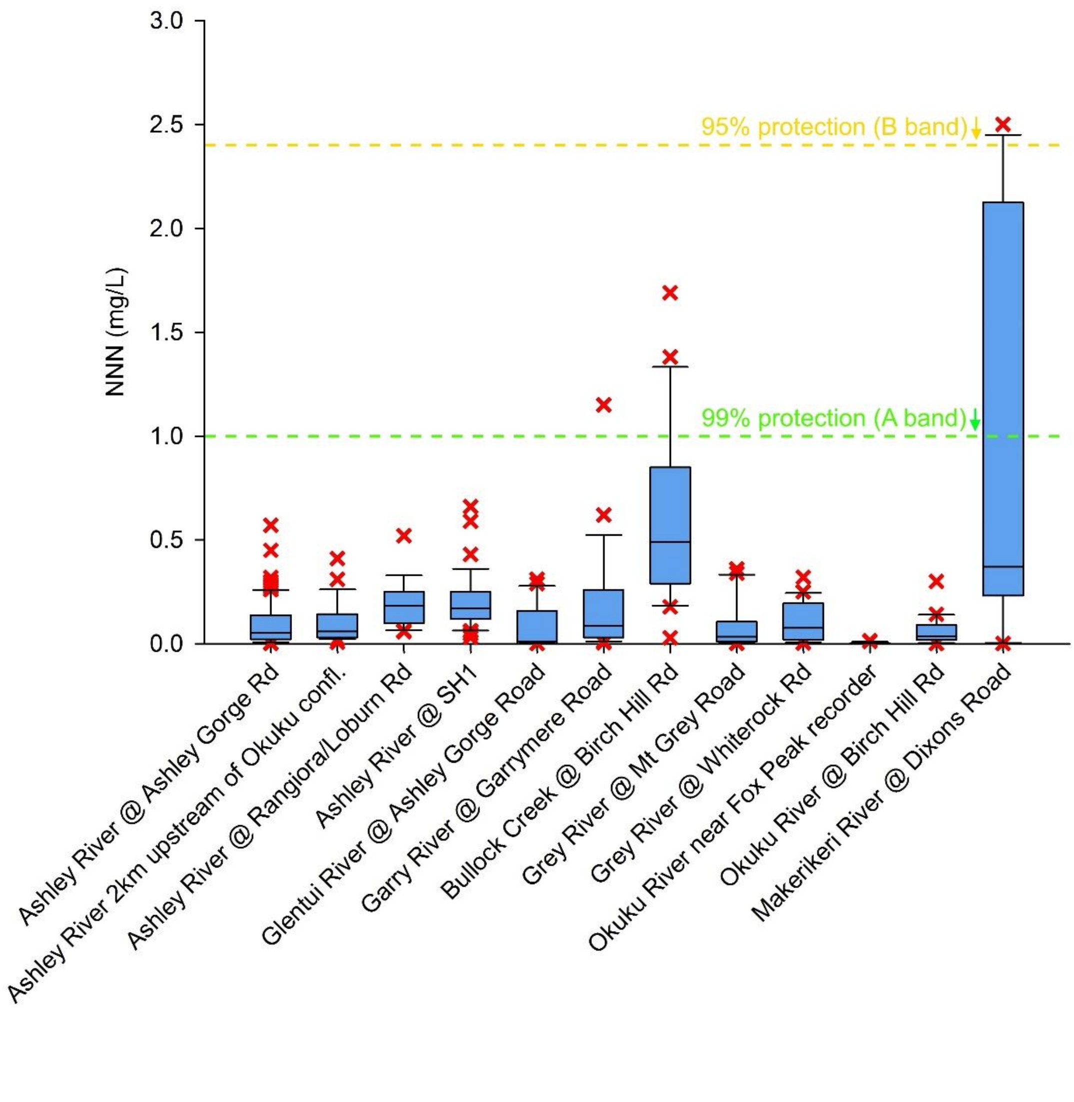

Figure 3-5.Distribution of NNN concentrations recorded in hill-fed rivers in the Ashley River catchment. The coloured lines represent thresholds for the protection of biodiversity from nitrate toxicity (Hickey, 2013) and the boundaries of NPS (2014) bands.

The degraded state of invertebrate communities in many of the hill-fed rivers in the Ashley River catchment is also unlikely to be the result of ammonia toxicity. Median NH_4N concentrations at all hill-fed sites in the Ashley River catchment were below the threshold for the 99% protection of biodiversity from ammonia toxicity and were in the A band under the NPS (2014) (Hickey, 2014; Ministry for the Environment, 2014) (Figure 3-6). Maximum NH_4N concentrations at all sites (not plotted), except Ashley River at Ashley Gorge Road, were also below the threshold for the 99% protection of biodiversity and in the NPS (2014) A band under. Although the maximum NH_4N concentration at Ashley River at Ashley Gorge Road (0.07 mg/L) exceeded the threshold for the 99% protection of biodiversity from ammonia toxicity (Table 2-4) the threshold for 95% protection was not breached and the site was only just in the B band under the NPS (2014) (Hickey, 2014; Ministry for the Environment, 2014). These data suggest that there is only a low risk of ammonia toxicity negatively affecting ecosystem health in hill-fed rivers in the Ashley River catchment.

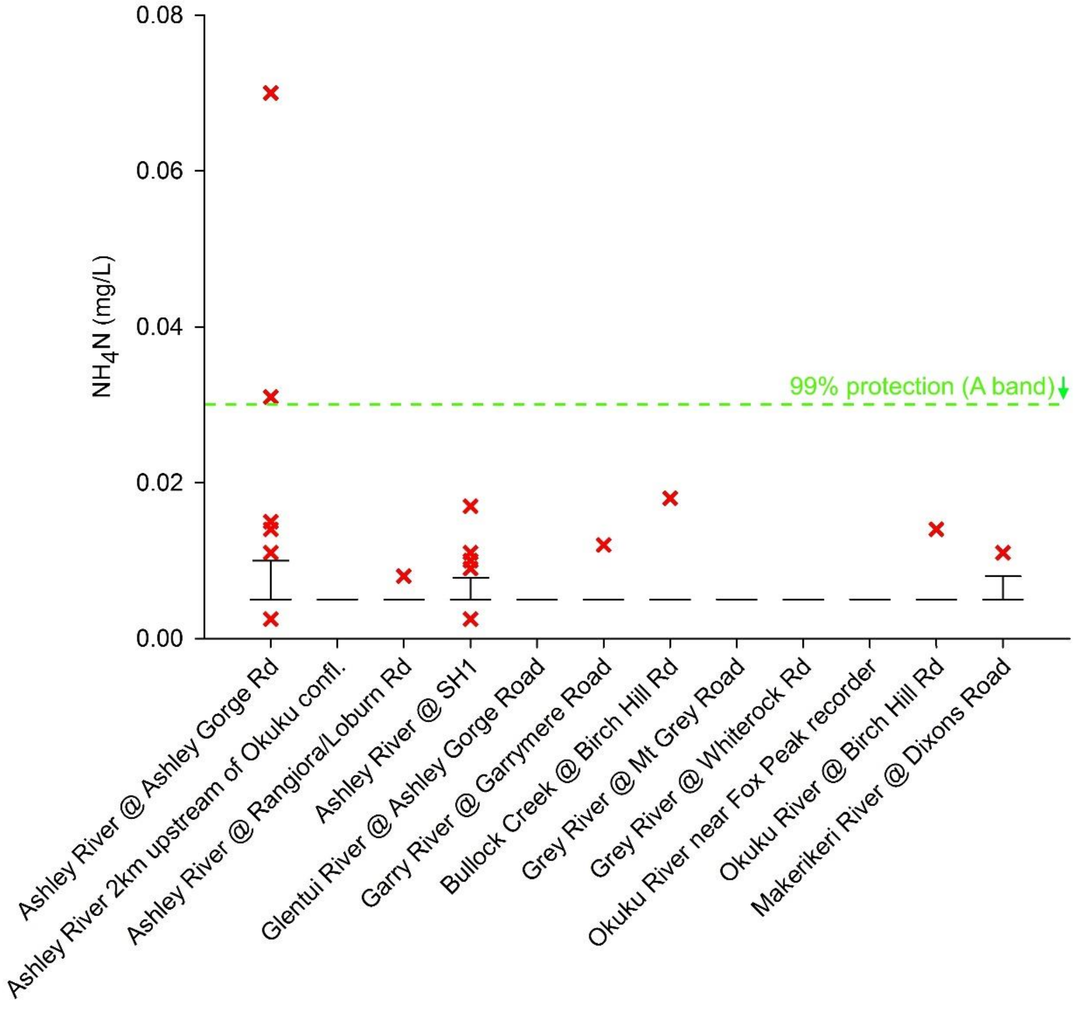

Figure 3-6.Distribution of NH_4N concentrations recorded in hill-fed rivers in the Ashley River catchment. The coloured lines represent thresholds for the protection of biodiversity from ammonia toxicity (Hickey, 2014) and the boundaries of NPS (2014) bands.

TSS

Suspended sediment does not appear to be an important regulator of invertebrate communities in hill-fed rivers in the Ashley River catchment. Median TSS concentrations recorded at all sites were very low, and well below the commonly cited threshold of 25 mg/L for the onset of detrimental effects (APEM, 2007; Rowe et al., 2003; Singleton, 2001) (Figure 3-7). TSS can change significantly with flow and the available data do not allow for definitive conclusions regarding the effects of suspended sediment in hill-fed rivers in the Ashley River catchment. However, the available data suggests that TSS isn't driving the generally degraded state of invertebrate communities in hill-fed rivers in the Ashley River catchment.

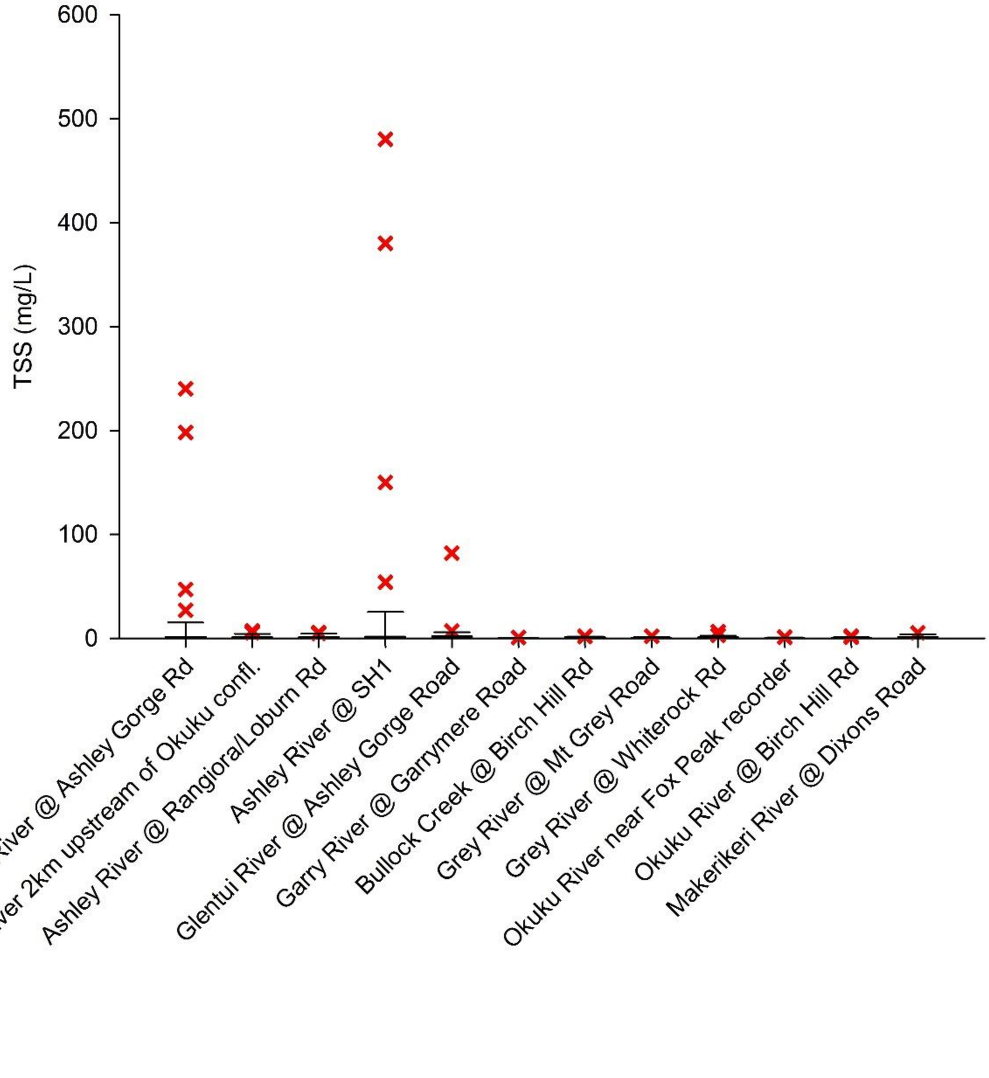

Figure 3-7 Distribution of TSS concentrations recorded in spring-fed rivers in the Ashley River catchment.

E.coli

From Environment Canterbury's SoE monitoring data, faecal contamination does not appear to pose a significant health risk at most hill-fed sites in the Ashley catchment. This is supported by data collected for Environment Canterbury's contact recreation monitoring programme, which has graded the Ashley River at Ashley Gorge Road and the Ashley River at Rangiora/Loburn Road as suitable for contact recreation since 2010 (Appendix 2). The MfE/MoH (2003) action level of 550 MPN/100 mL was only occasionally breached in four sites since between 2011 and 2016. These were the Ashley River at

Ashley Gorge Road and SH1, Glentui River at Ashley Gorge Road and Grey River at Mt Grey Road (Figure 3-8). Of the sites that didn't breach the 550 MPN/100mL action level, only two, Bullock Creek at Birch Hill Road and Makerikeri River at Dixons Road, had instances of the alert level of 260 MPN/100 mL being exceeded (Figure 3-8).

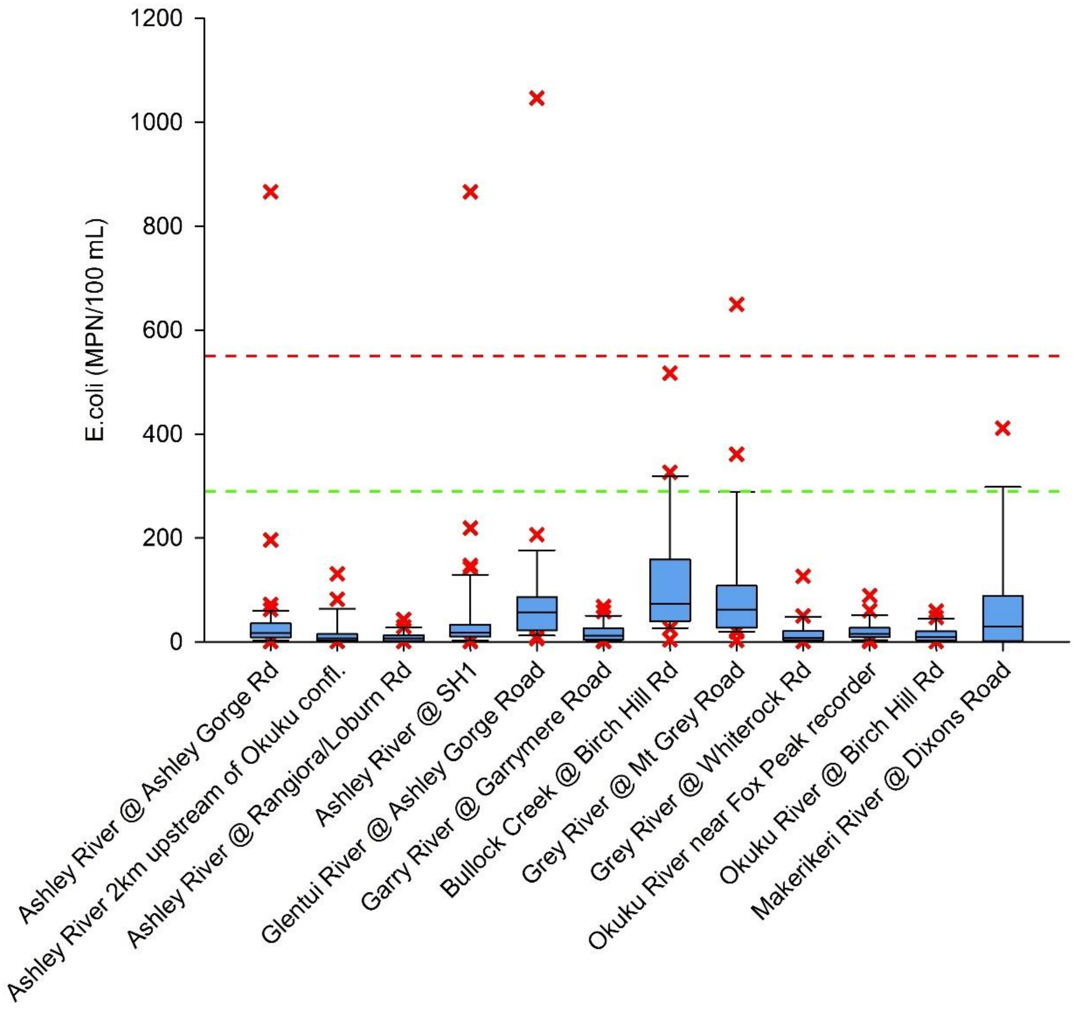

Figure 3-8 Distribution of *E.coli* levels recorded in hill-fed rivers in the Ashley River catchment. The redline indicates the threshold at which a site is considered unsuitable for contact recreation (MfE/MoH, 2003), the green line indicates the alert level prescribed by MfE/MoH (2003).

3.1.3 Trends in water quality

Only two sites have been monitored at a sufficient frequency for a long enough period to conduct trend analyses, these are Ashley River at Ashley Gorge Road and Ashley River at SH1. Initial analysis of the NH_4N concentrations at both sites indicated a step-change reduction in 2012 following a change in laboratories. This laboratory change, was accompanied by an increase in NH_4N detection limit and a reduction in resolution at low concentrations. Consequently, these data were not analysed further.

When adjusted for flow, the only statistically significant and environmentally meaningful trend in water quality observed in hill-fed rivers in the Ashley River catchment was a reduction in TSS in the Ashley River at SH1 since 2011 (Table 3-7). However, concentrations were initially low, and the ecological effects of this decrease are likely negligible.

Table 3-7 Temporal trends in various physico-chemical parameters in hill-fed rivers in the Ashley River catchment (over what timeline?)

		Ashley River @ Ashley Gorge Rd		Ashley River @ SH1	
	Flow adjusted	P	RSSE	P	RSSE
DIN	Flow adjusted	0.208	-4%	0.650	0%
	Unadjusted	0.067	-10%	0.948	0%
DRP	Flow adjusted	0.274	-4%	0.052	5%
	Unadjusted	0.020	-9%	0.633	0%
E coli	Flow adjusted	1.000	0%	0.466	-8%
	Unadjusted	0.459	-2%	1.000	0%
NNN	Flow adjusted	0.381	-3%	0.880	0%
	Unadjusted	0.061	-8%	0.760	0%
TSS	Flow adjusted	0.068	-9%	0.015	-30%
	Unadjusted	0.000	-66%	0.000	-35%

(light blue)	Statistically significant decrease. Not environmentally meaningful
(blue)	Statistically significant decrease. Environmentally meaningful
(light orange)	Statistically significant increase. Not environmentally meaningful
(orange)	Statistically significant increase. Environmentally meaningful

3.1.4 Comparison against the NPS

Attribute states varied only slightly within and between sites (Table 3-8). Most sites were in the A band for all measured[1] attributes and all sites met national bottom lines for all attributes. The specific values supported by the particular NPS attributes and a numeric and narrative explanation of each attribute state (A, B, C, D etc.) are outlined in Appendix 1.

[1] Environment Canterbury does not currently assess chlorophyll *a*. therefore sites were not assessed against this attribute

Table 3-8 Water quality results from hill-fed rivers in the Ashley River catchment collected since 2011 compared to numeric attributes as specified in the National Policy Statement for Freshwater Management (2014)

	Nitrate toxicity lowest grade	Ammonia toxicity lowest grade*	*E.coli* median	*E.coli* 95th percentile
Ashley River @ Ashley Gorge Rd	A	B	A	A
Ashley River 2km u/s of Okuku confl.	A	A	A	A
Ashley River @ Rangiora/Loburn Rd	A	A	A	A
Ashley River @ SH1	A	A	A	A
Glentui River @ Ashley Gorge Rd	A	A	A	B
Garry River @ Garrymere Rd	A	A	A	A
Bullock Creek @ Birch Hill Rd	A	A	A	B
Grey River @ Mt Grey Road	A	A	A	B
Grey River @ Whiterock Rd	A	A	A	A
Okuku River near Fox Peak recorder	A	A	A	A
Okuku River @ Birch Hill Rd	A	A	A	A
Makerikeri River @ Dixons Rd	B	A	A	B

* ammonia attribute state boundaries calculated at pH 8 and 20˚C. Site specific boundaries not calculated

** sites do not meet the requirements for undertaking activities likely to involve full immersion

3.1.5 Summary

There is limited water quality, habitat and ecosystem health data available for hill-fed rivers in the Ashley River catchment, and only one or two years of data exists for most of the sites discussed in this report. What limited data is available suggests that invertebrate communities are in a degraded state in half of the monitored hill-fed rivers in the Ashley River catchment, periphyton cover is generally low despite sufficiently high DIN concentrations to cause nuisance growths, and fine sediment cover is high at most sites.

