Interim Global Stormwater Consent

Surface Water Quality Monitoring Report for the period May 2013 – April 2014

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1 INTRODUCTION 1

2 METHODS 1

2.1 Sites and Sample Collection 1

2.2 Water Quality Parameters Tested 5

2.3 Data Analysis 7

2.3.1 Summary Statistics 7

2.3.2 Temporal Trend Analysis 8

3 RESULTS 10

3.1 Summary Statistics and Comparison to Guidelines 10

3.1.1 Dissolved Copper 10

3.1.2 Dissolved Lead 10

3.1.3 Dissolved Zinc 10

3.1.4 pH 11

3.1.5 Conductivity 11

3.1.6 Total Suspended Solids 12

3.1.7 Turbidity 12

3.1.8 Dissolved Oxygen 12

3.1.9 Water temperature 13

3.1.10 Biochemical Oxygen Demand 13

3.1.11 Total Ammonia (Ammoniacal Nitrogen) 13

3.1.12 Nitrate 14

3.1.13 Nitrate Nitrite Nitrogen 14

3.1.14 Dissolved Inorganic Nitrogen 15

3.1.15 Dissolved Reactive Phosphorus 15

3.1.16 *Escherichia coli* 15

3.2 Temporal Trends 33

4 DISCUSSION 36

5 REFERENCES 39

6 APPENDIX A: METAL HARDNESS MODIFIED TRIGGER VALUES 41

7 APPENDIX B: SUMMARY DATA..... 44

1 Introduction

In accordance with the requirements of the Interim Global Stormwater Consent (IGSC; CRC090292), this report summarises the results of the Christchurch City Council (CCC) water quality monitoring across four of the five major catchments of Christchurch City – the Avon, Heathcote, Halswell and Otukaikino, for the period May 2013 to April 2014. Monthly water samples were collected from 23 sites within these catchments (Table 1, Figure 1). The remaining 20 sites in the CCC's monitoring program are covered under the Styx and South-West Stormwater Management Plans (SMPs; Table 1).

2 Methods

2.1 Sites and Sample Collection

Water samples were collected monthly by the Christchurch City Council laboratory, according to the protocol outlined in the monitoring plan. The classification of each waterway with respect to the Environment Canterbury (ECan) Proposed Land and Water Regional Plan (pLWRP) are shown in Table 1. These classifications determine the relevant guideline levels under this plan for each of the measured parameters for the various waterways. All the waterways in this report are classified as 'spring-fed – plains – urban' or are unclassified (Otukaikino River at Groynes inlet and City Outfall Drain). Results are compared against these guidelines in this report.

Table 1. Christchurch City Council water quality monitoring sites required under the three current Environment Canterbury (ECan) stormwater consents. IGSC = Interim Global Stormwater Consent; SMP = Stormwater Management Plan; pLWRP = proposed Land & Water Regional Plan.

Catchment	Site Description	Easting	Northing	ECan Consent	ECan pLWRP Waterway Classification
Avon	Wairarapa Stream	2478250	5742915	IGSC	Spring-fed – plains – urban
	Waimairi Stream	2478232	5742784	IGSC	Spring-fed – plains – urban
	Avon River at Mona Vale	2478334	5742658	IGSC	Spring-fed – plains – urban
	Avon River at Carlton Mill corner[1]	2479737	5742871	IGSC	Spring-fed – plains – urban
	Riccarton Drain	2478683	5741631	IGSC	Spring-fed – plains – urban
	Addington Brook	2479427	5741438	IGSC	Spring-fed – plains – urban
	Avon River at Manchester St	2480890	5742093	IGSC	Spring-fed – plains – urban
	Dudley Creek	2482575	5743763	IGSC	Spring-fed – plains – urban
	Avon River at Dallington Tce/Gayhurst Rd	2483562	5742822	IGSC	Spring-fed – plains – urban
	Horseshoe Lake discharge	2484344	5744907	IGSC	Spring-fed – plains – urban
	Avon River at Avondale Rd[1]	2484754	5745170	IGSC	Spring-fed – plains – urban
	Avon River at Pages/Seaview Bridge	2487487	5744202	IGSC	Spring-fed – plains – urban
	Avon River at Bridge St	2487694	5742425	IGSC	Spring-fed – plains – urban
Heathcote	Heathcote River at Templetons Rd	2475913	5738508	South-West SMP	Spring-fed – plains – urban
	Haytons Drain at Retention Basin	2476019	5739207	South-West SMP	Spring-fed – plains – urban
	Curletts Road Drain upstream of Heathcote River	2476927	5739322	South-West SMP	Spring-fed – plains – urban
	Curletts Road Drain at motorway[2]	2476404	5739969	IGSC	Spring-fed – plains – urban
	Heathcote River at Rose St	2478700	5737528	South-West SMP	Spring-fed – plains – urban
	Cashmere Stream at Sutherlands Road	2476084	5735598	South-West SMP	Not classified
	Cashmere Stream at Worsleys Rd	2479030	5736765	South-West SMP	Banks Peninsula
	Heathcote River at Ferniehurst St	2479157	5737222	South-West SMP	Spring-fed – plains – urban
	Heathcote River at Bowenvale Ave	2481198	5737390	IGSC	Spring-fed – plains – urban
	Heathcote River at Opawa Rd/Clarendon Tce	2483072	5739226	IGSC	Spring-fed – plains – urban
	Heathcote River at MacKenzie Ave[1]	2483521	5739528	IGSC	Spring-fed – plains – urban
	Heathcote River at Catherine St[1]	2484415	5739494	IGSC	Spring-fed – plains – urban
	Heathcote River at Tunnel Rd	2485076	5739154	IGSC	Spring-fed – plains – urban

[1] Sites monitored for a reduced suite of parameters, excluding turbidity, total nitrogen, total phosphorus, metals and dissolved organic carbon
[2] This site has only recently been re-instated after access was limited by motorway works, therefore no data is available to be presented in this report

Catchment	Site Description	Easting	Northing	ECan Consent	ECan pLWRP Waterway Classification
	Heathcote River at Ferrymead Bridge	2486494	5738760	IGSC	Spring-fed – plains – urban
Styx	Smacks Creek at Gardiners Rd	2476803	5749571	Styx SMP	Unclassified[3]
	Styx River at Gardiners Rd	2476789	5748841	Styx SMP	Unclassified[3]
	Styx River at Main North Rd	2479066	5748834	Styx SMP	Unclassified[3]
	Kaputone at Blakes Rd	2480401	5749645	Styx SMP	Unclassified[3]
	Kaputone at Belfast Rd	2482195	5749882	Styx SMP	Unclassified[3]
	Styx River at Marshland Rd Bridge	2482359	5749393	Styx SMP	Unclassified[3]
	Styx River at Richards Bridge	2483977	5751255	Styx SMP	Unclassified[3]
	Styx River at Harbour Rd Bridge	2485000	5756366	Styx SMP	Unclassified[3]
Halswell	Halswell Retention Basin inlet[1,4]	2471698	5738633	IGSC	Not classified
	Halswell Retention Basin outlet[1, 4]	2471793	5738525	IGSC	Not classified
	Nottingham Stream at Candys Rd	2474530	5734689	South-West SMP	Spring-fed – plains
	Knights Stream at Sabys Road	2473720	5734461	South-West SMP	Spring-fed – plains
	Halswell River at Akaroa Highway	2474444	5733330	South-West SMP	Spring-fed – plains
Otukaikino	Otukaikino at Groynes inlet	2477878	5750484	IGSC	Not classified
	Wilsons Drain at Main North Road	2481242	5752409	Styx SMP	Waimakariri Regional Plan
City Outfall	City Outfall Drain	2485954	5739637	IGSC	Not classified

[3] Under the Natural Resources Regional Plan these waterways are classified 'spring-fed – plains' and it is likely the pLWRP will be amended to reflect this classification
[4] Note: these sites are within a stormwater basin and are not river sites, therefore comparison to receiving water quality guidelines is not relevant