The lack of data means that it is not possible to determine the drivers of degraded ecosystem health in hill-fed rivers in the Ashley River catchment. However deposited fine sediment is a likely cause as is the recent drought. Of the hill-fed sites in the Ashley River catchment where data are available, Bullock Creek at Birch Hill Road appears to be the most degraded in terms of invertebrate health, habitat quality and water quality, and the site suffers from high nitrates, high fine sediment cover, low DO and high periphyton cover.

In terms of recreation values, faecal contamination has only occasionally posed a risk to contact recreation in the past five years in the Ashley River, the Glentui River and the Grey River. Toxic cyanobacteria does not appear to pose a health risk throughout most hill-fed rivers. However, there are regularly significant *Phormidium* growths in the Ashley River at Ashley Gorge Road and Rangiora/Loburn Road during the summer months, which may pose a threat to recreational users health.

The only statistically significant, environmentally meaningful trend in water quality observed in hill-fed rivers in the Ashley River catchment was a reduction in TSS in the lower Ashley River.

3.2 Lower Ashley River catchment - spring-fed streams

3.2.1 Ecology and habitat

Invertebrates

Long-term invertebrate monitoring data exists for four spring-fed sites in the Ashley River catchment; Saltwater Creek at Toppings Road, Taranaki Creek at Greesons Road, Taranaki Creek at Preeces Road and Waikuku Stream at SH1. LWRP QMCI outcomes were breached at all of these sites in more than half of the water years monitoring was conducted between 2011 and 2016 (Table 3-9), and the composition of the invertebrate communities at these sites indicates only poor to fair water quality (Stark and Maxted, 2007).

There is only one year (2015) of invertebrate data available for Saltwater Creek at Factory Road and Taranaki Creek at Kings Ave, and categorical conclusions about the state or drivers of ecological health at these sites cannot be made. However, both sites did not meet the LWRP QMCI outcome in the 2015 water year and invertebrate community composition was indicative of poor water quality at both sites.

Table 3-9 Minimum QMCI scores recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Toppings Rd	**5**	4.4	4.9	3.8	4.9	5.8	4.8
Saltwater Creek @ Factory Rd		N/A	N/A	N/A	N/A	3.9	3.9
Taranaki Creek @ Gressons Rd		N/A	4.8	2.3	4.0	4.2	3.8
Taranaki Creek @ Preeces Rd		3.0	4.2	4.4	3.7	4.3	3.9
Taranaki Creek @ Kings Ave		N/A	N/A	N/A	N/A	3.3	3.3
Waikuku Stream @ SH1		3.4	4.5	3.0	5.1	5.4	4.3

Fish

Native species found in the lower Ashley River catchment between 2000 and 2016 were inanga, shortfin eel, longfin eel, Canterbury galaxias, lamprey (*Geotria australis*), upland bully, common bully (*Gobiomorphus cotidianus*) and giant bully (*G. gobioides*). Of these species lamprey, longfin eel and Canterbury galaxias are all classified as near threatened or threatened. There is also a population of the critically endangered Canterbury mudfish (*Neochanna burrowsius*) in the coastal wetlands near Tūtaepatu Lagoon. Predominately marine species also make forays into the streams in the lower Ashley catchment, and black flounder (*Rhombosolea retiaria*) and common smelt (*Retropinna retropinna*) were recorded between 2000 and 2016. Brown trout was the only introduced species recorded in the lower Ashley catchment between 2000 and 2016.

There is a significant amount of potential inanga spawning habitat in the catchment of the Ashley Estuary and in the coastal wetland area between the Waimakariri and Ashley Rivers (Figure 3-9). There are also eight known spawning sites in the catchment of Ashley Estuary (Figure 3-9). Add reference to the pc4 report?

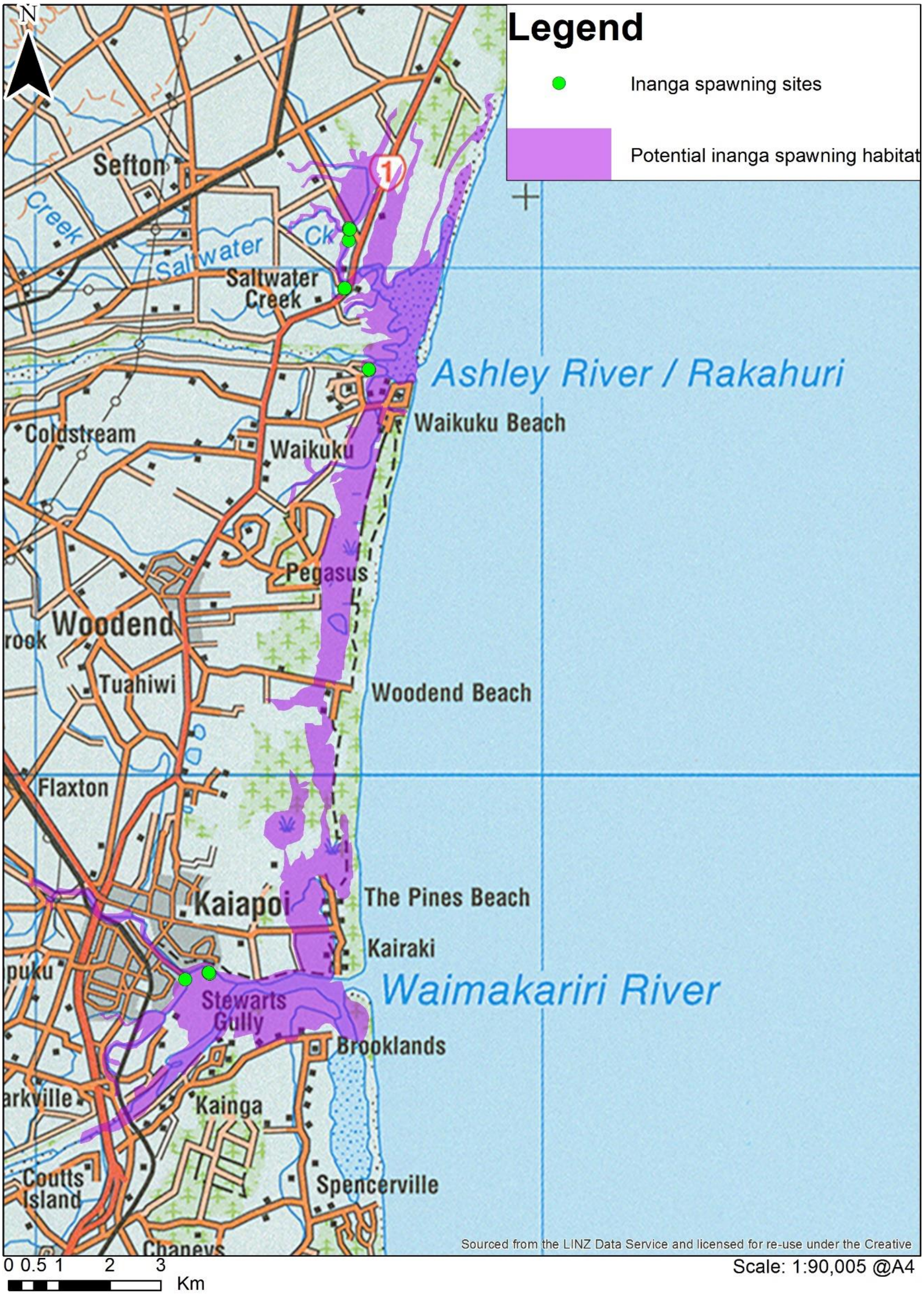

Figure 3-9 Map of inanga spawning sites and potential inanga spawning habitat in the Waimakariri CWMS Zone

Macrophytes and cyanobacteria

Total macrophyte cover varies between spring-fed rivers in the lower Ashley River catchment. Saltwater Creek at Factory Road, Taranaki Stream at Greesons Road, Taranaki Creek at Preeces Road and Waikuku Stream above the Ashley River confluence all failed to meet the LWRP total cover outcome of less than 50% every year monitoring was conducted between 2011and 2016 (Table 3-10). This indicates that total macrophyte cover may be having some negative ecological effects at these sites, and may contribute to degraded invertebrate communities. At the Waikuku stream at SH1 site the LWRP total macrophyte outcome was only breached once between 2011 and 2016 (Table 3-10), and total macrophyte cover is unlikely to be having significant ecological effects at this site.

Table 3-10 Maximum total macrophyte cover (%) recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Factory Rd		95	90	85	95	90	91
Taranaki Creek @ Gressons Rd		75	55	55	90	90	73
Taranaki Creek @ Preeces Rd	**50**	70	90	100	100	100	92
Waikuku Stream @ SH1		45	50	60	40	35	46
Waikuku Stream above Ashley confl.		N/A	N/A	N/A	100	95	98

The state and ecological importance of emergent macrophytes appears to differ between spring-fed rivers in the Ashley River catchment. Taranaki Creek at Greesons Road, Taranaki Creek at Preeces Road and Waikuku Stream above the Ashley River confluence failed to meet the LWRP emergent macrophyte outcome of less than 30% coverage in the 2014 and 2015 water years (Table 3-11), indicating that emergent macrophytes are likely having some negative ecological effects at these sites, and may contribute to degraded invertebrate communities. Waikuku Stream at SH1 and Saltwater Creek at Factory Road met the LWRP emergent macrophyte cover outcome every year between 2011 and 2016 (Table 3-11), and emergent macrophyte cover is unlikely to be having significant ecological effects at these sites.

Table 3-11 Maximum emergent macrophyte cover (%) recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Factory Rd		20	10	10	25	50	23
Taranaki Creek @ Gressons Rd		70	20	35	85	65	55
Taranaki Creek @ Preeces Rd	**30**	10	15	15	80	80	40
Waikuku Stream @ SH1		10	5	5	15	15	10
Waikuku Stream above Ashley confl.		N/A	N/A	N/A	60	75	68

For the most part cyanobacteria does not appear to pose a health risk in spring-fed streams in the Ashley River catchment. All sites met the LWRP outcome for benthic cyanobacteria cover (50%) since 2011 (Table 3-12), and the MfE and MoH (2009) alert guideline (<20%) was only breached at one site (Taranaki Creek at Greesons Road) on one occasion (2013).

Habitat metrics have not been monitored regularly in Taranaki Creek at Kings Avenue and macrophyte and cyanobacteria data were not analysed.

Table 3-12 Maximum cyanobacterial mat cover (%) recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Factory Rd		N/A	0	3	2	2	2
Taranaki Creek @ Gressons Rd		N/A	0	30	15	5	13
Taranaki Creek @ Preeces Rd	**50**	N/A	0	0	0	5	1
Waikuku Stream @ SH1		N/A	0	20	0	1	5
Waikuku Stream above Ashley confl.		N/A	N/A	N/A	3	2	3

Fine sediment cover

Deposited fine sediment cover is high throughout the spring-fed rivers in the Ashley River catchment. All sites regularly failed to meet the LWRP fine sediment cover outcome between 2011 and 2016 (Table 3-13). Fine sediment cover was lowest in Waikuku Stream at SH1, and LWRP outcome was met at this site in 2011 (Table 3-13). Furthermore, the median value recorded at this site was less than the Clapcott et al. (2011) biodiversity protection guideline value of 20% (Figure 3-10). In the remaining sites fine sediment cover was consistently high between 2011 and 2016, and 75% of recorded observations at all sites exceeded the Clapcott et al. (2011) biodiversity protection guideline value of 20% (Figure 3-10). Given the detrimental effects of deposited fine sediment on invertebrates, it is likely that sedimentation is contributing to the degraded state of invertebrate communities in spring-fed rivers in the Ashley River catchment. This is partially supported by the patterns observed in Waikuku stream at SH1, where fine sediment cover was low compared to other sites (Table 3-13 and Figure 3-10) and LWRP QMCI outcomes were met most frequently (Table 3-9). The lower fine sediment cover in Waikuku stream at SH1 may also explain why potentially detrimental macrophytes beds have not proliferated to the same extent as in other sites (Table 3-10, Table 3-11).

Again there is insufficient habitat data to discuss the state and effects of fine sediment cover in Taranaki Creek at Kings Avenue

Table 3-13 Maximum fine sediment cover (%) recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Factory Rd		100	100	100	100	100	100
Taranaki Creek @ Gressons Rd		40	100	100	100	100	88
Taranaki Creek @ Preeces Rd	**20**	100	100	100	85	100	97
Waikuku Stream @ SH1		10	30	40	40	45	33
Waikuku Stream above Ashley confl.		N/A	N/A	N/A	100	100	100

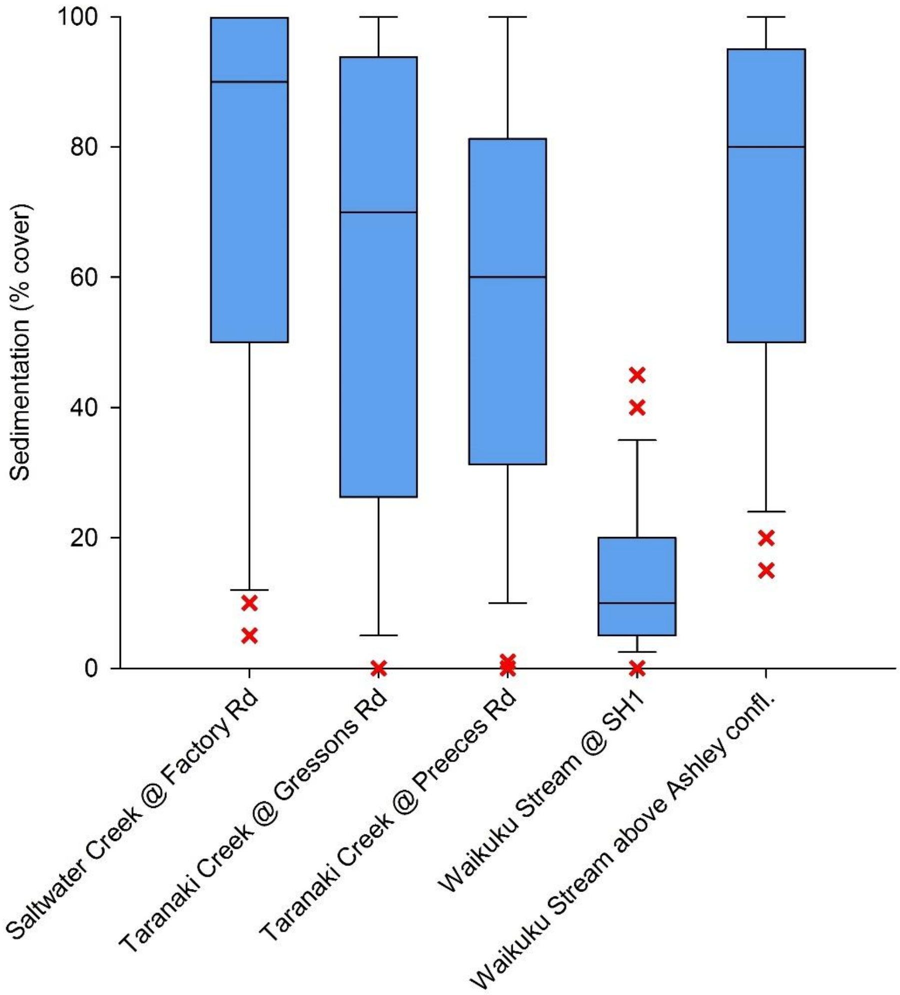

Figure 3-10 Distribution of fine sediment cover data recorded in spring-fed rivers in the Ashley River catchment.

Water temperature and dissolved oxygen

The single monthly measurements of temperature collected for Environment Canterbury's State of the Environment Monitoring Programme are not representative samples and can only be used to identify where outcomes have definitely been breached. The LWRP temperature outcome were met at all spring-fed sites in Ashley River catchment between 2011 and 2016 (Table 3-14). However, this does not necessarily mean that at some points temperatures did not exceed the 20°C threshold.

Table 3-14 Maximum temperature (°C) recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Factory Rd	**20**	13.1	13.6	14	17.1	15.2	14.6
Taranaki Creek @ Gressons Rd		13.4	14.3	14.8	16.8	15.6	15.0
Taranaki Creek @ Preeces Rd		14.5	14.9	15.6	18.7	16.7	16.1
Taranaki Creek @ Kings Ave		N/A	N/A	N/A	18.2	18.3	18.3
Waikuku Stream @ SH1		13.1	13.5	15.1	16.1	14.9	14.5
Waikuku Stream above Ashley confl.		N/A	N/A	N/A	17.6	14.1	15.9

As with temperature, the measurements of DO saturation made by Environment Canterbury are not representative samples and can only be used to identify where outcomes have definitely been breached. With the exception of Taranaki Creek at Preeces Road, and Waikuku Stream at SH1, all sites failed to meet LWRP DO saturation outcome at least once between 2011 and 2016 (Table 3-6). These data highlight a significant issue on Taranaki Creek at Greesons Road and Kings Avenue, where annual minimum DO saturations were exceptionally low. It is possible that this is contributing to the degraded state of invertebrate communities in Taranaki Creek. However, continual DO monitoring would be required to confirm this. That recorded observations of DO saturation in the remaining sites did not exceed LWRP outcomes between 2011 and 2016 does not mean that outcomes are always being met in Taranaki Creek at Preeces Road, and Waikuku Stream at SH1.

Table 3-15 Minimum DO saturation (%) recorded in spring-fed rivers in the Ashley River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Saltwater Creek @ Factory Rd	**70**	70.8	71.9	62.5	75.6	70.4	70.2
Taranaki Creek @ Gressons Rd		64.7	50	49.5	47.6	36	38.0
Taranaki Creek @ Preeces Rd		78.9	84	76.2	85	86.2	82.1
Taranaki Creek @ Kings Ave		N/A	N/A	N/A	34.5	30.3	32.4
Waikuku Stream @ SH1		85.9	86.9	84.8	84.6	84.3	85.3
Waikuku Stream above Ashley confl.		N/A	N/A	N/A	49.6	69.2	59.4

3.2.2 Current state of water quality

Nutrients as a driver of plant growth

Water quality data suggests that plant available nutrient concentrations are sufficiently high in spring-fed streams in the Ashley River catchment to cause nuisance macrophyte growths. DIN concentrations recorded in all spring-fed streams in the Ashley River catchment since 2011 were, at a minimum, in the "adequate" range for macrophyte growth with median values exceeding the level indicative of a 70% probability of nuisance growth (Matheson et al., 2012) (Figure 3-11). DIN concentrations at Taranaki Creek at Greesons Road were in the "high" range for macrophyte growth, and the median value at this site exceeded the level indicative of a 90% probability of nuisance macrophyte growth (Matheson et al., 2012) (Figure 3-11).

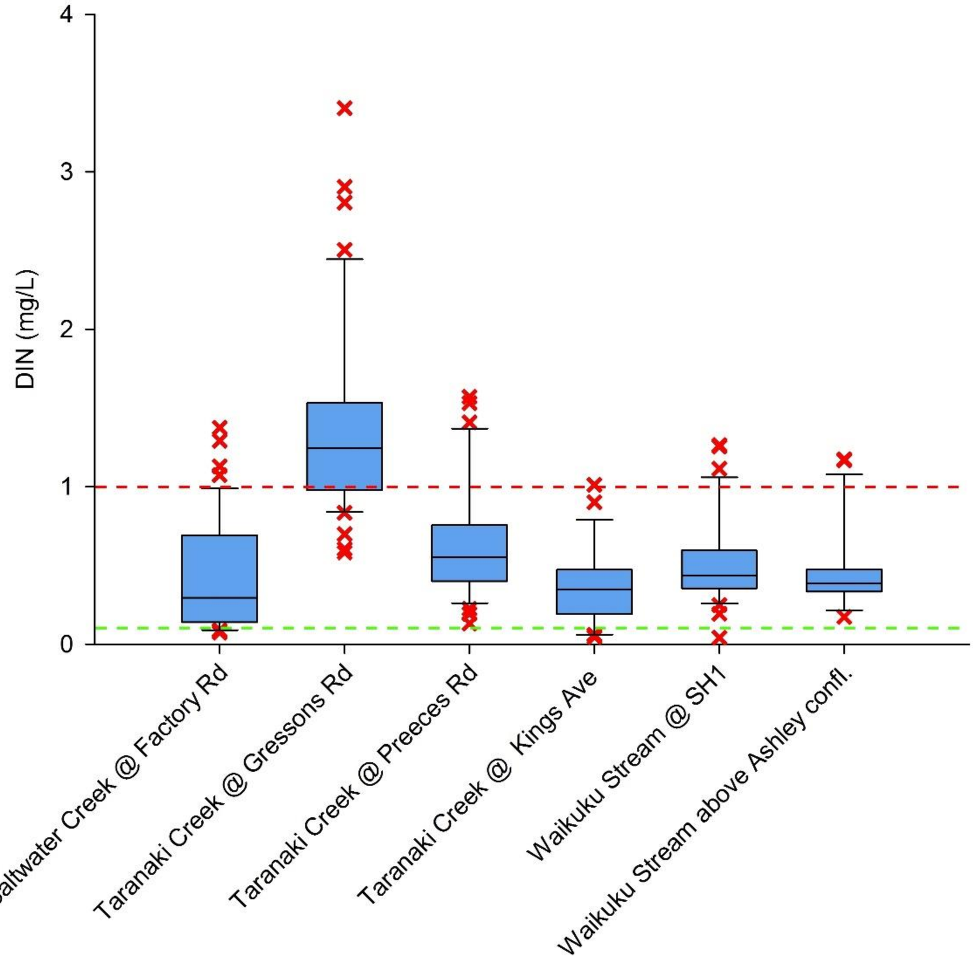

Figure 3-11 Distribution of DIN concentrations recorded in spring-fed rivers in the Ashley River catchment. Red and green lines indicate the concentrations at which there is a 0.9 and 0.7 probability of nuisance macrophyte growths respectively (Matheson et al., 2012).