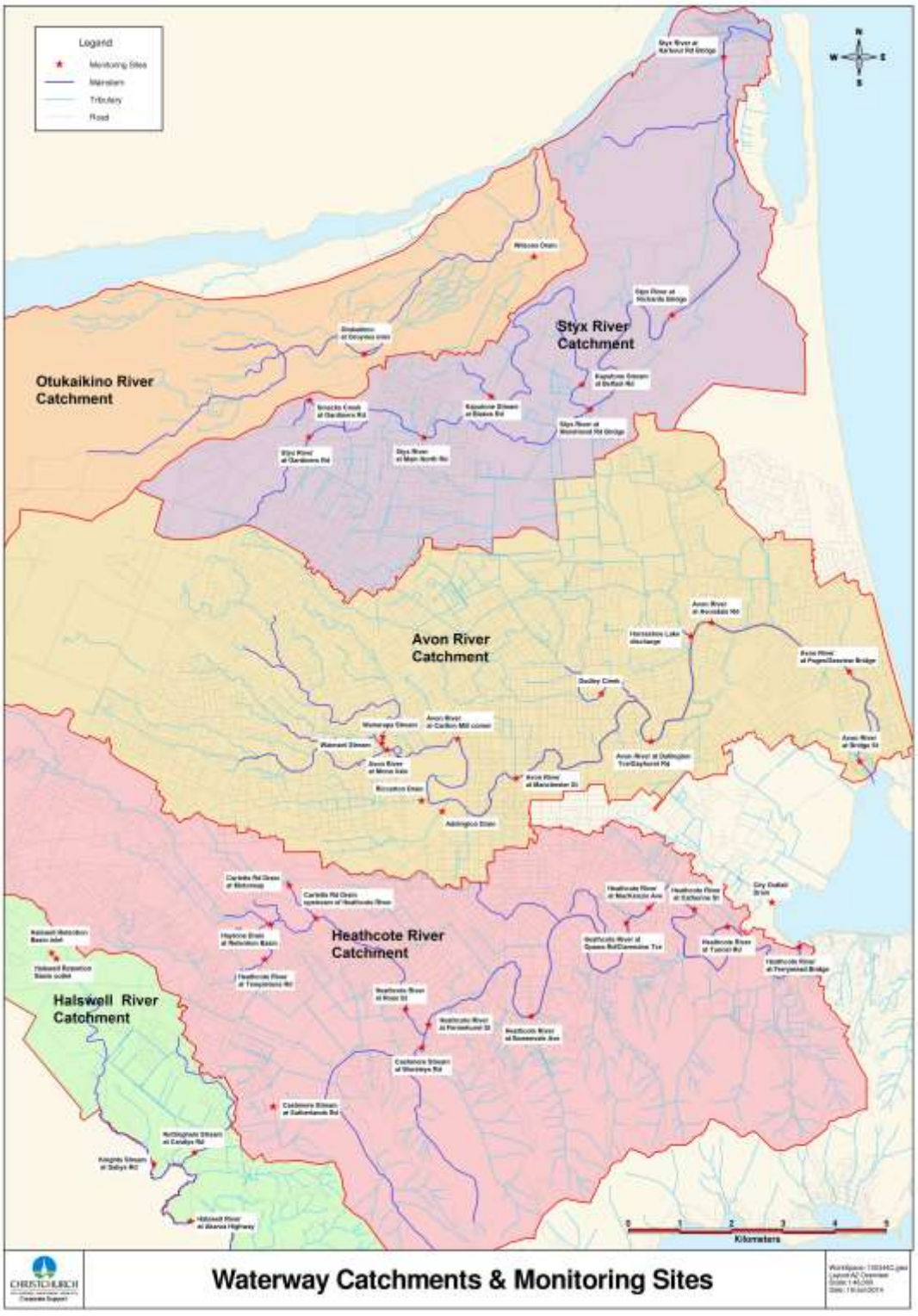

Figure 1. Location of Christchurch City Council surface water quality monitoring sites[5,6]

[5] the Haytons Drain at Wigram Road site no longer exists, as this waterway is now piped at this location

[6] this map incorrectly shows the Riccarton Main Drain site as being upstream of Riccarton Avenue, when it is downstream of Deans Avenue

2.2 Water Quality Parameters Tested

The samples were tested at the laboratory for a range of different water quality parameters, as outlined in Table 2. A brief discussion of each parameter, their importance and relevant guideline levels are included in the following paragraphs.

Metals, in particular, *copper*, *lead* and *zinc*, can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behaviour (Harding, 2005). The toxicity of metals in freshwater, and therefore the risk of adverse biological effects, alters depending on the hardness, pH and alkalinity of the water, with a positive relationship between toxicity and water hardness (ANZECC 2000). Therefore, trigger levels should be calculated with consideration of water hardness (ANZECC 2000). For this monitoring report, this is relevant for dissolved copper, lead and zinc. The Council has previously calculated Hardness Modified Trigger Values (HMTV) for metals in Christchurch Rivers in accordance with ANZECC (2000) methodology (see Appendix A) and these values are therefore used in this monitoring report.

pH is a measure of acidity or alkalinity, on a scale from 0 to 14; a pH value of seven is neutral, less than seven is acidic and greater than seven is alkaline. The water quality standards in the pLWRP for 'spring-fed – plains – urban' waterways are a lower and upper pH limit of 6.5 and 8.5, respectively. Appropriate pH levels are essential for the physiological functions of biota, such as respiration and excretion (Environment Canterbury, 2009). Aquatic species typically have tolerances for certain pH levels and alteration of pH can result in changes in the composition of fish and invertebrate communities, with generally a positive relationship between pH and the number of species present (Collier et al. 1990).

Conductivity is a measure of how well water conducts an electrical current. Pure water has very low conductivity, but dissolved ions in the water (e.g. contaminants such as metals and nutrients) increase conductivity. Traditionally, conductivity has been compared to the guideline value of <175 µS/cm recommended by Biggs (1988) to avoid excessive periphyton growth. However, this guideline may be less relevant in urban waterways, where other contaminants that will not encourage periphyton growth may be contributing to high conductivity, such as metals. It is also noted that ECan do not consider this guideline value is useful, due to natural variations in levels (Abigail Bartram, ECan, personal communication). They instead consider that analysis of trends is more useful, which is the approach adopted in this report.

Elevated levels of suspended sediment (*Total Suspended Solids*, TSS) in the water column decrease the clarity of the water and can adversely affect aquatic plants, invertebrates and fish (Crowe & Hay, 2004; Ryan, 1991). For example, sediment can affect photosynthesis of plants and therefore primary productivity within streams, interfere with feeding through the smothering of food supply, and can clog suitable habitat for species (Crowe & Hay, 2004; Ryan, 1991). A guideline level for TSS is not provided in the pLWRP. Ryan (1991) recommends a guideline value of 25 mg/L to ensure protection of aesthetic and ecological values.

Turbidity is a measure of the transmission of light through water. Suspended matter in the water column causes light to be scattered or absorbed as is travels through the water. As for TSS, turbidity decreases the clarity of the water and can negatively affect

stream biota (Ryan, 1991). A guideline level for this parameter is not provided in the pLWRP. ANZECC (2000) provides a guideline of 5.6 Nephelometric Turbidity Units (NTU) for lowland rivers.

Dissolved Oxygen (DO) is the concentration of oxygen dissolved or freely available in water and is commonly expressed as percent saturation. Adequate DO levels are essential for aquatic animals, such as fish and invertebrates, and can be influenced by many factors, including temperature, velocity, decomposition of organic material, and the photosynthesis and respiration of aquatic plants. The DO minimum water quality standard in the pLWRP for 'spring-fed – plains – urban' waterways is 70%.

High *water temperature* can affect aquatic biota, with some studies showing that the presence of sensitive macroinvertebrates decreases with increasing temperature (Wahl et al., 2013). The pLWRP water quality standard for temperature is a maximum of 20°C.

Biochemical Oxygen Demand (BOD_5) is an indicator of the amount of biodegradable organic material in the water and the amount of oxygen required by bacteria to break down this material. High BOD_5 values are due to plant matter, nitrogen and phosphorus, and indicate the potential for bacteria to deplete oxygen levels in the water. The pLWRP does not have a guideline level for this parameter. The Ministry for the Environment (1992) guideline level is 2 mg/L.