Although, high enough to facilitate prolific macrophyte growth, DRP concentrations were relatively low in spring-fed rivers in the Ashley catchment compared to DIN. DRP concentrations in Taranaki Creek at Greesons Road and Waikuku Stream at SH1 and above the Ashley River confluence were in the “good” range for macrophyte growth, within which the probability of nuisance macrophyte growths is only 30% (Matheson et al., 2012) (Figure 3-11). In the remaining spring-fed sites DRP concentrations were in the “adequate” range for macrophyte growth, and median values exceeded the level indicative of a 70% probability of nuisance macrophyte growths (Matheson et al., 2012) (Figure 3-12).

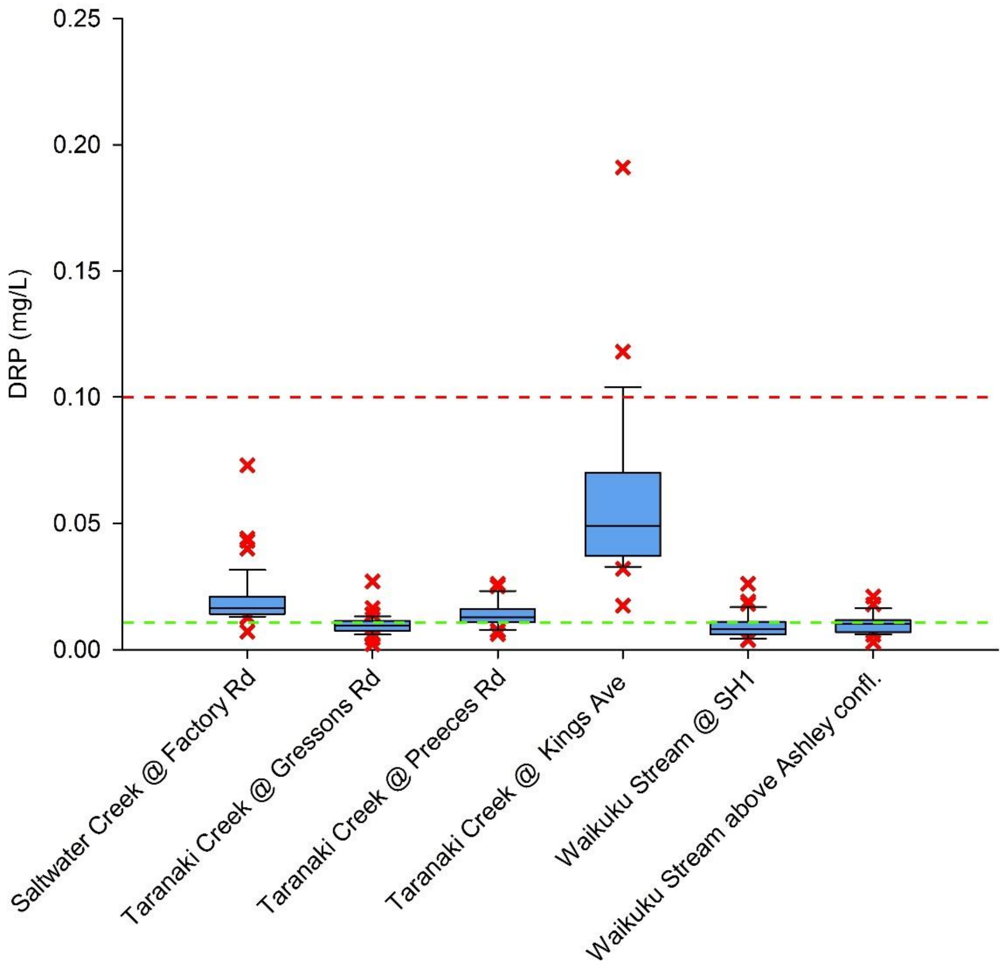

Figure 3-12 Distribution of DRP concentrations recorded in spring-fed rivers in the Ashley River catchment. Red and green lines indicate the concentrations at which there is a 0.9 and 0.7 probability of nuisance macrophyte growths respectively (Matheson et al., 2012).

Nutrient availability is just one of a number of factors that influence macrophyte growth in spring-fed streams, and elevated DIN and DRP concentrations will not always result in nuisance macrophyte growths. However, as nuisance macrophyte growths **have been regularly observed** in most spring-fed streams in the Ashley River catchment since 2011, it is apparent that factors such as light availability, flow conditions and rooting substrate are not limiting macrophyte growth, and that current DIN and DRP are facilitating nuisance macrophyte growth in these streams., with the exception of Waikuku Stream at SH1.

Nutrients as a toxicant

The degraded state of invertebrate communities in spring-fed rivers throughout the Ashley River catchment is unlikely to be the result of nitrate toxicity. With the exception of Taranaki Creek at Greesons Road site, all sites had median and 95th percentile (not plotted) NNN concentrations below the threshold for the 99% protection of biodiversity from nitrate toxicity (Table 2-3), and were in the A band for this attribute under the NPS (2014) (Hickey, 2013; Ministry for the Environment, 2014) (Figure 3-13). Although the median and 95th percentile (2.25 mg/L) NNN concentration in Taranaki Creek at Greesons Road were above the thresholds for 99% protection of biodiversity from nitrate toxicity, they were well below the 95% protection thresholds (Hickey, 2013) (Table 2-3), and only just in the B band under the NPS (2014). These data suggest that there is likely only a low risk of nitrate toxicity negatively affecting ecosystem health in spring-fed rivers in the Ashley River catchment.

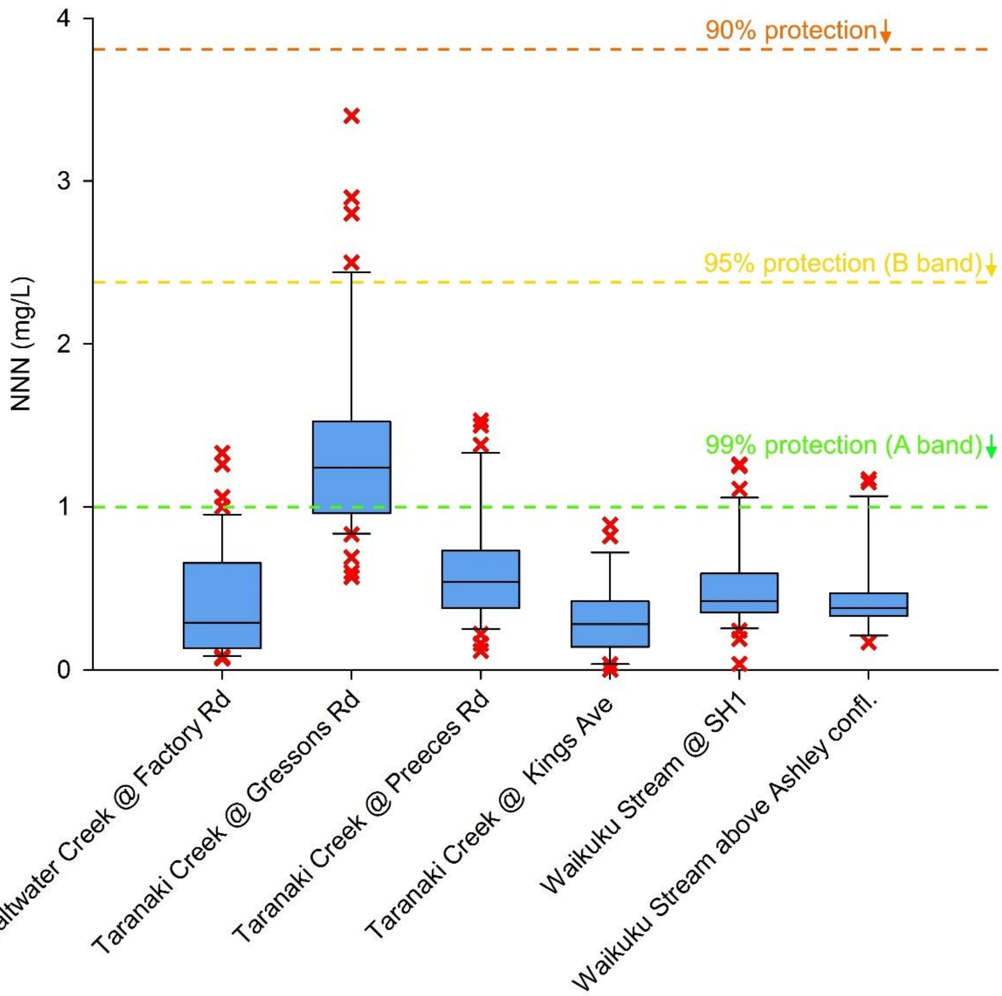

Figure 3-13. Distribution of NNN concentrations recorded in spring-fed rivers in the Ashley River catchment. The coloured lines represent thresholds for the protection of biodiversity from nitrate toxicity (Hickey, 2013) and the boundaries of NPS (2014) bands.

Ammonia toxicity is also unlikely to be a key driver of the degraded invertebrate communities observed throughout spring-fed rivers in the Ashley River catchment. With the exception of Taranaki at Gressons Road, all spring-fed sites in the Ashley River catchment had median NH_4N concentrations below the threshold for the 99% protection of biodiversity from ammonia toxicity and were in the A band for this attribute under the NPS (2014) (Hickey, 2014; Ministry for the Environment, 2014) (Figure 3-14). Although the median NH_4N concentration at Taranaki Creek at Greesons Road was above the threshold for 99% protection of biodiversity from ammonia toxicity, it was well below the 95% protection thresholds (Table 2-4) (Hickey, 2014), and only just in the B band under the NPS (2014).The maximum NH_4N concentrations recorded in Taranaki Creek at Greesons Road, and Waikuku Stream at SH1 and above the Ashley River confluence were below the threshold for the 99% protection of biodiversity (Table 2-4) (Hickey, 2014) and in the A band under the NPS (2014). However, maximum NH_4N concentrations recorded at Saltwater Creek at Factory Road and Taranaki Creek at Preeces Road and Kings Avenue (0.13 mg/L, 0.07 mg/L and 0.19 mg/L respectively) exceeded the threshold for the 99% protection of biodiversity (Table 2-4). However, maximum concentrations at these sites were again, well below the threshold for the 95% protection of biodiversity from ammonia toxicity (Table 2-4) (Hickey, 2014) and only just in the B band under the NPS (2014).

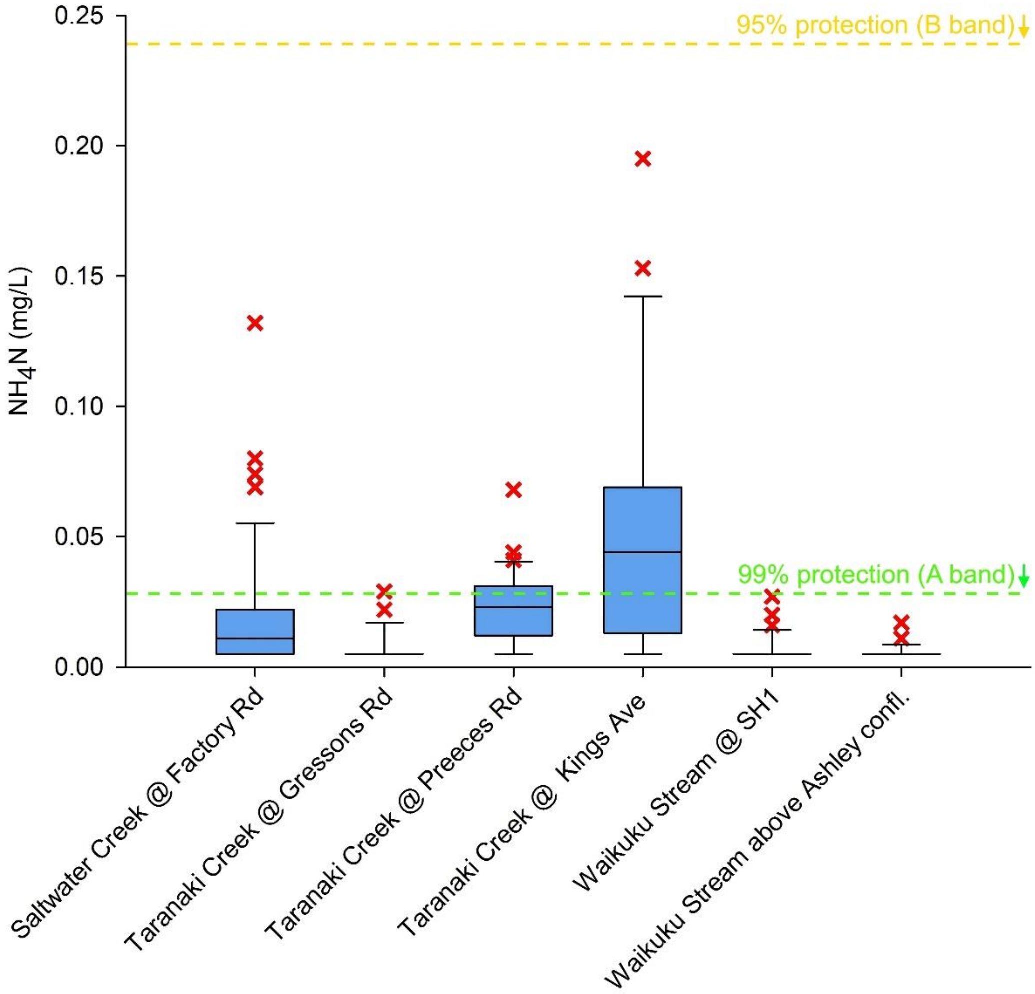

Figure 3-14 Distribution of NH_4N concentrations recorded in spring-fed rivers in the Ashley River catchment. The coloured lines represent thresholds for the protection of biodiversity from ammonia toxicity (Hickey, 2014) and the boundaries of NPS (2014) bands.

TSS

TSS does not appear to be a contributor of the degraded state of invertebrate communities in spring-fed streams in the Ashley River catchment. TSS concentrations recorded at all sites were below the commonly cited threshold of 25 mg/L for the onset of detrimental effects (APEM, 2007; Rowe et al., 2003; Singleton, 2001) (Figure 3-7). However, TSS concentration can change significantly with flow, and the available data does not allow for definitive conclusions regarding the effects of suspended sediment in spring-fed rivers in the Ashley River catchment.

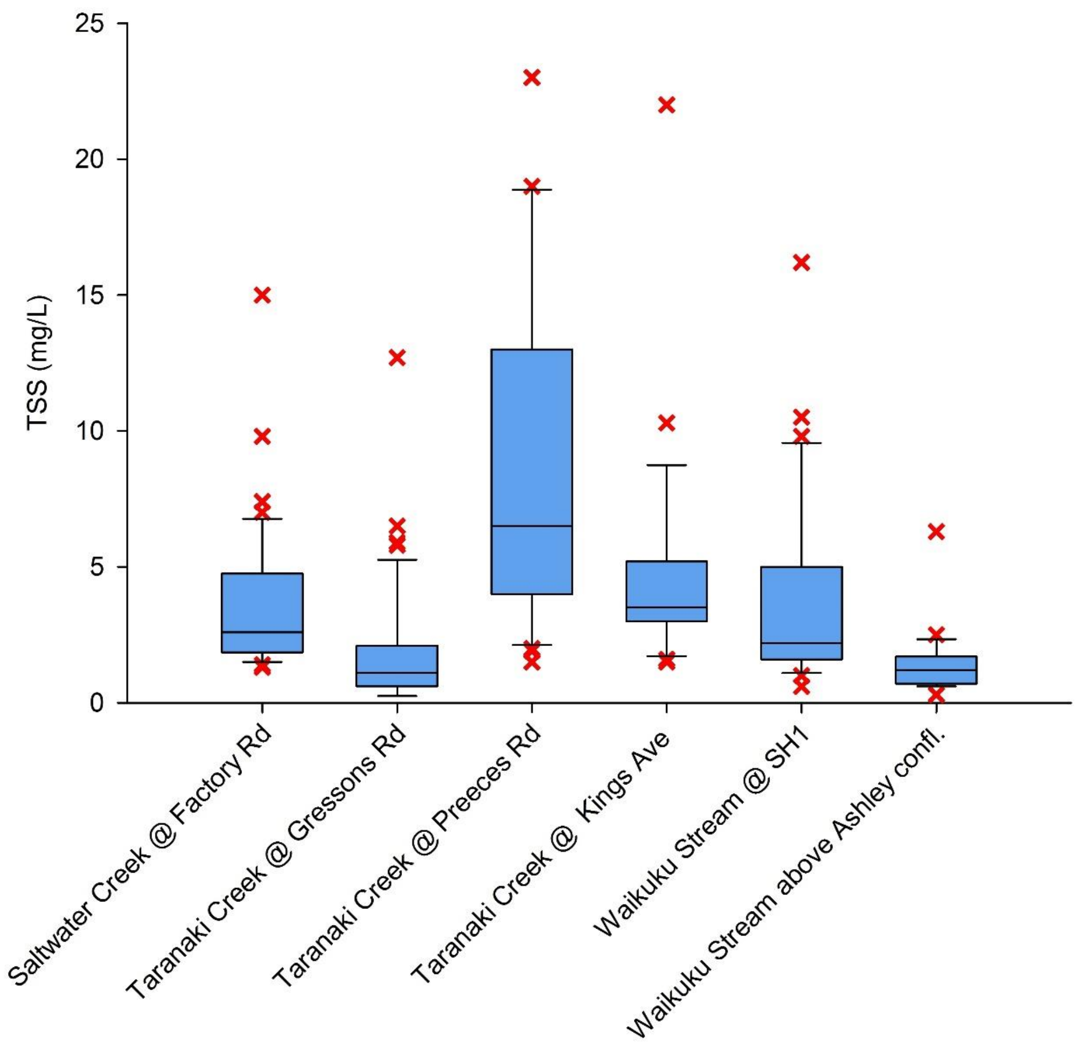

Figure 3-15 Distribution of TSS concentrations recorded in spring-fed rivers in the Ashley River catchment.

E.coli

Spring-fed rivers in the Ashley River catchment are generally unsuitable for contact recreation due to significant faecal contamination. At all sites the MfE/MoH (2003) action level of 550 MPN/100 mL was breached regularly between 2011 and 2016, and median *E.coli* levels exceeded the alert level of 260 MPN/100 mL (Figure 3-16)

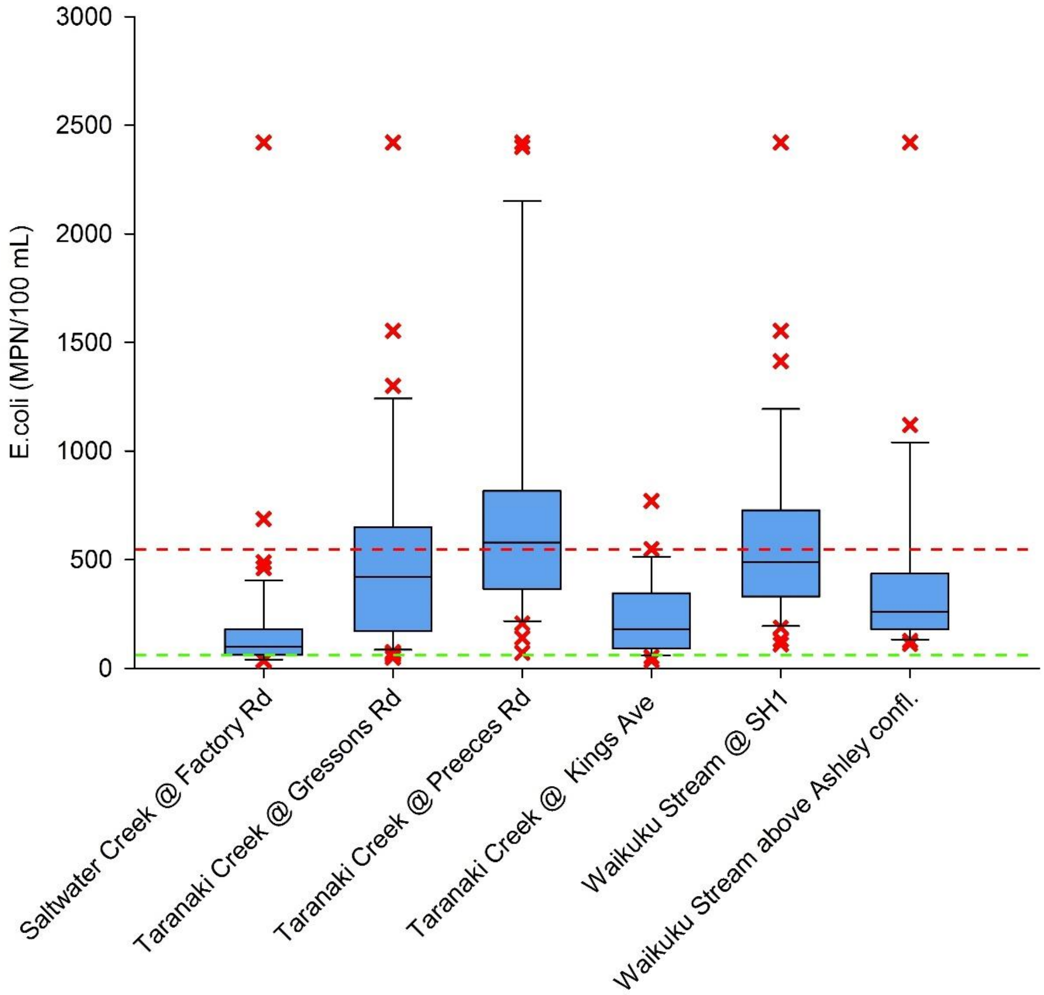

Figure 3-16 Distribution of *E.coli* levels recorded in spring-fed rivers in the Ashley River catchment. The redline indicates the threshold at which a site is considered unsuitable for contact recreation (MfE/MoH, 2003), the green line indicates the alert level prescribed by MfE/MoH (2003).