Total ammonia (ammoniacal nitrogen) is typically a minor component of the nitrogen available for plant growth, but at high levels can have toxic effects on aquatic ecosystems. The toxicity of ammonia varies with pH (ANZECC, 2000). Therefore, the pLWRP water quality standards also vary depending on pH, ranging from 2.57 mg/L at pH 6 to 0.18 mg/L at pH 9 (Environment Canterbury, 2012). For this report, the water quality standard was adjusted based on the median pH levels for all river sites (i.e. the two stormwater basin sites were not included) being 8.0 for the monitoring period, resulting in an ammonia standard of 0.9 mg/L.

Nitrate can also be toxic to stream biota and guidelines for this parameter have recently been developed to protect freshwater species (Hickey, 2013). Guidelines are available for 99%, 95% and 90% species protection. As the pLWRP uses a 90% level of species protection for 'spring-fed – plains – urban' waterways, this equivalent level of protection for the Hickey (2013) nitrate level was used for the sites in this report. It is also noted that these guidelines define this level of protection as being appropriate for highly disturbed systems, which the urban sites of this IGSC monitoring program represent. Within this 90% level of species protection there are two guideline values: the 'grading' guideline (3.8 mg/L) that provides for ecosystem protection for average long-term exposure (measured against medians) and the 'surveillance' guideline (5.6 mg/L) that assesses seasonal maximum concentrations (measured against annual 95% percentiles). Both guideline levels have been assessed in this report to investigate both long-term and short-term effects.

Elevated concentrations of *Nitrate Nitrite Nitrogen* (NNN) can lead to the proliferation of aquatic plants and algae, because nitrate and nitrite are oxidised forms of nitrogen that are readily available to plants. The pLWRP does not have a guideline value for this parameter, but the ANZECC (2000) water quality guidelines provide a trigger value of 0.444 mg/L for lowland rivers to avoid excessive plant growth.

Dissolved Inorganic Nitrogen (DIN), which is the sum of ammonia, nitrite and nitrate, is also discussed in this report, as this parameter has a water quality standard in the pLWRP, providing a measure of the risk of eutrophication and toxicity (Environment Canterbury, 2012). This value for 'spring-fed – plains – urban' waterways is 1.5 mg/L.

Dissolved Reactive Phosphorus (DRP) is a soluble form of phosphorus that is readily available for use by plants. Phosphorus is an essential nutrient for plant growth and can limit primary production at low levels, but can cause proliferation of algae and aquatic plants at high levels. The pLWRP standard for 'spring-fed – plains – urban' waterways is 0.016 mg/L.

Escherichia coli is a bacterium that is commonly used as an indicator of freshwater faecal contamination and therefore health risk from contact recreation (Ministry for the Environment, 2003). The pLWRP water quality standards state that 95% of samples should be below 550 *E. coli*/100 mL for 'spring-fed – plains – urban' waterways.

Table 2. Parameters analysed in water samples taken in accordance with Interim Global Stormwater Consent

Parameter	Units of measurement
Dissolved cadmium	mg/L
Dissolved copper	mg/L
Dissolved lead	mg/L
Dissolved zinc	mg/L
pH	
Electrical conductivity	µS/cm
Total Suspended Solids (TSS)	mg/L
Turbidity	NTU
Dissolved Oxygen (DO)	mg/L and % saturation
Water temperature	°C
Biochemical Oxygen Demand (BOD_5)	mg/L
Total ammonia (ammoniacal nitrogen)	mg/L
Nitrate nitrogen	mg/L
Nitrite nitrogen	mg/L
Nitrate-Nitrite-Nitrogen (NNN)	mg/L
Dissolved Inorganic Nitrogen (DIN)	mg/L
Total nitrogen	mg/L
Dissolved Reactive Phosphorus (DRP)	mg/L
Total phosphorus	mg/L
Faecal coliforms[7]	CFU/100 mL
Escherichia coli	CFU/100 mL
Enterococci[7]	MPN/100 mL
Dissolved Organic Carbon (DOC)	mg/L
Water hardness	g/m^3 as calcium carbonate

2.3 Data Analysis

2.3.1 Summary Statistics

Summary statistics of monthly water quality data at the sites were analysed using IBM® SPSS® Statistics 20. To allow analysis, water quality values that were less than the

[7] Not analysed at all sites

laboratory Limit of Detection (LOD) were converted to half the detection limit. Data was graphed using boxplots, to show medians and interquartile ranges. Statistical outliers were not removed from these summary statistics, as values were assumed to be 'real', providing useful information on variations in the concentrations recorded. The sites are ordered from upstream to downstream in the graphs, with mainstem and tributary sites colour-coded.