3.2.3 Trends in water quality

Initial analysis of NH_4N concentrations indicated a step-change reduction at Taranaki Creek at Gressons Road and Waikuku Stream at SH1 in 2012, following a change in laboratories which was accompanied by an increase in detection limit and a reduction in resolution at low concentrations. Consequently, these data were not analysed further.

All water quality trends observed in spring-fed sites in the Ashley River catchment were in a downward direction. Between 2004 and 2016 a statistically significant and environmentally meaningful decreasing trends in *E.coli*, NH_4N and TSS was observed in Saltwater Creek at Factory Road (Table 3-16). Between 2000 and 2016 a statistically significant and environmentally meaningful decreasing trend in DRP was observed in Taranaki Creek at Greesons Road and a decreasing trend in NH_4N was observed in Taranaki Creek at Preeces Road (Table 3-16). Over this time there was also significant and meaningful decreasing trends in DIN, NNN and TSS in Waikuku stream at SH1 (Table 3-16)

Table 3-16 Temporal trends in various physico-chemical parameters in spring-fed rivers in the Ashley River catchment

		Saltwater Creek @ Factory Rd		Taranaki Creek @ Gressons Rd		Taranaki Creek @ Preeces Rd		Waikuku @ Stream SH1	
	Adjustment	P	RSSE	P	RSSE	P	RSSE	P	RSSE
DIN	Flow adjusted							0.011	-2%
	Unadjusted	0.165	-3%	1.000	0%	0.469	-1%	0.012	-3%
DRP	Flow adjusted							0.020	-3%
	Unadjusted	0.148	-1%	0.001	-2%	0.733	0%	0.101	-1%
E coli	Flow adjusted							0.261	-2%
	Unadjusted	0.000	-12%	0.151	3%	0.308	2%	0.482	-2%
NH_4N	Flow adjusted								
	Unadjusted	0.000	-11%			0.037	-3%		
NNN	Flow adjusted							0.023	-2%
	Unadjusted	0.272	-2%	0.964	0%	0.454	-1%	0.020	-3%
TSS	Flow adjusted							0.009	-5%
	Unadjusted	0.001	-7%	0.552	-2%	0.093	-3%	0.000	-8%

Statistically significant decrease. Not environmentally meaningful

Statistically significant decrease. Environmentally meaningful

Statistically significant increase. Not environmentally meaningful

Statistically significant increase. Environmentally meaningful

3.2.4 Comparison against the NPS

All sites were in the A band or B band the nitrate toxicity, ammonia toxicity and median *E.coli* attributes (Table 3-17). However, with the exception of Saltwater Creek at Factory Road, all sites were above the B band for 95th percentile *E.coli* attribute indicating that the requirements for undertaking activities likely to involve full immersion are not being met (Table 3-17). The specific values supported by the particular attributes and a numeric and narrative explanation of each attribute state (A, B, C, D etc.) are outlined in Appendix 1.

Table 3-17 Water quality results from spring-fed rivers in the Ashley River catchment compared to numeric attributes as specified in the National Policy Statement for Freshwater Management (2014)

	Nitrate toxicity lowest grade	Ammonia toxicity lowest grade*	*E.coli* median	*E.coli* 95th percentile
Saltwater Creek @ Factory Rd	A	B	A	B
Taranaki Creek @ Gressons Rd	B	A	B	**
Taranaki Creek @ Preeces Rd	A	B	B	**
Taranaki Creek @ Kings Ave	A	B	A	**
Waikuku Stream @ SH1	A	A	B	**
Waikuku Stream above Ashley confl.	A	A	B	**

* ammonia attribute state boundaries calculated at pH 8 and 20˚C. Site specific boundaries not calculated

** sites do not meet the requirements for undertaking activities likely to involve full immersion

3.2.5 Summary

Invertebrate communities are in a degraded state throughout the spring-fed rivers in the Ashley River catchment, and there are a number of factors that could be contributing to this. Macrophyte cover is generally high at monitored spring-fed sites, and water quality data suggests that elevated DIN and DRP concentrations caused by adjacent land-use is driving this. Deposited fine sediment cover is also high in all spring-fed streams in the Ashley River catchment, and is undoubtedly a key driver of poor ecosystem health and high macrophyte cover in these systems. Although NNN and NH_4N concentrations at some sites exceed thresholds for the 99% protection of biodiversity, nitrate and ammonia toxicity are unlikely to be significant drivers the degraded state of invertebrate communities.

In terms of recreational value, spring-fed rivers in the Ashley River catchment are unsuitable for primary contact recreation due to significant faecal contamination. However, toxic cyanobacteria does not appear to pose a health risk in these streams.

Decreasing trends were observed in *E.coli*, NH_4N and TSS in Saltwater Creek, DRP and NH_4N in Taranaki Creek and DIN, NNN and TSS in Waikuku stream.

3.3 Kaiapoi River spring-fed streams

3.3.1 Ecology and Habitat

Invertebrates

Invertebrate communities are generally in a degraded state in spring-fed rivers in the Kaiapoi River catchment. With the exception of Kaiapoi River at Heywards Road and Cust River at Tippings Road, all sites failed to meet LWRP QMCI outcomes in at least half the years sampling was conducted between 2011 and 2016 (Table 3-18). Sites on the Ohoka River, the Cam River, and the South Brook have consistently failed to meet LWRP outcomes, and the composition of invertebrate communities in these streams is indicative of poor (QMCI <4.00), or only fair (QMCI 4.00 - 4.99) water quality (Table 3-18) (Stark and Maxted, 2007).

Recorded QMCI scores for the Kaiapoi and Cust Rivers vary markedly both within and between sites. While sites in the lower Kaiapoi River and lower Cust River (at Island Road and Skewbridge Road respectively) did not meet the LWRP QMCI outcomes in the last five years, upstream sites in these rivers regularly did. Invertebrate community composition in the Kaiapoi River at Harpers and Heywards Roads and the Cust River at Tippings Road between 2011 and 2016 indicated that, during this period, water quality was generally good [QMCI 5.00 - 5.99 (Stark and Maxted, 2007)] (Table 3-18).

That invertebrate communities were healthiest in the upper Kaiapoi River is particularly interesting, as this also where some of the highest nitrate concentrations in the Kaiapoi River catchment were recorded (see pg. 46). This highlights that the health of invertebrate communities in spring-fed streams in the catchment is driven by a combination of factors not just diffuse nutrient discharges.

Table 3-18 Minimum QMCI scores recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Rd		5.0	4.3	4.4	4.9	5.6	4.9
Kaiapoi River @ Heywards Rd		6.1	6.6	5.3	5.6	5.0	5.7
Kaiapoi River @ Island Rd		N/A	4.5	2.8	4.5	4.1	4.0
Cust River @ Tippings Rd		5.3	7.1	5.2	3.8	3.8	5.0
Cust River @ Skewbridge Rd	**5**	4.1	3.3	4.0	3.4	4.8	3.9
Ohoka Stream @ Bradley's Rd		3.6	3.3	2.5	3.8	3.8	3.4
Ohoka River @ Island Rd		N/A	4.8	3.1	5.9	4.7	4.6
Cam River @ Bramleys Rd		4.9	4.2	4.7	3.3	5.0	4.4
South Brook @ Marsh Rd		3.1	2.5	3.1	2.8	4.1	3.1

Fish (including all rivers in the Waimakariri River catchment north of the main stem)

Native fish species found in the lower Waimakariri River catchment between 2000 and 2016 were inanga, shortfin eel, longfin eel, upland bully, common bully and giant bully. Of these species inanga and longfin eels are classified as near threatened (Goodman et al., 2014). Predominantly marine species recorded were black flounder and yellow eye mullet (*Aldrichetta forsteri*). Brown trout, tench (*Tinca tinca*) and perch (*Perca fluviatilis*) were the only introduced sport fish recorded in the lower Waimakariri catchment between 2000 and 2016. However, it is known that rainbow trout (*Oncorhynchus mykiss*) and Chinook salmon (*O. tshawytscha*) are also present in the catchment. Introduced pest fish recorded in the lower Waimakariri catchment between 2000 and 2016 were rudd (*Scardinius erythropthalmus*) and goldfish (*Carassius auratus*)

Between 2000 and 2016 shortfin eel, longfin eel, koaro (*Galaxias brevipinnis*), Canterbury galaxias, upland bully and brown trout were recorded in the upper Waimakariri catchment. There are also populations of critically endangered Canterbury mudfish (*Neochanna burrowsius*) in the upper reaches of the Eyre River

There is a significant amount of potential inanga spawning habitat in the lower reaches of the Kaiapoi River, Courtenay Stream, Kaikainui Stream and Kairaki Creek (Figure 3-9). There are also four known spawning sites in the catchment, three on the Kaiapoi River and one in Courtenay Stream (Figure 3-9).

Macrophytes, periphyton and cyanobacteria

Total macrophyte cover may be having detrimental effects on ecosystem health in some, but not all, spring-fed streams in the Kaiapoi catchment. Sites in the Kaiapoi River at Island and Heywards Roads (one year of data only), the Ohoka River at Island Road and the North Brook at Marsh Road all failed to meet the LWRP total macrophyte outcome in at least half of the water years in which monitoring was conducted between 2011 and 2016 (Table 3-19). This indicates that total macrophyte cover may contribute to the degraded state of invertebrate communities at these sites. All other sites regularly met the LWRP outcome for total macrophyte cover between 2011 and 2016 (Table 3-19), and the available data suggests that total macrophyte cover is unlikely to be having significant ecological effects in the Cust River, the Cam River, the Kaiapoi River at Harpers Road, or the South Brook.

Table 3-19 Maximum total macrophyte cover (%) recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Road		N/A	30	N/A	15	30	25
Kaiapoi River @ Heywards Rd		N/A	95	N/A	N/A	N/A	95
Kaiapoi River @ Island Rd		65	100	95	92	75	85
Cust River @ Skewbridge Rd		10	15	5	10	25	13
Ohoka River @ Island Rd	**50**	90	80	20	45	85	64
Cam River @ Marsh Rd		90	60	35	20	35	48
Cam River @ Bramleys Road		25	45	65	45	50	46
South Brook @ Marsh Rd		75	20	35	15	70	43
North Brook @ Marsh Rd		70	85	65	40	90	70

Emergent macrophytes are unlikely to be having significant ecological effects in spring-fed rivers in the Kaiapoi River catchment. With the exception of in the Kaiapoi River Heywards Road, where monitoring was only conducted for one year, all sites regularly met the LWRP emergent macrophyte outcome of less than 30% cover between 2011 and 2016 (Table 3-20).

Table 3-20 Maximum emergent macrophyte cover (%) recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Road		N/A	15	N/A	10	15	13
Kaiapoi River @ Heywards Rd		N/A	40	N/A	N/A	N/A	40
Kaiapoi River @ Island Rd		5	20	10	10	10	11
Cust River @ Skewbridge Rd		10	15	5	10	20	12
Ohoka River @ Island Rd	**30**	10	10	10	10	20	12
Cam River @ Marsh Rd		0	0	5	10	20	7
Cam River @ Bramleys Road		10	15	15	20	20	16
South Brook @ Marsh Rd		15	10	15	10	20	14
North Brook @ Marsh Rd		50	15	15	10	25	23

The available data suggests that nuisance periphyton growths are not of major ecological concern in the Cust River. Although predominately spring-fed, the Cust River does have a hill-fed form, and in some years the plant community may be dominated by periphyton rather than macrophytes. Yet in four of the past five water years the LWRP long-filamentous periphyton cover outcome of 30% (applicable to both hill-fed lower and spring-fed rivers) was met at the Skewbridge Road site.

Benthic cyanobacteria does not appear to be a health risk in spring-fed streams in the Kaiapoi River catchment. All sites met the LWRP outcome for benthic cyanobacteria cover (50%) every year in which monitoring was conducted between 2011 and 2016 (Table 3-12). Although, the MfE/ MoH (2009) alert guideline (<20%) was breached in the Cust River at Skew bridge Road during the 2014 and 2015 water years, mean annual maximum cover at the site did not breach this threshold.

Table 3-21 Maximum cyanobacterial mat cover (%) recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Road		N/A	0	N/A	2	1	1
Kaiapoi River @ Heywards Rd		N/A	0	N/A	N/A	N/A	0
Kaiapoi River @ Island Rd		N/A	0	20	5	20	11
Cust River @ Skewbridge Rd		N/A	0	0	40	40	20
Ohoka River @ Island Rd	**50**	N/A	N/A	2	0	10	4
Cam River @ Marsh Rd		N/A	0	0	0	0	0
Cam River @ Bramleys Road		N/A	0	5	0	20	6
South Brook @ Marsh Rd		N/A	0	0	0	10	3
North Brook @ Marsh Rd		N/A	0	2	1	0	1

Fine sediment cover

Deposited fine sediment cover is high in most of the spring-fed rivers in the Kaiapoi River catchment. The recorded exceptions being the Cust River at Skewbridge Road, the North Brook at Marsh Road and the South Brook at Marsh Road. At these sites the LWRP fine sediment outcome was met in three of the past five years (Table 3-22), and median fine sediment cover was below the guideline value (20%) for the protection of biodiversity (Clapcott et al., 2011) (Figure 3-17). The remaining sites failed to meet the LWRP fine sediment outcome in at least half of the water years monitoring was conducted between 2011 and 2016 (only one year of data available for the Kaiapoi River at Heywards Road) (Table 3-22). Fine sediment cover was also consistently very high, with at least 25% of recorded values at all sites, exceeding the guideline value for the protection of biodiversity (Clapcott et al., 2011) (Figure 3-17). This suggests that the effects of fine sediment in the Kaiapoi River are persistent rather than transient.

Table 3-22 Maximum fine sediment cover (%) recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Road		N/A	90	N/A	65	80	78
Kaiapoi River @ Heywards Rd		N/A	90	N/A	N/A	N/A	90
Kaiapoi River @ Island Rd		15	100	80	95	95	77
Cust River @ Skewbridge Rd		15	10	60	20	30	27
Ohoka River @ Island Rd	**20**	30	5	60	20	30	29
Cam River @ Marsh Rd		90	100	100	95	100	97
Cam River @ Bramleys Road		10	15	40	80	40	37
South Brook @ Marsh Rd		20	25	25	15	20	21
North Brook @ Marsh Rd		10	10	15	40	80	31

Given the detrimental effects of deposited fine sediment, it is likely that the high degree of sedimentation in numerous spring-fed streams in the Kaiapoi River catchment is contributing to the degraded state of invertebrate communities in these systems. The only apparent exception being the Kaiapoi River at Heywards Road, where QMCI scores were the highest in the catchment, despite a high degree of sedimentation. However, monthly monitoring of fine sediment cover was only conducted at this site during the 2012 water year, and this short data record, may not reflect normal conditions, under which fine sediment cover may be much lower. Indeed annual estimates of fine sediment cover made for Environment Canterbury's AEH programme suggests that fine sediment cover at the Heywards Road site is normally below 20%, which may well explain the healthy state of the resident invertebrate community. However, these data were not collected at a high enough frequency to present as annual maximums in Table 3-22.

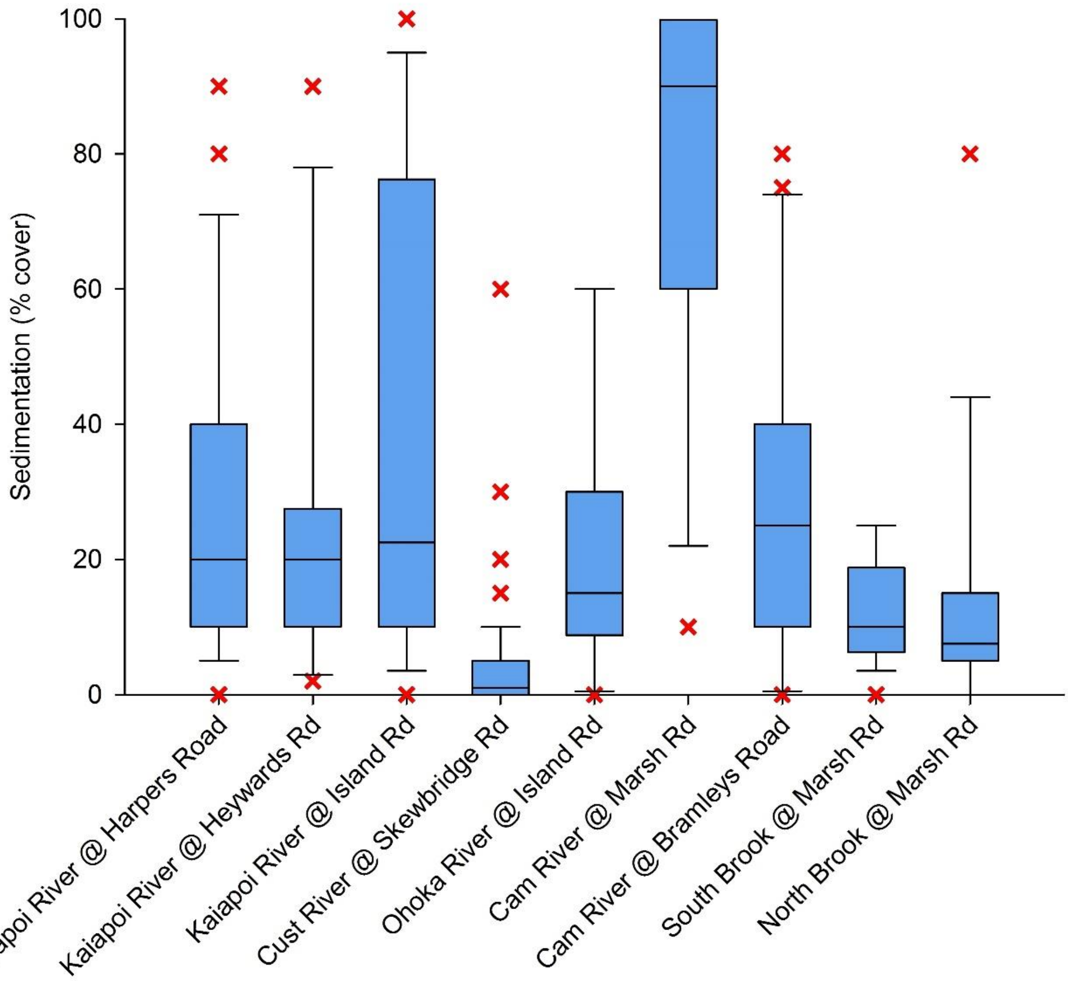

Figure 3-17 Distribution of fine sediment cover data recorded in spring-fed rivers in the Kaiapoi River catchment.

Water temperature and dissolved oxygen

The single monthly measurements of temperature collected for Environment Canterbury's State of the Environment Monitoring Programme are not representative samples, and can only be used to identify where outcomes have definitely been breached. Annual maximum temperatures recorded at all sites between 2011 and 2016 were under the LWRP outcome (Table 3-23). However, this does not necessarily mean that at some point during this period temperatures did not exceed the 20°C threshold.

Table 3-23 Maximum temperature (°C) recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Road		N/A	15	N/A	14	13.6	14.2
Kaiapoi River @ Heywards Rd		N/A	14.6	N/A	N/A	14.5	14.6
Kaiapoi River @ Island Rd		15.3	15.6	14.9	14.7	15.2	15.1
Cust River @ Skewbridge Rd		18.2	18.3	16.3	16.6	15.5	17.0
Ohoka River @ Island Rd	**20**	14.9	16.1	14.7	16.7	14	15.3
Cam River @ Marsh Rd		13.3	14.5	14	14.8	14.2	14.2
Cam River @ Bramleys Road		14.5	15.8	15.2	15.2	15.3	15.2
South Brook @ Marsh Rd		14	15.4	14	15.3	15	14.7
North Brook @ Marsh Rd		14.3	15.3	14.8	15.1	15.8	15.1

As with temperature, the measurements of DO saturation made by Environment Canterbury can only be used to identify where outcomes have definitely been breached. Recorded DO saturations at all sites met the LWRP outcome in at least four of last five water years (Table 3-24), and the Kaiapoi River at Harpers Road and the Ohoka River at Island Road sites each failed to meet the outcome in only one year. Again, that recorded observations of DO saturation in the remaining sites did not exceed LWRP outcomes does not mean that these threshold were not breached, but the results do indicated that low DO may not be a critical issue

Table 3-24 Minimum DO saturation (%) recorded in spring-fed rivers in the Kaiapoi River catchment from 2011 to 2015. Values highlighted in red fail to meet LWRP outcomes.

	LWRP outcome	2011	2012	2013	2014	2015	Mean
Kaiapoi River @ Harpers Road		N/A	78.5	N/A	70.6	65.1	71.4
Kaiapoi River @ Heywards Rd		N/A	84.7	N/A	N/A	83.7	84.2
Kaiapoi River @ Island Rd		87.1	76.4	70.5	85.4	85.5	81.0
Cust River @ Skewbridge Rd		89.7	90.2	77.4	90	91.8	87.8
Ohoka River @ Island Rd	**70**	65.9	83.2	83	91.3	76.1	79.9
Cam River @ Marsh Rd		94.9	88	91.2	86	90	90.0
Cam River @ Bramleys Road		95.2	86.8	82	88.1	93	89.0
South Brook @ Marsh Rd		82.5	80	79.8	90.9	75	81.6
North Brook @ Marsh Rd		94.9	83.3	83.5	93.2	96.7	90.3

3.3.1 Current state of water quality

Nutrients as a driver of plant growth

Between 2011 and 2016 plant available nutrient concentrations were sufficiently high in all spring-fed streams in the Kaiapoi River catchment to allow macrophytes to proliferate. DIN concentrations at all sites were, at a minimum, in the “adequate” range for macrophyte growth with median values exceeding the level indicative of a 70% probability of nuisance macrophyte growths (Matheson et al., 2012) (Figure 3-18). Furthermore, DIN concentrations at all monitored sites in the Kaiapoi River, the Cust River the Ohoka River and the South Brook were in the “high” range for macrophyte growth, and median values at these sites exceeded the level indicative of a 90% probability of nuisance macrophyte growths (Matheson et al., 2012) (Figure 3-18). These data suggest that there is at least a moderate risk of nuisance macrophyte growths in spring-fed streams in the Kaiapoi River catchment.

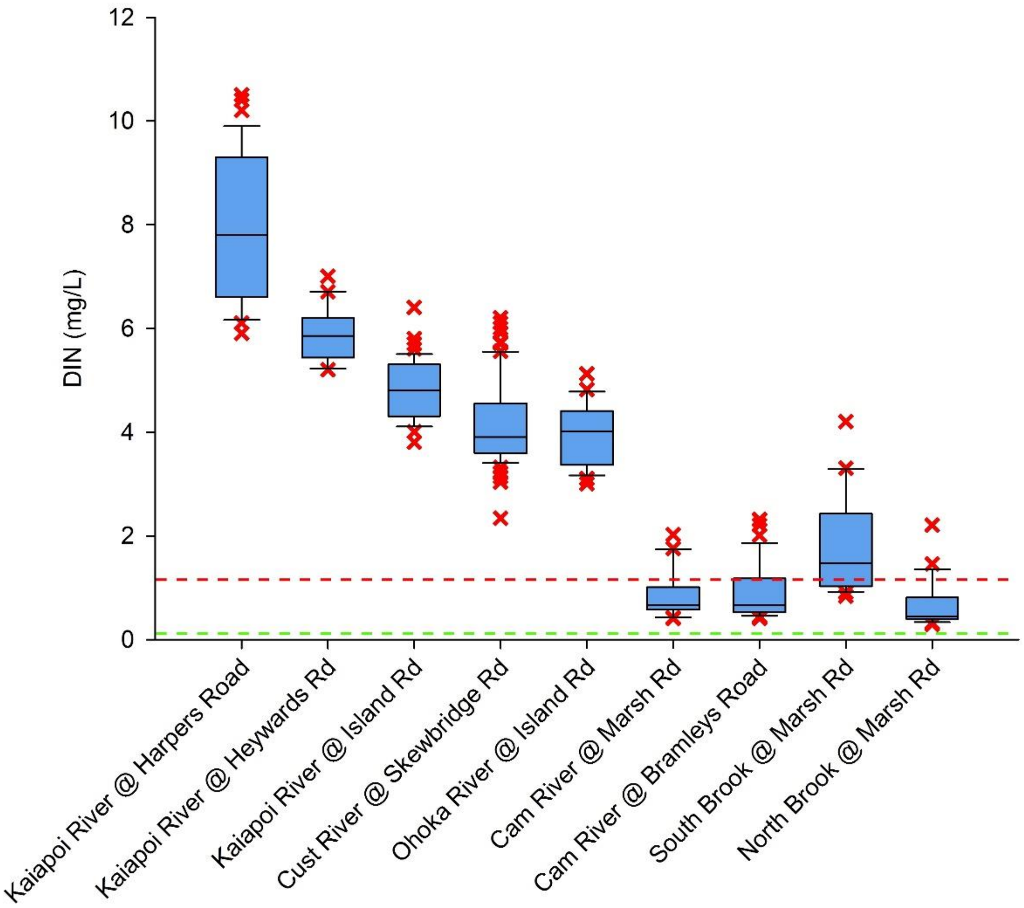

Figure 3-18 Distribution of DIN concentrations recorded in spring-fed rivers in the Kaiapoi River catchment. Red and green lines indicate the concentrations at which there is a 0.9 and 0.7 probability of nuisance macrophyte growths respectively (Matheson et al., 2012).

Although still sufficiently high to promote nuisance macrophyte growths, DRP concentrations were relatively low in spring-fed rivers in the Kaiapoi River catchment when compared to DIN concentrations. DRP concentrations in the Cust River at Skewbridge Road, the Ohoka River at Island Road and the Cam River at Marsh Road were in the “adequate” range for macrophyte growth, and median values at these sites exceeded the threshold indicative of a 70% probability of nuisance macrophyte growths (Matheson et al., 2012) (Figure 3-19). In the remaining sites median DRP concentrations were in the “good” range for macrophyte growth, within which the probability of nuisance macrophyte growths is 30% (Matheson et al., 2012) (Figure 3-19).

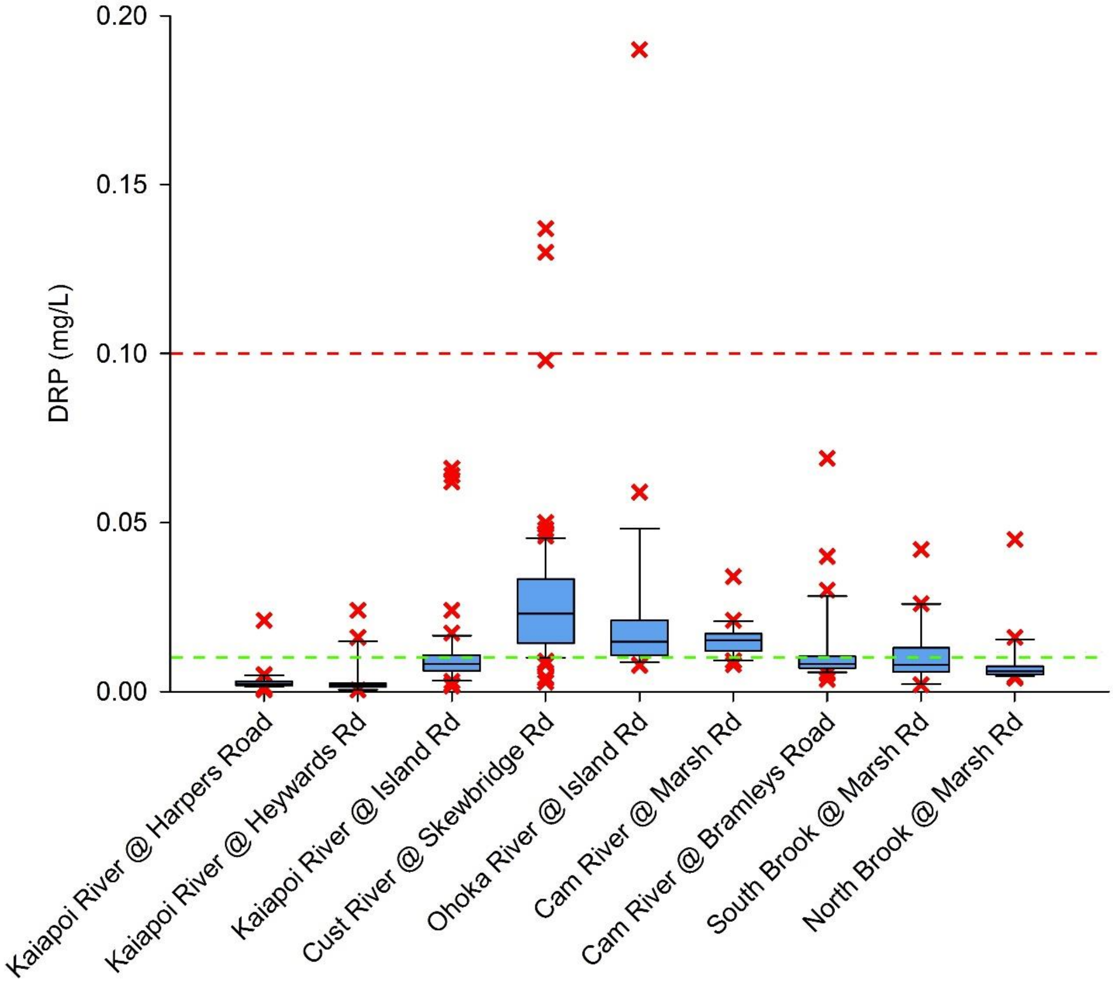

Figure 3-19 Distribution of DRP concentrations recorded in spring-fed rivers in the Kaiapoi River catchment. Red and green lines indicate the concentrations at which there is a 0.9 and 0.7 probability of nuisance macrophyte growths respectively (Matheson et al., 2012).

Nutrient availability is just one of a number of factors that influence macrophyte growth in spring-fed streams, and elevated DIN and DRP concentrations will not always result in nuisance macrophyte growths. However, as nuisance macrophyte growths **have been regularly observed** in most spring-fed streams in the Kaiapoi River catchment, it is apparent that factors such as light availability, flow conditions and rooting substrate are not limiting macrophyte growth, and current DIN and DRP concentrations are sufficient for nuisance growths in these streams.

Although spring-fed, the Cust River does have a hill-fed form, and in some years the plant community may be dominated by periphyton rather than macrophytes. Therefore, nutrient data must also be considered in terms of periphyton growth. Median DIN and DRP concentrations in the Cust River at Skewbridge Road far exceeded thresholds for the protection of biodiversity and trout habitat and angling values in rivers where the periphyton accrual period is 30 days (Biggs, 2000). Despite this, nuisance periphyton growths were rarely observed at the site, suggesting that factors other than nutrient availability, such as light availability, temperature or water velocity, and substrate type are limiting periphyton growth (Biggs, 2000).

Nutrients as toxicants

Water quality data suggests that there is significant ecological risk from nitrate toxicity in the Kaiapoi Cust and Ohoka Rivers. The highest NNN concentrations in the catchment were recorded in the Kaiapoi River at Harpers Road. There the median (Figure 3-20) and the 95th percentile (10.34 mg/L, not plotted) of recorded NNN concentrations far exceeded thresholds for the 80% protection of biodiversity (Hickey, 2013) and were above national bottom lines for nitrate toxicity under the NPS (2014) (Table 2-3). That bottom lines are not being met will have a significant influence on the future management of the catchment, as these values (median NNN = 6.9 mg/L; 95th percentile NNN = 9.8 mg/L) represent the maximum nitrate limits that can be set by a water plan. Concentrations will have to reduce in the Kaiapoi River catchment if these limits are to be met at Harpers Road. Median values (Figure 3-20) and 95th percentiles of NNN concentrations recorded in the Kaiapoi River at Heywards Road, the Kaiapoi River at Island Road and the Cust River at Skewbridge Road (95th percentiles = 6.84 mg/L, 5.69 mg/L and 5.7 mg/L respectively) exceeded thresholds for the 90% protection of biodiversity (Hickey, 2013) and were in the C band for nitrate toxicity under the NPS (2014) (Table 2-3). Although both the median and 95th percentile (4.94 mg/L) of NNN concentrations recorded in the Ohoka River at Island road were also in the C band under the NPS (2014), concentrations were slightly lower than in the Kaiapoi and Cust Rivers, and 95th percentile did not exceed the threshold for the 90% protection of biodiversity (Table 2-3).

NNN concentrations were much lower in the Cam River catchment, than in the Kaiapoi, Cust and Ohoka Rivers, and it is unlikely that nitrate toxicity is having detrimental effects on ecosystem health in this system. The median (Figure 3-20) and 95th percentile (3.5 mg/L) of NNN concentrations recorded in the South Brook at Marsh Road exceeded thresholds for the 99% protection of biodiversity (Hickey, 2013) and were in the B band for nitrate toxicity under the NPS (2014) (Table 2-3). Median NNN values recorded in the Cam River at Marsh Road, the Cam River at Bramleys Road and the North Brook at Marsh Road were below the threshold for the 99% protection of biodiversity (Hickey, 2013) (Table 2-3) and in the A band for nitrate toxicity under the NPS (2014). However 95th percentile of NNN concentrations recorded at all three sites (1.87 mg/L, 2.22 mg/L and 1.78 mg/L in the Cam River at Marsh Road, the Cam River at Bramleys Road and the North Brook at Marsh Road respectively) exceeded the threshold for the 99% protection of biodiversity and were in the B band for nitrate toxicity (Table 2-3). Although thresholds for the 99% protection of biodiversity were breached in every site in the Cam River catchment, 95% protection thresholds were not breached (Hickey, 2013), and it is unlikely that nitrate toxicity is having a significant effect on ecosystem health at these sites.

Despite the risks posed by the high nitrates in the upper Kaiapoi River, resident invertebrate communities, particularly those at the Heywards Road site, are still healthy compared to those in other streams in the catchment (Table 3-18). Consequently, it is apparent that nitrate toxicity is not the only, or most important, driver of ecosystem health in the Kaiapoi River catchment. This is not to say that if NNN concentrations were to decrease, biodiversity would not improve. Rather, there may be multiple stressors driving the degraded state of invertebrate communities in the Kaiapoi River catchment, and factors such as deposited fine sediment and macrophyte growth are likely also important.

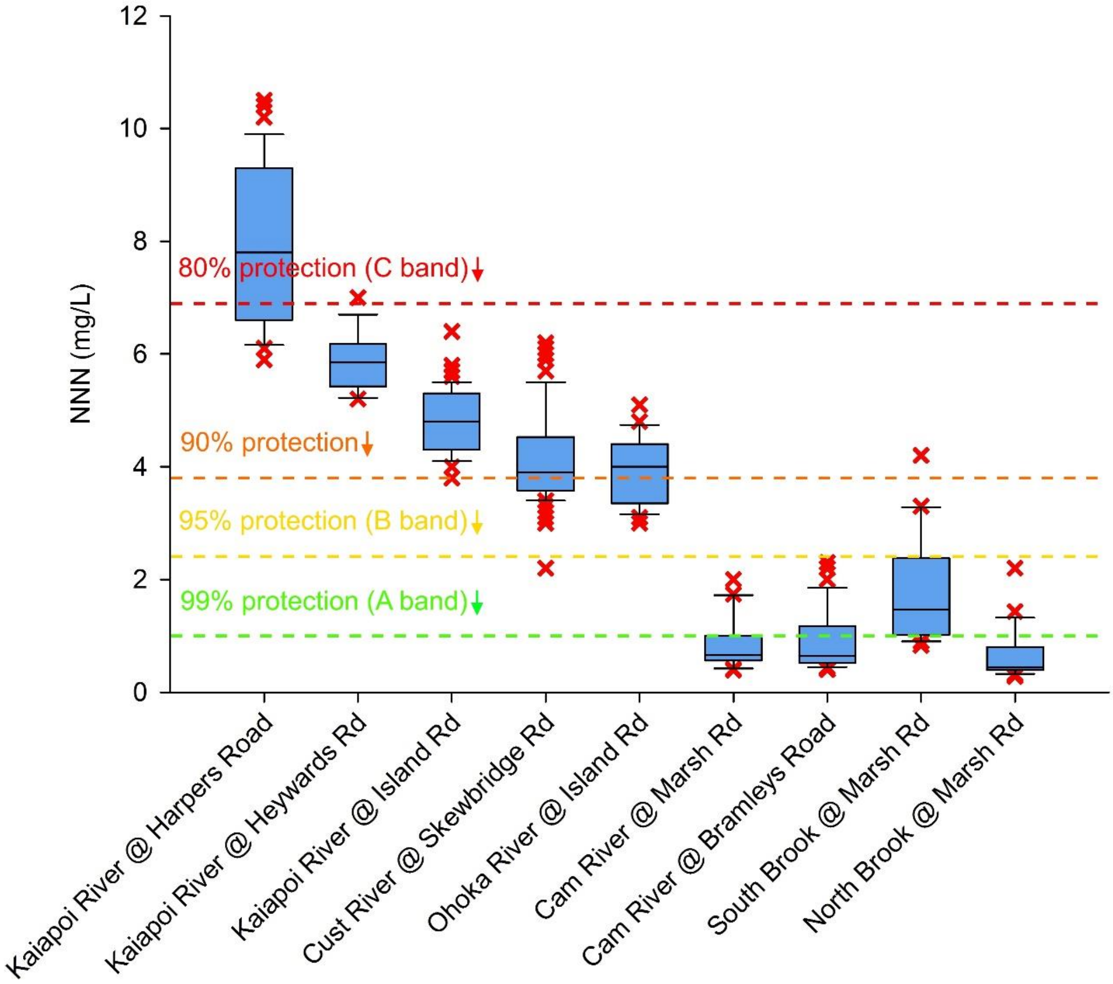

Figure 3-20 Distribution of NNN concentrations recorded in spring-fed rivers in the Kaiapoi River catchment. The coloured lines represent thresholds for the protection of biodiversity from nitrate toxicity (Hickey, 2013) and the boundaries of NPS (2014) bands.

Ammonia toxicity does not appear to be a significant threat to ecosystem health in spring-fed rivers in the Kaiapoi River catchment. Median NH_4N concentrations at all of the spring-fed sites in the Kaiapoi River catchment were below the threshold for the 99% protection of biodiversity (Hickey, 2014) (Table 2-3), and were in the A band for ammonia toxicity under the NPS (2014) (Figure 3-21). Although not plotted, the maximum NH_4N concentrations in the Kaiapoi River at Harpers Road, the Kaiapoi River at Heywards Road, the Cam River at Bramleys Road and the North Brook at Marsh Road (0.02 mg/L, 0.01 mg/L, 0.047 mg/L and 0.043 mg/L respectively) were also below the threshold for the 99% protection of biodiversity (Hickey, 2014) and in the A band for ammonia toxicity under the NPS (2014). Maximum NH_4N concentrations recorded in the Kaiapoi River at Island Road, the Cust River at Skewbridge Road, the Ohoka River at Island Road, the Cam River at Marsh Road and the South Brook at Marsh Road (0.09 mg/L, 0.16 mg/L, 0.16 mg/L, 0.06 mg/L and 0.07 mg/L respectively) did exceed the threshold for the 99% protection of biodiversity from ammonia toxicity (Hickey, 2014) (Table 2-4). However, the maximum concentrations at these sites were well below the threshold for 95% protection (Hickey, 2014) and only just in the B band under the NPS (2014). These data suggest that there is likely only a low risk of ammonia toxicity negatively affecting invertebrate communities in the Kaiapoi River catchment

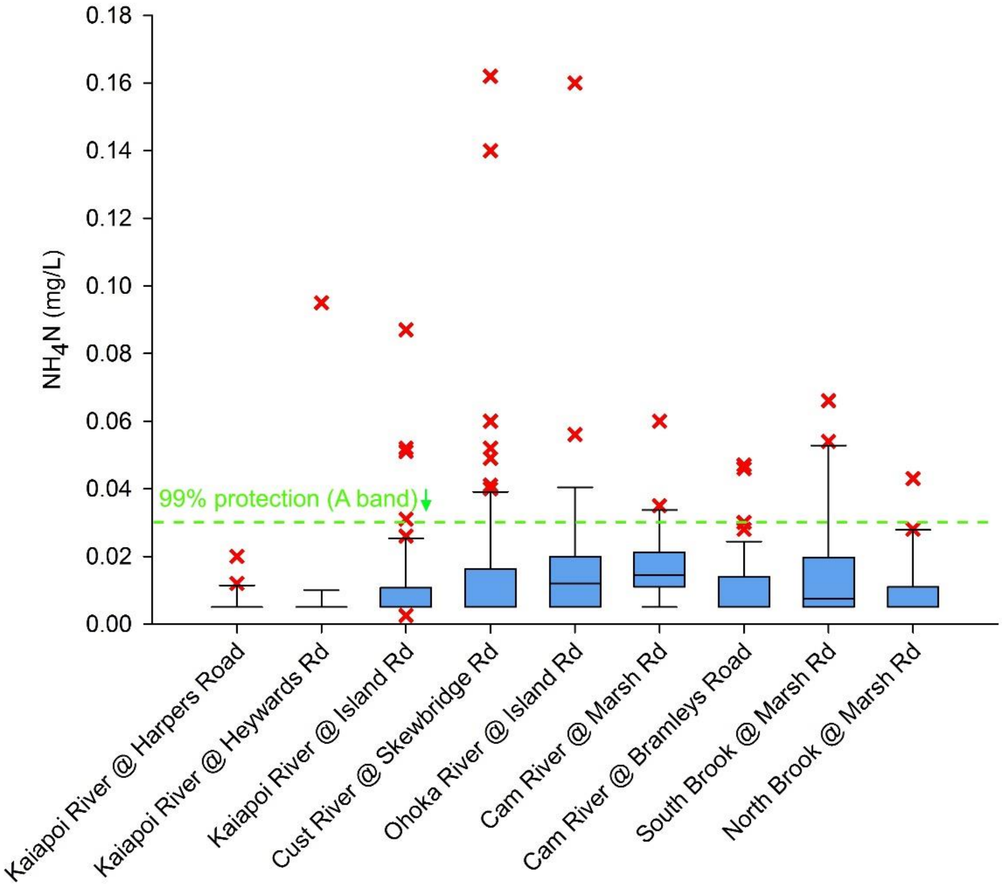

Figure 3-21 Distribution of NH_4N concentrations recorded in spring-fed rivers in the Kaiapoi River catchment. The coloured lines represent thresholds for the protection of biodiversity from ammonia toxicity (Hickey, 2014) and the boundaries of NPS (2014) bands.

TSS

TSS does not appear to be a contributor of poor ecosystem health in spring-fed streams in the Kaiapoi River catchment. Seventy-five percent of TSS concentrations recorded at all sites were below the commonly cited threshold of 25 mg/L for the onset of detrimental effects (APEM, 2007; Rowe et al., 2003; Singleton, 2001) (Figure 3-22). The only very high TSS concentration recorded in the past five years in the Kaiapoi River catchment was during a 7.5 m^3/sec flood in the Cust River, when TSS concentration at the Skewbridge Road sites was140 mg/L (Figure 3-22).

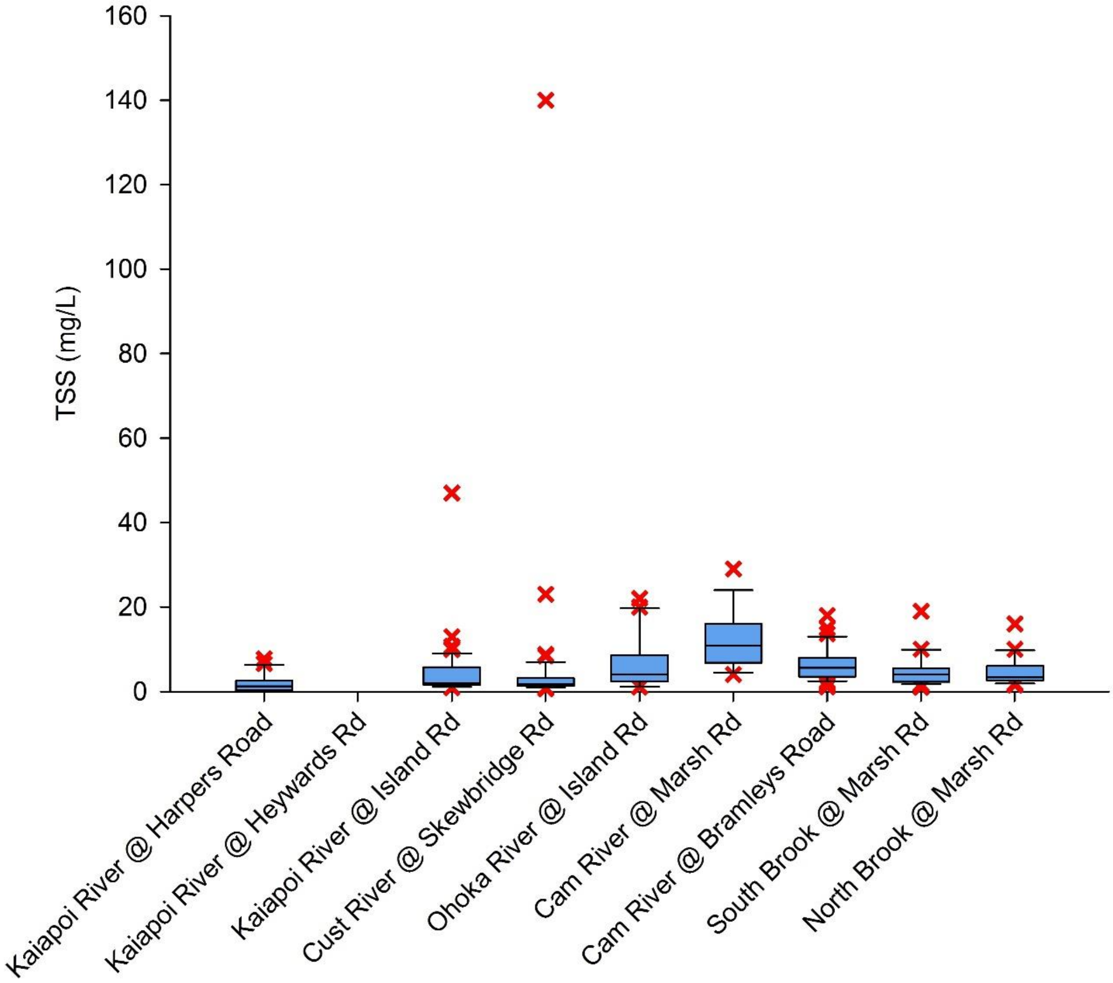

Figure 3-22 Distribution of TSS concentrations recorded in spring-fed rivers in the Kaiapoi River catchment.

E.coli

Most spring-fed rivers in the Kaiapoi River catchment are unsuitable for contact recreation due to significant faecal contamination. Median *E.coli* levels at all sites exceeded the alert level of 260 MPN/100 mL. With the exception of at Kaiapoi River at Heywards Road, the MfE/MoH (2003) action level of 550 MPN/100 mL has been breached at all sites during the past five water years. In addition, median *E.coli* levels at all sites exceeded the alert level of 260 MPN/100 mL (Figure 3-23). Although data for the site is not presented in the body of this report, Environment Canterbury's contact recreation monitoring programme has also graded the Kaiapoi River through Kaiapoi as unsuitable for contact recreation since 2010 (Appendix 2)

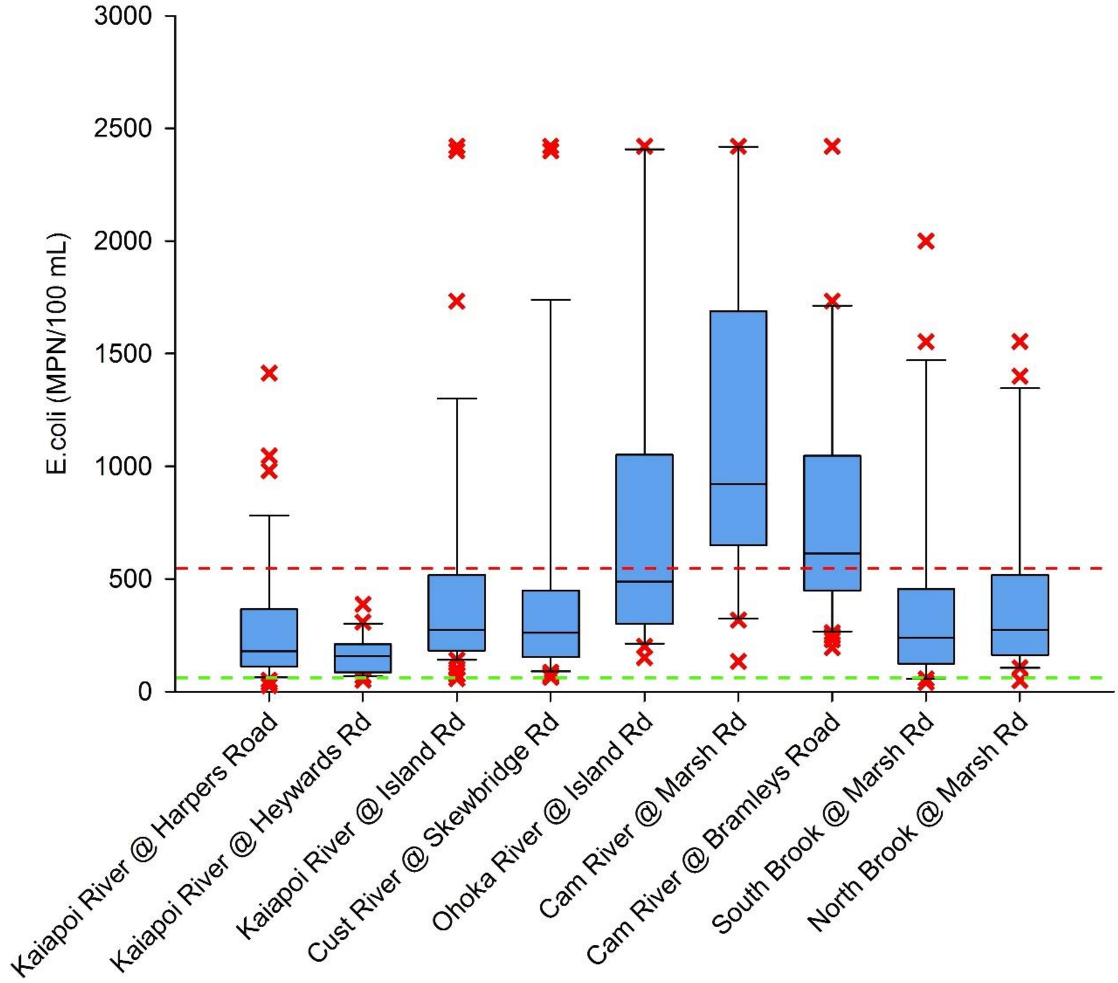

Figure 3-23 Distribution of *E.coli* levels recorded in spring-fed rivers in the Kaiapoi River catchment. The redline indicates the threshold at which a site is considered unsuitable for contact recreation (MfE/MoH, 2003), the green line indicates the alert level prescribed by MfE/MoH (2003).

3.3.2 Trends in water quality

Initial analysis of the NH_4N concentrations indicated a step-change reduction in 2012 at the Kaiapoi River at Island Road, the Cust River at Skewbridge Road, the Cam River at Marsh Road, the Cam River at Bramley's Road, the South Brook at Marsh Road, and the North Brook at Marsh Road. This reduction occurred at the same time as Environment Canterbury changed the laboratories which was accompanied by an increase in detection limit and a reduction in resolution at low concentrations. Consequently, these data were not analysed further.

Significant and environmentally meaningful water quality trends in both directions were observed in spring-fed rivers in the Kaiapoi River catchment. Between 1999 and 2016 statistically significant and environmentally meaningful upward trends in DIN and NNN, and a significant and meaningful downward trend in DRP were observed in the Kaiapoi River at Island Road (Table 3-25). Over the same period significant and meaningful downward trends in DIN, NNN and TSS were observed in the Cust River at Skewbridge Road (Table 3-25) and significant downward trends in DRP NH_4N and TSS were observed in the Ohoka River at Island Road (Table 3-25). Decreasing trends in *E.coli* and TSS were observed in the South Brook at Marsh Road between 2005 and 2016. Over the same period decreasing trends in DRP were observed in the North Brook at Marsh Road (Table 3-25).

Table 3-25 Temporal trends in various physico-chemical parameters in spring-fed rivers in the Kaiapoi River catchment

		Kaiapoi River @ Island Rd		Cust River @ Skewbridge Rd		Ohoka River @ Island Rd		Cam River @ Marsh Rd		Cam River @ Bramleys Road		South Brook @ Marsh Rd		North Brook @ Marsh Rd	
	Adjustment	P	RSSE	P	RSSE	P	RSSE	P	RSSE	P	RSSE	P	RSSE	P	RSSE
DIN	Flow adjusted	0.000	2%	0.000	-1%	0.005	-1%			0.076	-4%			0.542	-4%
	Unadjusted	0.000	2%	0.006	-1%	0.003	-1%	0.467	-1%	0.000	-5%	0.266	-2%	0.968	0%
DRP	Flow adjusted	0.000	-4%	0.238	-2%	0.000	-6%			0.096	-10%			0.310	4%
	Unadjusted	0.000	-4%	0.182	-2%	0.000	-7%	0.670	0%	0.000	-78%	0.070	-5%	0.004	-5%
E coli	Flow adjusted	0.388	-2%	0.871	0%	0.730	-1%			0.149	-11%			1.000	2%
	Unadjusted	0.375	-2%	0.642	-1%	0.736	0%	0.767	1%	0.149	3%	0.002	-12%	0.161	-4%
NH_4N	Flow adjusted					0.000	-9%								
	Unadjusted					0.000	-9%								
NNN	Flow adjusted	0.000	2%	0.001	-1%	0.015	-1%			0.105	-4%			0.542	-3%
	Unadjusted	0.000	2%	0.004	-1%	0.010	-1%	0.549	-1%	0.000	-4%	0.235	-2%	0.842	0%
TSS	Flow adjusted	0.142	-3%	0.185	-2%	0.011	-5%			0.460	-4%			0.408	-2%
	Unadjusted	0.367	-2%	0.028	-6%	0.005	-5%	0.741	2%	0.011	-3%	0.002	-10%	0.582	-2%

- (light blue) Statistically significant decrease. Not environmentally meaningful
- (blue) Statistically significant decrease. Environmentally meaningful
- (light orange) Statistically significant increase. Not environmentally meaningful
- (orange) Statistically significant increase. Environmentally meaningful

3.3.3 Comparison against the NPS

Attribute states varied significantly within and between sites. Kaiapoi River at Harpers Road was in the D band for the nitrate toxicity attribute, and did not meet national bottom lines which will have a significant influence on the future management of the catchment. All other sites were either in the B or C band for that attribute. All sites were in the A or B bands for the ammonia toxicity attribute, and in the B or C bands for the median *E.coli* attribute (Table 3-26). However, with the exception of Kaiapoi River at Heywards Road, all sites were above the B band for 95th percentile *E.coli* attribute, which indicates that the requirements for undertaking activities likely to involve full immersion are not being met (Table 3-26). The specific values supported by the particular attributes and a numeric and narrative explanation of each attribute state (A, B, C, D etc.) are outlined in Appendix 1.

Table 3-26 Water quality results compared to numeric attributes as specified in the National Policy Statement for Freshwater Management (2014)

	Nitrate toxicity lowest grade	Ammonia toxicity lowest grade*	*E.coli* median	*E.coli* 95th percentile
Kaiapoi River @ Harpers Road	D	A	B	**
Kaiapoi River @ Heywards Rd	C	A	B	B
Kaiapoi River @ Island Rd	C	B	B	**
Cust River @ Skewbridge Rd	C	B	B	**
Ohoka River @ Island Rd	C	B	B	**
Cam River @ Marsh Rd	B	B	C	**
Cam River @ Bramleys Road	B	A	C	**
South Brook @ Marsh Rd	B	B	B	**
North Brook @ Marsh Rd	B	B	B	**

* ammonia attribute state boundaries calculated at pH 8 and 20˚C. Site specific boundaries not calculated

** sites do not meet the requirements for undertaking activities likely to involve full immersion

3.3.4 Summary

Invertebrate communities are in a degraded state in most spring-fed rivers the Kaiapoi River catchment. Fine sediment cover is also high across the catchment, which is undoubtedly a key driver of poor ecosystem health. Although, the available data suggests nitrate toxicity is not the most important driver of degraded invertebrate health throughout much of the catchment, the exceedingly high nitrate concentrations observed in the Kaiapoi River, the Cust River and the Ohoka River are undoubtedly a contributing factor. Elevated nutrient concentrations may also be having indirect effects on invertebrates by allowing potentially detrimental macrophytes to proliferate.

In terms of recreational value spring-fed rivers in the Kaiapoi River catchment are unsuitable for contact recreation due to significant faecal contamination. However, toxic cyanobacteria does not appear to pose a health risk.

Increasing trends in DIN and NNN were observed in the Kaiapoi River, while decreasing trends in the same parameters were observed in the Cust River. Decreasing trends were also observed in TSS in the Cust River, in TSS, DRP and NH_4N in the Ohoka River, in *E.coli* and TSS in the South Brook and in DRP in the North Brook.

Under the NPS for freshwater management (2014) national bottom lines for nitrate toxicity are not being met in the upper Kaiapoi River. That bottom lines are not being met will have a significant influence on the future management of the catchment, as these values represent the maximum nitrate limits that can be set by a plan. Therefore, nutrient inputs from adjacent land use will have to reduce if this limit is to be met in the Kaiapoi River at Harpers Road.

3.4 Upper Ashley River – Lees Valley

There has not been comprehensive long-term data collected from Lees Valley, but quarterly water sampling was conducted in 2014/15 (18 months of quarterly data). The limited available data indicates that current nutrient concentrations are low. However, as the river reaches through Lees Valley and the Gorge are currently in excellent condition, any increase in nutrient concentrations should be avoided, as this could result in ecologically detrimental algal growths. The spring-fed stream systems and wetland areas in the Lees Valley are also important aquatic habitats. Their maintenance of these habitats is important to ensure they do not become sources of contaminants such as sediment, phosphorus and *E coli* that could affect the significant ecological and recreational values of the waterways in this area

3.5 Lower tidal Kaiapoi River

Extensive reaches of the lower Kaiapoi River below the three streams confluence (Silverstream, Ohoka, and Cust Main Drain) and the lower Cam River (below the Bramley Road monitoring site) are tidal, and support a wide array of ecological, cultural, recreational and commercial values. Historically the lower Kaiapoi River was the North Brach of the Waimakariri River, and was a significant flood hazard. This necessitated the diversion of the Waimakariri River into “Wrights Cut”. Today the Kaiapoi River is an oversized channel, with a tidal zone that passes through the middle of Kaiapoi, a town that prides itself on the title of “River Town”. Kaiapoi has a long history of both utilising the river for transport and storm water, and addressing environmental issues associated with industry (Kaiapoi Woolen Mills, North Canterbury Freezing Works, Wool Scours and Tannery). The current emphasis is on understanding the river system, and improving both the habitat and water quality to enhance its value as ‘selling point’ for the town of Kaiapoi.

The challenge in managing and improving the Kaiapoi River is that it behaves like a tidal coastal lagoon, or lake, with long water residence time and interactions with the Waimakariri River, both in terms of tidal inundation from the sea and inundation with backflows of Waimakariri River floodwater. Understanding and managing this system is; therefore, much more complicated than managing the linear issues facing swiftly flowing streams and rivers. Effective management will require a mix of practices normally associated with “lake management”, “estuary management” and “river management”. Investigations and monitoring are underway in the Kaiapoi River to develop an understanding of this complex system, so that it can be managed appropriately.

3.6 Courtenay Stream and Kaikainui Stream

The Courtenay Stream and its tributary the Kaikainui Stream are a significant spring fed stream system to the south and east of Kaiapoi. Courtenay Stream picks up flow from a large number of springs close to the margin of the Waimakariri River. However, nitrate concentrations in these springs indicate this water is primarily from the Waimakariri Zone rather from the Waimakariri River. Issues in Courtenay Stream are likely to be very similar to those of other studied spring fed streams in the zone and include high nutrient concentrations, sediment accumulation, and excessive macrophyte growths.

The Kaikainui Stream was historically a strongly flowing spring fed stream system, but most of the strongest flowing springs in its headwaters have now been diverted into the Courtenay Stream. Today the stream primarily receives flow from the storm water from the southern part of Kaiapoi Township and surface run-off from the area to the south of the town. As a result, most reaches of the Kaikainui are sluggish or stagnant. At its lower end the Stream has been configured as a storm water treatment facility to settle out suspended sediments and treat/accumulate common storm water contaminants. Consequently, the issues with Kaikanui Stream; predominantly centre around the treatment of stormwater management issues

3.7 Eyre River and hill fed tributaries, and View Hill Stream.

The Eyre River and View Hill Stream drain the majority of the foot hill area to the south of Oxford Township. The upper catchments of both streams comprise a broad network of small gravel streams that descend from the foothills, sometimes along narrow valleys and exit onto the plains. At the foot of the hills, there are also remnants of extensive wetlands and spring systems. For the majority of the time flows from the Eyre River and View Hill Stream are lost into the plains gravels, and are a significant part of the water balance of the Eyre groundwater allocation zone.

The Eyre River can still flow the length of the plains, particularly in winter after heavy or sustained rainfall. These episodes are important in providing opportunities for recruitment of fish (particularly native fish like eels) into the perennial headwater streams and wetlands. Past sampling has indicated that the water quality of the Eyre River catchment is generally good, and when it flows across the plains water quality is likely to be high.

Historical water quality data on these river systems will be made available as separate memos.

3.8 Losses to the Waimakariri River

The Eyre River and Kaiapoi River are the two major connections to the Waimakariri River, through which water and contaminant loads are discharged. However, consideration should be given to any other pathways where contaminant loads may be discharged from the zone. Large braided rivers such as the Waimakariri River frequently contain seeps and springs along their margins that are fed by adjacent aquifers. These need to taken into account in management of contaminants.

It is known that nutrient rich seeps and springs discharge along the northern bank of the Waimakariri River, and it is likely that these seeps discharge nutrients lost from the Waimakariri Zone. Some of these seeps and springs form a significant spring fed stream (Smiths Stream) that arises in the bed of the Waimakariri. Recent sampling of Smiths Stream indicates that nitrate concentrations are very high, and that the stream receives a significant nutrient load from the Waimakariri zone. There has not been a comprehensive search for similar systems in the bed of the Waimakariri. However, the potential existence of these systems should be considered when calculating loads lost from the zone and quantifying the impact of land-use on the Waimakariri River.

Data collected from Smiths Stream will be written up in a separate memorandum.

3.9 Cust River

The Cust River arises in the foothills north west of Oxford, and meanders through a number of landforms (plains, basins, relic river valleys and wetlands), before joining the Kaiapoi River. The comprehensive water quality data presented in this report for the Cust River system is limited to a single site on the lower reaches of the Cust Main Drain. This site is only representative of the values, habitats and water quality in the lower spring fed and wetland fed river reaches. The upper Cust River has both perennial and intermittently flowing reaches that support very different values and habitats to the Cust Main Drain. These have been studied in past investigations and some recent snapshot or gap-filling sampling. These data will be presented later in short memorandum.

Recently NIWA (National Institute of Water and Atmospheric Research) has completed four years (2012 to 2016) of sampling at two sites on the Cust River, including a site in the upper Cust. These data have been accessed from NIWA and collated by contract into a data report. This was accessed too late to incorporate into this report, but provides a comprehensive picture of the ecology of the site in the upper catchment.

3.10 Coastal wetlands and drains

The coastal area between the Pegasus Bay Sand Dunes and State Highway One is an important and unique area of the zone, with a number of significant water features. These include the remnants of the springs and wetlands behind the dune systems; the significant historical Kaiapohia Pa site, Tutaipatu Lagoon; and the areas that are currently being rehabilitated by Te Kōhaka o Tūhaitara Trust such as the Pines Beach lagoon. Further inland, other wetland and lake systems are found, including an array of gravel pits (the Kaiapoi Lakes subdivision and associated lake reserves, currently worked gravel operations) and the recent Pegasus Township lake and wetlands. These are all drained by either managed drain networks or modified stream systems (McIntosh's Drain, Jockey Baker Creek, Kairaki Stream/Saltwater Creek) or connect into major spring fed streams (Taranaki Creek).

A number of these waterways have been investigated historically (i.e. Kaiapoi Lakes), are currently monitored by other agencies (Pegasus Lake) or are the subject of some current “gap-filling” investigations. These data was not available for this report and will be developed as separate memorandum.

4 Discussion

Invertebrate monitoring data suggests that aquatic ecosystem health is degraded throughout much of the Waimakariri CWMS zone. There is limited long term invertebrate data available for hill-fed rivers in the Ashley River catchment, and only the Ashley and Grey Rivers have data records longer than one year. However, the limited data does suggest that invertebrate community heath in most hill-fed rivers in the catchment was degraded on the years that that sampling was conducted. Indeed, the only rivers where recorded QMCI scores did not breach the LWRP outcome at least once were the Glentui and Garry Rivers. Similarly, the composition of invertebrate communities in spring-fed systems in both the Ashley River and Kaiapoi River catchment indicate that water quality in these systems is either poor or only fair (Stark and Maxted, 2007). The only spring-fed site to regularly meet the LWRP QMCI outcome in either catchment was the Kaiapoi River at Heywards Road, where invertebrate community composition was consistently indicative of either good or excellent water quality (Stark and Maxted, 2007). The drivers behind the poor invertebrate communities in the Waimakariri zone are likely complex, and somewhat difficult to determine from the available data.

At high concentrations nitrate and ammonia are toxic to aquatic fauna, and toxicity effects can be important drivers of ecosystem health in agricultural landscapes like the Waimakariri CWMS zone. However, the available data suggests that ammonia toxicity is not a significant risk to biodiversity in any of the zones rivers and streams. In the Ashley River catchment the risk of nitrate toxicity affecting biodiversity is also low. However, there is a significant risk of nitrate toxicity impacting ecosystem health in the Kaiapoi River, the Cust River and the Ohoka River, and a number of thresholds set to protect biodiversity have been breached in these rivers since 2011 (Hickey, 2013). The highest nitrate concentrations in the zone were recorded in the Kaiapoi River at Harpers Road, where both the median and the 95th percentile values exceeded thresholds for the 80% protection of biodiversity (Hickey, 2013). Despite the risks posed by the high nitrate concentrations in the upper Kaiapoi River, invertebrate communities are still healthy when compared to other streams in the catchment, and indeed many other lowland Canterbury rivers. This suggests that nitrate toxicity is unlikely to be the most important driver of ecosystem health in the Kaiapoi River catchment. This is not to say that if NNN concentrations were lower, biodiversity would not improve, rather there may be multiple stressors driving degraded ecosystem health in the Kaiapoi River catchment and factors such as fine sediment and macrophyte growth are also likely to be important. Although perhaps not the most important driver of ecological function, high nitrate concentrations in the upper Kaiapoi River are currently breaching national bottom lines for nitrate toxicity under the NPS (2014) (Hickey, 2013; Ministry for the Environment, 2014) which will have a significant influence on the future management of the catchment.

The role of aquatic plants on ecosystem health likely differs throughout the Waimakariri CWMS Zone. Despite DIN and DRP concentrations exceeding thresholds to protect benthic biodiversity from nuisance periphyton growths (Biggs, 2000), filamentous algal cover in most hill-fed rivers in the Ashley River catchment is generally below the LWRP periphyton outcome and the threshold for the protection of biodiversity (Biggs, 2000). Periphyton cover is, therefore, unlikely to be a key driver of the degraded invertebrate communities observed throughout much of the hill-fed rivers in the Ashley catchment. On the other hand, high concentrations of DIN and DRP combined with suitable growing conditions has led to high macrophyte cover throughout spring-fed streams in the Ashley River and Kaiapoi River catchment. LWRP total macrophyte and/or emergent macrophyte outcomes are regularly not being met at sites in Saltwater Creek, Taranaki Creek, Waikuku Stream, the Kaiapoi River the Ohoka River and the North Brook. This indicates that macrophyte cover may be having some negative ecological effects in certain reaches of these rivers, and may contribute to the degraded state of resident invertebrate communities. However, these effects are likely minimal compared to those caused by benthic fine sediment cover in these rivers.

The findings of this assessment highlight the risk posed by fine sediment input into rivers throughout the Waimakariri CWMS zone. Although suspended sediment concentrations are low throughout the zone, benthic fine sediment cover in hill-fed and spring-fed rivers in both the Ashley River and Kaiapoi River catchments generally exceeds LWRP outcomes and guideline values for the protection of biodiversity (Clapcott et al., 2011). Benthic sediment has a range of negative ecological effects on invertebrates, and has been shown to be the most important predictor of invertebrate community composition in some Canterbury streams (Greenwood et al., 2012). Given the detrimental effects of deposited fine sediment on invertebrates, it is likely that the high degree of sedimentation in rivers in the Waimakariri CWMS zone, particularly spring-fed systems, is contributing to the degraded state of resident invertebrate communities.

In terms of recreational value, the health risks posed by faecal contamination and toxic cyanobacteria vary between the zones hill-fed and spring-fed rivers. Faecal contamination is generally low in hill-fed rivers in the Ashley River catchment. However, Environment Canterbury's targeted contact recreation monitoring indicates that toxic cyanobacteria regularly poses a health risk at bathing sites along the Ashley River (Appendix 2). Most spring-fed rivers in both the Ashley River and Kaiapoi River catchment are unsuitable for contact recreation due to significant faecal contamination. Conversely toxic cyanobacteria does not appear to pose a significant health risk in these systems.

The only increasing trends in water quality observed in any of the rivers in the Waimakariri CWMS zone was an increase in DIN and NNN concentrations in the Kaiapoi River at Island Road. Decreasing trends in DIN, NNN, NH_4N, DRP, *E.coli* and TSS were observed in a number of spring-fed streams in both the Waimakariri and Ashley River catchments, and TSS was also found to be decreasing in the Ashley River at SH1.

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Appendix 1 National Policy Statement for Freshwater Management (2014) attribute tables

The following tables provide numeric and narrative descriptions of relevant attributes and attribute states

Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	Nitrate (Toxicity)		
Attribute Unit	mg NO_3-N/L (milligrams nitrate-nitrogen per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median	Annual 95th Percentile	
A	≤1.0	≤1.5	High conservation value system. Unlikely to be effects even on sensitive species
B	>1.0 and ≤2.4	>1.5 and ≤3.5	Some growth effect on up to 5% of species.
C	>2.4 and ≤6.9	>3.5 and ≤9.8	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
National Bottom Line	6.9	9.8	
D	>6.9	>9.8	Impacts on growth of multiple species, and starts approaching acute impact level (ie risk of death) for sensitive species at higher concentrations (>20 mg/L)

Value	Ecosystem health		
Freshwater Body Type	Lakes and rivers		
Attribute	Ammonia (Toxicity)		
Attribute Unit	mg NH_4-N/L (milligrams ammoniacal-nitrogen per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median*	**Annual Maximum***	
A	≤0.03	≤0.05	99% species protection level: No observed effect on any species tested
B	>0.03 and ≤0.24	>0.05 and ≤0.40	95% species protection level: Starts impacting occasionally on the 5% most sensitive species
C	>0.24 and ≤1.30	>0.40 and ≤2.20	80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)
National Bottom Line	**1.30**	**2.20**	
D	>1.30	>2.20	Starts approaching acute impact level (ie risk of death) for sensitive species

* Based on pH 8 and temperature of 20°C.

Compliance with the numeric attribute states should be undertaken after pH adjustment.

Value	Human health for recreation		
Freshwater Body Type	Lakes and rivers		
Attribute	*E. coli**		
Attribute Unit	*E. coli*/100 mL (number of *E. coli* per hundred millilitres)		
Attribute State	Numeric Attribute State	Sampling Statistic	Narrative Attribute State
A	≤260	Annual median	People are exposed to a very low risk of infection (less than 0.1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating)
		95th percentile	People are exposed to a low risk of infection (up to 1% risk) when undertaking activities likely to involve full immersion.
B	>260 and ≤540	Annual median	People are exposed to a low risk of infection (less than 1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	People are exposed to a moderate risk of infection (less than 5% risk) when undertaking activities likely to involve full immersion. 540 / 100ml is the **minimum acceptable state** for activities likely to involve full immersion.
C	>540 and ≤1000	Annual median	People are exposed to a moderate risk of infection (less than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating). People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities likely to involve immersion.
National Bottom Line	1000	Annual median	
D	>1000	Annual median	People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).

*Escherichia coli

Appendix 2 Memorandum regarding recreational water quality within the Waimakariri zone

FROM : KIMBERLEY ROBINSON AND MICHAEL GREER

TO : WAIMAKARIRI WATER ZONE COMMITTEE

SUBJECT : RECREATIONAL WATER QUALITY WITHIN THE WAIMAKARIRI ZONE

Background

Waterborne bacteria and cyanobacteria can affect human health causing respiratory or gastrointestinal illness, or skin infections. The purpose of this memorandum is to briefly summarise the recreational water quality for freshwater sites within the Waimakariri Zone.

Methods

Microbial water quality

The microbial quality of popular freshwater (rivers and lakes) and coastal (beaches and bays) swimming sites around Canterbury is assessed each summer for trends and risks to human health. The freshwater programme is based on the *Microbiological water quality guidelines for marine and freshwater recreational areas* (MfE & MoH, 2003), and measures concentrations of the faecal indicator bacteria *Escherichia coli*. *Escherichia coli* are an indicator of faecal contamination from warm blooded animals, which is in turn is an indication of the likely presence of disease causing organisms (bacteria, protozoa and viruses).

At each site, a weekly water sample for *Escherichia coli* is taken using a sterilised container from the shore of a river or lake at approximately 20 cm below the surface at a point where the depth of water is 1 metre. If a river site is less than 1m deep, the sample is taken from a deep run, or an inflow to a pool. The sample is chilled to a temperature below 8^{O}C, and analysed by Hill Laboratories in Christchurch, within 24 hours of the sample being taken. Results are reported on the Environment Canterbury website[2] typically between 24-48 hours after the sample being taken.

Data collected from this monitoring are assessed and reported in two ways:

- the number of faecal indicator organisms from a sample are compared to trigger values, and
- the suitability for recreation (referred to as suitability for recreation grade) is determined based on 5 years of bacteriological data and an assessment of contaminant risk factors in the vicinity of the site.

Each sample result is used to identify any immediate health risks at a site (for more information refer to Appendix 1), are important for monitoring changes in water quality and to determine surveillance modes (Table 2 in Appendix 1). When a sample result exceeds the Alert (260 E.coli per 100 ml of water) or Action (550 E.coli per 100 ml of water) guideline values, as prescribed by the Ministry for the Environment and the Ministry of Health (MfE & MoH, 2003), the site is re-sampled as soon as possible and management interventions are deployed if necessary (e.g. temporary warning signs, notification via Environment Canterbury website and Facebook page).

The suitability for recreation grade describes the general condition of site in terms of faecal contamination risk, and is used to track the changes to a site overtime. As prescribed by MfE/MOH 2003 guidelines the Suitability for Recreation Grade is calculated for each site at the end of each sampling season using a qualitative risk grading of the catchment, supported by the direct weekly measurements of faecal indicator bacteria made at the site. From this information sites are graded as very poor, poor, fair, good, or very good (Details on the how the grades are calculated are presented in Appendix 1).

[2] (http://ecan.govt.nz/services/online-services/monitoring/swimming-water-quality/Pages/Default.aspx)

Sites graded ‘very good’, ‘good’ and ‘fair’ are considered suitable for contact recreation, although ‘good’ and ‘fair’ sites may at times not be suitable. Sites graded ‘poor’ and ‘very poor’ are generally considered unsuitable for contact recreation, and there is public notification of this, via permanent signage at the site and/or through the media.

Weekly microbial monitoring for the faecal indicator bacteria *Escherichia coli* is carried out at six sites (Figure 1):

1. Ashley River at Rangiora-Loburn Bridge
2. Ashley River at Gorge
3. Kaiapoi River at Boat Ramp
4. Waimakariri River at Reids Reserve
5. Waimakariri River at Stewarts Gully
6. Lake Pegasus at Moto Quay

Cyanobacteria

Cyanobacteria blooms in both rivers and lakes can pose a risk to human and animal health via the production of cyanotoxins. Consequently, the presence of cyanobacteria can affect the suitability of a site for recreation. Environment Canterbury has monitored phytoplankton (floating algae, including cyanobacteria) in lowland lakes for many years, and has also been monitoring benthic cyanobacteria (which grow as mats on river stones) in rivers since 2007. In 2009 the Ministry for the Environment and Ministry of Health in 2009 released the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters: Interim Guidelines*, (MfE & MoH, 2009), which provide a robust monitoring method for planktonic and benthic cyanobacteria. Since this documents release, Environment Canterbury has established an cyanobacteria monitoring programme and response protocol. Potentially toxic benthic cyanobacteria mats are monitored weekly at five sites in the Waimakariri CWMS zone (Figure 1). These are:

1. Ashley River at Rangiora-Loburn Bridge
2. Ashley River at SH1
3. Ashley River at Gorge
4. Waimakariri River at Reids Reserve
5. Waimakariri River at Stewarts Gully.

When cover of cyanobacteria is low (<20% cover) coarse estimates of cover are made weekly (surveillance mode – see Appendix 2). When the cover starts to increase (>20%), a monitoring response protocol is initiated and quantitative surveys are carried out (for a full methodology refer to Appendix 3).

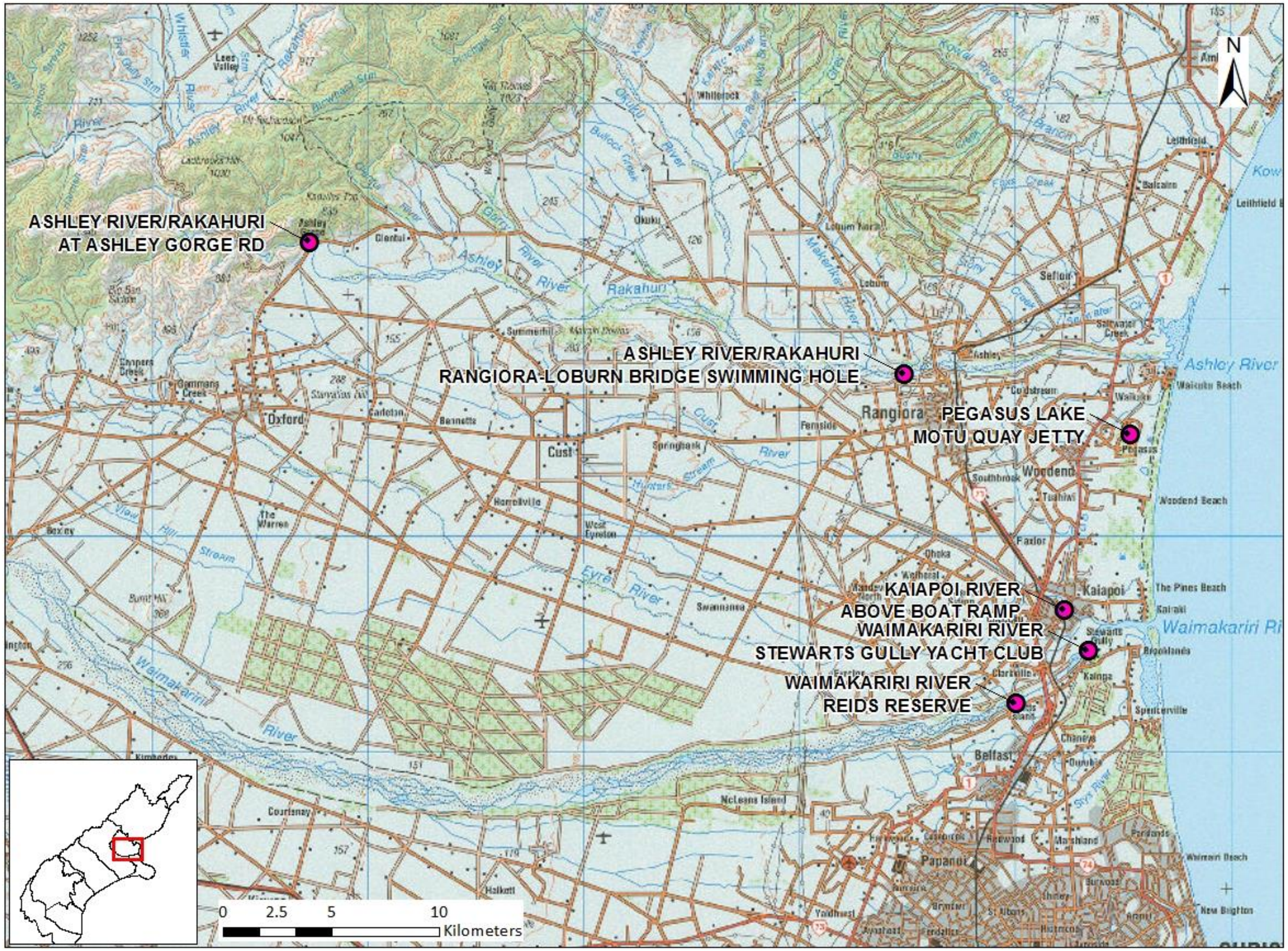

Figure A2-1 Study site locations

Pegasus Lake is not monitored for planktonic cyanobacteria by Environment Canterbury, but instead by the subdivision developer. In recent years, a public health warning has been issued by the Canterbury District Health Board (CDHB) due to elevated volumes of potentially toxic planktonic cyanobacteria in this lake.

Results

Microbial water quality

The Rakahuri/Ashley River is generally considered suitable for recreational activities involving full immersion, with grades of fair to good spanning the record of sampling based on microbial quality (Table 1). At times the Rakahuri/Ashley Gorge site may not be suitable for recreation due to elevated faecal indicator bacteria in the river following heavy rainfall. Grades with an asterix have been adjusted to reflect the suitability for recreation with the exception of rainfall affected data. These grades are under the provision that signage is in place advising that the site may not be suitable for recreation up to 48 hours following rainfall.

The Kaiapoi River has been consistently graded very poor for the duration of monitoring and the Waimakariri sites have been regularly graded as poor. Therefore, these sites are not considered suitable for recreational activities involving full immersion. Environment Canterbury have recently begun monitoring the Pegasus Lake at Moto Quay. A site must be monitored for 3 seasons before a grade can be calculated.

Table A2-1 Suitability for recreation grades

Site	2010/11	2011/12	2012/13	2013/14	2014/15
Ashley River/Rakahuri - gorge	Good*	Fair	Good*	Good*	Fair
Ashley River/Rakahuri above Rangiora-Loburn bridge	Fair	Fair	Fair	Fair	Fair
Kaiapoi River (Town)	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor
Waimakariri River - Reids Reserve	N/A	Fair*	Poor	Poor	Poor
Waimakariri River - Stewarts Gully	N/A	Insufficient data	Insufficient data	Poor	Poor

*excludes rainfall data

Cyanobacteria

Cyanobacteria survey data is only presented for sites where greater than 20% cover has been observed and quantitative surveys conducted. Therefore, results are not presented for the Ashley Gorge, Waimakariri River at Reids Reserve and Waimakariri River at Stewarts Gully sites, as cover has not exceeded the 20% cover threshold at those locations.

Cyanobacteria cover at both the Rangiora-Loburn Bridge and SH1 Bridge sites exceeded the 20% cover in 2010-11, 2012-13, and 2013-14 and threshold health warnings were issued by the Canterbury District Health Board on those years. Health warnings were also issued for the SH1 site in 2014-15. No warnings were issued in 2015-15 for the Rangiora-Loburn Bridge site, which was likely the result of bridge repairs resulting in sufficiently high water velocities to prevent cyanobacteria establishment. No warnings have been issued for any site on the Rakahuri/Ashley River for the 2015-16 season and this is most likely due to sustained low flows, which is known to reduce cyanobacteria cover (Heath *et al.* 2012).

Table A2-2: Annual maximum cover of potentially toxic benthic cyanobacteria and health warning status

Site	Season	Annual Max survey cover	Notes
Ashley River at SH1	**2010-11**	>80	Subsequent health warning issued by CDHB
	2011-12	<20	No health warning required
	2012-13	32	Subsequent health warning issued by CDHB
	2013-14	37	Subsequent health warning issued by CDHB
	2014-15	30.5	Subsequent health warning issued by CDHB
	2015-16	<20	10% bankside observation; No health warning required
Ashley River above Rangiora-Loburn bridge	**2010-11**	>80	Subsequent health warning issued by CDHB
	2011-12	<20	No health warning required
	2012-13	46.05	Subsequent health warning issued by CDHB
	2013-14	30.75	Subsequent health warning issued by CDHB
	2014-15	<20	13% bankside observation; No health warning required
	2015-16	<20	2% bankside observation; No health warning required

Summary

While sites on the Rakahuri/Ashley River are generally suitable for recreational activities involving full immersion in terms of microbial water quality, these sites may be considered a public health risk at times due to moderate-high cyanobacteria cover. At sites where faecal contamination is below public health risk thresholds, the public health risk for cyanobacteria is the major factor contributing to whether a site is suitable for recreation.

References

Heath MW, Brasell K, Young RG, Wood SA, Ryan KG 2012. Hutt River *Phormidium* Habitat Suitability Criteria and Hydraulic Habitat Assessment. Prepared for Greater Wellington Regional Council. School of Biological Sciences, Victoria University of Wellington Report No. MH01. 2012

Ministry for the Environment and Ministry of Health, 2003. *Microbiological water quality guidelines for marine and freshwater recreational areas.* Ministry for the Environment, Wellington.

Ministry for the Environment and Ministry of Health. 2009. *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines.* Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi and WM Williamson. Wellington: Ministry for the Environment.

Appendix 1. The national microbiological guidelines for recreational water quality

The recreational water quality monitoring programme follows the *Microbiological water quality guidelines for marine and freshwater recreational areas* (MfE & MoH, 2003). The 2003 guidelines use a qualitative risk grading of the catchment, supported by the direct measurement of faecal indicator bacteria to assess the suitability of a site for contact recreation which is provided as the Suitability for Recreation Grade.

These two components combine to give a site an overall *Suitability for Recreation Grade* (SFRG) (Table 1).

The two components to grading an individual site are:

- the *Sanitary Inspection Category* (SIC), which generates a qualitative risk assessment of the susceptibility of a water body to faecal contamination; and
- historical microbiological results (based on the 95th percentile of 5 years data). This generates a *Microbiological Assessment Category* (MAC), which provides a measurement of the actual water quality over time.

Table 1 Suitability for recreation grade (SFRG) matrix for freshwater sites (MfE & MoH, 2003)

Susceptibility to faecal influence		Microbiological Assessment Category (MAC) (95 percentile of 5 years data)			
		A	B	C	D
Freshwater		≤ 130 *E. coli*/100 mL	131-260 *E. coli*/100 mL	261-550 *E. coli*/100 mL	>550 *E. coli*/100 mL
Sanitary Inspection Category (SIC)	Very low	Very good	Very good	Follow-up*	Follow-up*
	Low	Very good	Good	Fair	Follow-up*
	Moderate	Follow-up*	Good	Fair	Poor
	High	Follow-up*	Follow-up*	Poor	Very poor
	Very high	Follow-up*	Follow-up*	Follow-up*	Very poor

* Indicates unexpected results requiring investigation (reassess SIC and MAC)

The Suitability for Recreation Grade describes the ***general condition*** of a site at any given time. The risk of becoming sick from swimming increases from sites graded 'very good' to 'very poor'. Sites graded 'very good', 'good' and 'fair' are considered suitable for contact recreation, although 'good' and 'fair' sites may at times not be suitable. Sites graded 'poor' and 'very poor' are generally considered unsuitable for contact recreation, and there is public notification of this, via permanent signage at the site and/or through the media. Appendix 1 provides a summary of what each of the grades means, based on the MfE/MoH (2003) guidelines.

Ongoing monitoring is an important component of the assessment of monitoring sites. This is particularly important for sites graded 'good' to 'poor', which tend to have variable water quality and contaminant risks. While the site grades will not change during the bathing season as a result of the monitoring during that season, the data collected during the season is important for monitoring unpredictable changes in water quality and for determining if management intervention is necessary (e.g. temporary warning signs, notification via Environment Canterbury website and Facebook page). The ongoing seasonal monitoring provides data for re-assessment of grades at the end of each summer.

During the summer monitoring season, individual sample results are used to determine surveillance modes (Table 2). When a sample result exceeds the Alert or Action guideline values the site is re-sampled as soon as possible. Some sites that have 'poor' or 'very poor' grades and have permanent warning signage are not re-sampled after exceedance of the Alert or Action modes.

Table 2 Response modes for sampling results during the summer monitoring period (MfE & MoH, 2003)

Surveillance modes	Single sample result	Action
Acceptable-Green mode	≤ 140 Enterococci /100 mL ≤ 260 *E.coli* /100 mL	Continue routine monitoring
Alert- Amber mode	>140 and ≤ 280 Enterococci/100 mL >260 and ≤ 550 *E.coli* /100 mL	Increase sampling Identify and report on possible sources
Action – Red mode	> 280 Enterococci/100 mL > 550 *E.coli* /100 mL	Increase sampling Identify and report on possible sources Erect warning signs Inform public

Microbiological assessment Categories (MAC)

A Microbiological Assessment Category (MAC) is calculated based on the 95th percentile value for all sites with at least three years of microbiological data, including the data collected over the summer of 2014-15. Site grades are provisional until they are based on five years of data.

Rainfall affected data

Rivers

For those river sites with 'poor' grades where rainfall is known to influence results, the MAC was also calculated on a subset of data that had all rainfall-affected results removed.

The criteria for removing rainfall-affected data aims to only remove data that match climatic/flow conditions that would deter people from swimming at the site. Criteria are:

- moderate to heavy rain on day of sampling
- river in flood, i.e. high flows (max. 2 days following peak flood)
- water turbid, i.e. still in flood

Sanitary Inspection Categories (SIC)

Environment Canterbury staff review the Sanitary Inspection Category (SIC) for each site with the categories ratified by the TAs and Public Health agencies.

Suitability for recreation grades at end of 2014-15 summer

The SIC and suitability for recreation grade for each site are summarised in Appendix 2. For more detailed information on the SIC, MAC and suitability for recreation grade at each site please refer to the annual summary report on the Environment Canterbury website. The 2014-2015 summary report will be available on the website in November.

http://ecan.govt.nz/services/online-services/monitoring/swimming-water-quality/Pages/Default.aspx

Appendix 2. Monitoring and response protocol for benthic cyanobacterial blooms in Canterbury Rivers (drafted by C&PH)

Background

Dog deaths and increased public awareness related to toxic cyanobacterial blooms has resulted in the release of a document titled "New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters: Interim Guidelines" by the Ministry for the Environment and Ministry of Health. This document outlines a suggested monitoring and response protocol for benthic and planktonic cyanobacteria in freshwater. These guidelines address the risk to public health from cyanobacteria in recreational waters. They do not specifically address the risk to public health from drinking water affected by cyanobacteria, or the risk to the health of animals (specifically dogs) from contacting or ingesting cyanobacteria.

This protocol does not cover the monitoring of cyanotoxins in drinking water supplies. The Drinking Water Standard for New Zealand 2005 (revised 2008) refers to cyanobacteria. Public Health Units should be consulted for more information where drinking water supplies are concerned. The results of cyanobacteria monitoring will be of interest to water supply managers, who will be advised of concerns by Public Health staff.

Roles and Responsibilities

Community and Public Health (C&PH), Public Health South (PHS), Environment Canterbury (ECan), and relevant Canterbury Territorial Authorities (TAs) have agreed to the framework for roles and responsibilities as recommended in section 2.4.1 of the MfE/MoH guidelines and outlined below.

- ECan coordinates the monitoring, sample analysis and reporting strategy.
- ECan implements surveillance and alert-level monitoring.
- C&PH/PHS reviews the effectiveness of the monitoring and reporting strategy.
- ECan informs C&PH/PHS and the relevant TA if alert or action levels are reached.
- C&PH/PHS ensures that the TA is informed.
- C&PH/PHS or the TA (with assistance from ECan) informs the public (including local runanga contacts) when the action level is exceeded, e.g. through media releases. C&PH/PHS and the TA jointly decide whether to erect warning signs at affected water bodies.
- It is the responsibility of C&PH/PHS to downgrade alert levels in accordance with the guidelines and in consultation with TAs and ECan.
- ECan collates the information for state of the environment reporting and a review of management policies.
- ECan will also post up to date information/warnings on their Swimming Water Quality web pages throughout the season. TA's are encouraged to post similar information on their web sites.

Legal Implications

While adherence to the guidelines is not mandatory, all agencies involved in water quality monitoring have legal obligations to protect public health. Legal action can be avoided by notifying the public as soon as a health risk is identified.

Public Education and Awareness

ECan and TA staff will ensure that Councillors are made aware of the issues surrounding recreational contact with water by humans, stock and dogs, and the need to be prepared should a cyanobacterial bloom event result in media coverage. C&PH/PHS, ECan and TAs will jointly increase public education and awareness by developing a base level of understanding of these issues within their communities. This may be achieved through articles in the local newspapers, information signs, pamphlets and attendance at local meetings. ECan will also post up to date information/warnings on their Swimming

Water Quality web pages throughout the season. TAs are encouraged to post similar information on their web sites.

ECan have developed an information poster and leaflet for display and distribution. TAs are encouraged to display these signs on community notice boards and campsites as appropriate. The parks section of ECan will be responsible for ensuring they are displayed in areas within their jurisdiction.

Signage

C&PH have developed permanent signs which are interchangeable between information and warning status. TAs are encouraged to erect these signs where mat proliferations have occurred in the past and have caused health concerns (e.g. dog deaths) in previous years, and/or where the alert level has been triggered.

It will be the TAs responsibility to ensure that the status of the signs are current. In some locations the change to the signs will be made by ECan samplers to ensure a timely response. A change to the warning status will be required when action level (red mode) is triggered. Replacement with the information version of the sign will occur when the action level has been downgraded, with the decision made by C&PH/PHS.

Note: ECan park staff will be responsible for ensuring that signage is current at recreational water spots within their jurisdiction.

Permanent Signs: Information/Warning to be erected at the following sites:

Region	Location	Responsibility
Christchurch	Nil	
Kaikoura	Nil	
Selwyn	Selwyn River at Glentunnel campsite	SDC
	Selwyn River at Whitecliffs – upstream of bridge	SDC
	Selwyn River at Whitecliffs – campsite	SDC
Waimakiriri	Ashley River at Rangiora-Loburn Bridge	ECan Parks
	Ashley River at SH1	ECan Parks
	Waimakariri River at Reids Reserve	ECan Parks
Hurunui		
	Waipara River at Teviotdale (2)	HDC
	Hurunui River SH1	
	Waiau River at Waiau (2)	
Ashburton	Nil	
Timaru	Opihi River at SH1	TDC
	Opihi River at Waipopo	TDC
	Opihi River at Saleyards Bridge	TDC
	Pareora River at Huts	TDC

Monitoring

ECan will undertake visual assessments and site surveys at rivers across the region that are popular for recreation and are considered to be at-risk of developing cyanobacterial blooms during the summer months. Surveillance monitoring will be based on bank-side visual estimates whereas Alert-level monitoring will involve fully quantitative transect surveys.

The following alert levels are taken from the MfE/MoH guidelines:

Alert Level	Actions
Surveillance Level (Green Mode) Up to 20% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Undertake weekly bank-side observations between spring and autumn at representative locations in the water body where known mat proliferations occur and where there is recreational use.

Alert level (Amber Mode) 20-50% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Notify the public health unit. • Conduct quantitative transect surveys at least fortnightly. • Recommend erecting an information sign that provides the public with information on the appearance of mats and the potential risks. • Consider increasing the number of survey sites to enable risks to recreational users to be more accurately assessed. • If toxigenic cyanobacteria dominate the samples, testing for cyanotoxins is advised. If cyanotoxins are detected in mats or water samples, consult the testing laboratory to determine if levels are hazardous.
Action Level (Red mode) ***Situation 1:*** Greater than 50% coverage of potentially toxigenic cyanobacteria attached to substrate, ***or*** ***Situation 2****:* Up to 50% where potentially toxigenic cyanobacteria are visibly detaching from substrate, accumulating as scums along river's edge or becoming exposed on the river's edge as the river levels drop.	• Immediately notify the public health unit. • If potentially toxic taxa are present then consider testing samples for cyanotoxins. • Notify the public of the potential risk to health – this should include temporary warning signage and a media release.

It is recommended that the Action level (red mode) not be changed from a higher to a lower level (e.g., from Action to Alert) until the percentage cover falls below the Action level (red mode) on successive surveying occasions (conducted at least fortnightly). The regularity of flushing flows should also be considered when downgrading health alerts.

Appendix 3. Field procedures for benthic cyanobacteria monitoring

(Adapted from NZ guidelines for Cyanobacteria in recreational Waters)

PURPOSE AND SCOPE: This section is to inform the sampler of the requirements and steps to obtain a representative in-stream observation of benthic cyanobacteria. This assessment produces data that will be used and analysed to determine the public health risk associated with potentially toxic benthic cyanobacteria mat presence.

RESPONSIBILITY: Initially by the sampler's supervising officer then the sampler.

PROCEDURE: During the summer months when recreational uses of Canterbury's rivers and streams are at their greatest, monitoring for the presence of potentially toxic benthic cyanobacteria mats is carried out. Summer students are employed during the university holidays to carry out this monitoring. Initially a bankside estimate is conducted at pre-determine popular recreational water quality sites, where the sampler will estimate the percent cover of a river reach that is covered in potentially toxic benthic cyanobacteria mats. Where the cover is below 20% the site is considered to be in surveillance mode. If the bankside estimate finds there is more than 15% cyanobacteria at a particular site, or there are sloughed mats accumulating along the river's edge and/or on stones protruding from the water's surface, a more intensive quantitative survey needs to be completed.

The following procedure details the quantitative survey methods and should be followed at each sampling site if the bank-side survey estimates more than 15% cover of potentially toxic benthic cyanobacteria:

- Initially do an inspection of a 30-60 m reach containing riffles and runs, taking note of the presence of cyanobacteria mats, and mark out 4 transect locations ~10-15 m apart.
- Fill in the time (in NZST, i.e. subtract one hour from daylight savings time) and date on the survey sheet and note the general presence / absence of cyanobacteria mats and any detached mats.
- Using the underwater viewer and starting at the most downstream transect to prevent disturbances of un-surveyed transects, wade into the river at a 90 degree angle to the river flow
- Split the transect into 5 equally spaced sites with the closest to waters edge site ~0.1-0.15 m deep, and the farthest site no deeper than 0.6m
- Hold viewer ~20cm under the water and estimate the proportion of viewer area taken up by the cyanobacterial mat to within 5% accuracy. Cover should only be recorded if mats are **> 1mm thick**, although it is also useful to record the presence of thins mats **(i.e. < 1 mm thick)**.
- Note the transect length, whether it's in a riffle or run, substrate type, and whether mats are detaching and/or exposed.
- Take temperature by dipping the end of the thermometer in the water for at least a minute.
- Move <u>upstream</u> to next transect and repeat survey.

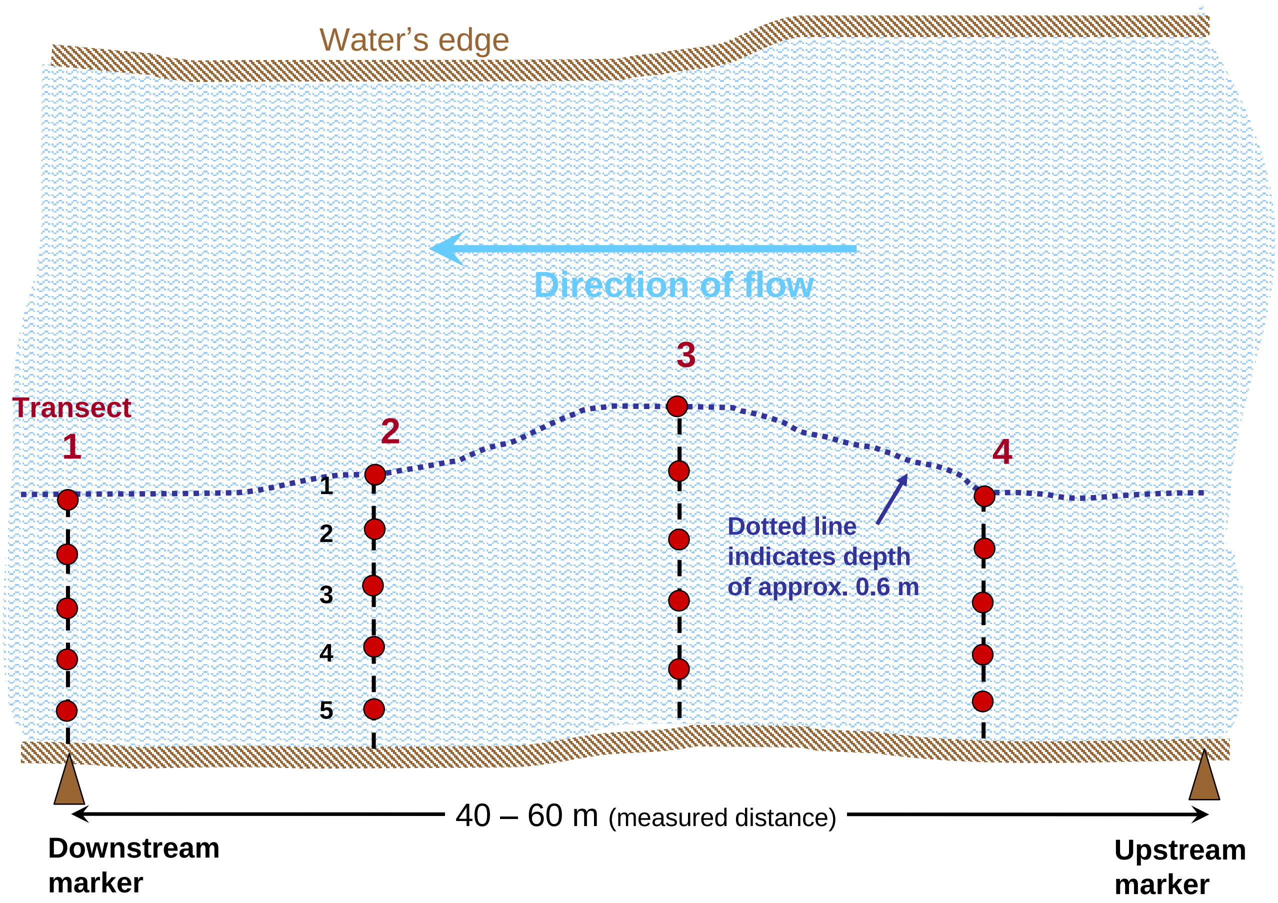

Figure 3: Schematic layout of transects (numbered in red) and survey areas (red circles, numbered in black) at a site (not to scale).

The numbering indicates the order in which assessments are made, and corresponds to the numbers on the monitoring form. The transects are spaced evenly along the survey reach. It may not always be possible to have five viewer results (i.e., steep sided rivers). In these circumstances take as many views as practical, per transect. If the river does not exceed 0.6 m in depth the transect should span its entire width (Source: C Kilroy, NIWA).

Calculate the average percent (%) cyanobacteria cover for each transect, then average % cover for each site. This is the figure used for determining the alert level of the monitoring and response protocols (Appendix 1)