The dark lines in the boxes of the boxplots represent the medians, and the bottom and top lines of the boxes represent the 25th and 75th percentiles, respectively. The T-bars that extend from the boxes approximate the location of 95% of the data. Circles represent statistical outliers and stars represent extreme outliers. In some cases, boxplots do not show all components, such as the percentiles, due to a lack of variation in the data, with some showing only the medians. This usually occurred where a large proportion of the data were below the laboratory limit of detection.

2.3.2 Temporal Trend Analysis

Temporal trend analysis was carried out on data collected monthly from all the sites between January 2007 and December 2013. The exception to this was dissolved metals, which have only been analysed since 2011. Total metals were originally sampled at the instigation of the monitoring program, but dissolved metals are now considered to be more relevant because they constitute the bio-available proportion of metals that can have adverse effects on biota (ANSECC, 2000). The guidelines also pertain to dissolved metals, not total metals.

Trend analysis was conducted using the Time Trends software developed by NIWA (NIWA, 2011). Trend analysis cannot be performed on parameters that have a high proportion of data below the LOD or very small values, therefore analyses were unable to be undertaken for dissolved copper, dissolved lead, dissolved zinc and dissolved reactive phosphorus. The Seasonal Kendall trend test was used to test the significance of trends. The non-parametric Seasonal Kendall Sen Slope Estimator was then used to measure the magnitude and direction of the trend, normalised by dividing by the site median, to provide a measure of the slope as a percent change per year (NIWA 2011). Where water quality results were less than the LOD, the Time Trends software converted these values to 10% below the LOD.

The concentrations of parameters can vary depending on the flow rates at the time of sampling, due to variations in the level of dilution. Therefore, flow-adjusted data can be used in the Time Trends software to account for this potentially confounding factor. In previous monitoring reports, as flow data was not available for all sites, flow from one site each in the Avon River (at Gloucester Street) and Heathcote River (at Ferniehurst Street) was used across all sites in these respective catchments. As there was no flow data available for the Halswell River catchment, the previous 24-hour total rainfall amount was used as a surrogate for flow. However, it is now considered that both these non site-specific approaches could introduce biases into the analyses. In particular, rainfall data is considered to only give an indication of the intensity of the event, not the site-specific dilution factor. Consequently, for this report the Avon River Gloucester Street flow gauge was only used for the Manchester Street site. This was considered appropriate, as flow at Gloucester Street is likely representative of that at Manchester, as the sites are only ~640 metres apart and there are no waterways discharging into the river between these two points. The Heathcote River Ferniehurst Street flow site was not considered suitable for any of the sites in this monitoring report

(the corresponding Ferniehurst Street water quality monitoring site is now part of the South-West SMP monitoring).

For the one site with flow data (Avon River at Manchester Street), parameter concentrations were adjusted by the flow (m^3/s) at the time of sampling, using the Locally Weighted Scatterplot Smoothing (LOWESS) method. However, flow accounted for little of the variation in the concentrations recorded at this site for all parameters (the maximum contribution being 25%, with many values much lower than this). Therefore, only unadjusted data was presented in the time trends results in this report. For the other sites, given the large interval of monitoring (since 2007), it is assumed that variations in flow rates between sampling events will not strongly influence concentrations (as was shown with the Manchester Street site), as most events will have been conducted during baseflow conditions.

3 Results

3.1 Summary Statistics and Comparison to Guidelines

Appendix B presents the summary statistics for each site and parameter for the monitoring period. The results of the monitoring in relation to the receiving water quality guidelines are detailed below.

3.1.1 Dissolved Copper

The concentrations of dissolved copper for a significant proportion of samples at all sites were below the LOD of 0.002 mg/L (analysed as half this value, 0.001 mg/L, to allow statistics to be undertaken), as shown by the medians for every site being equivalent to this value and many sites not exhibiting an interquartile range, due to the lack of variability in the data (Figure 2). However, the respective guideline level was exceeded on at least one sampling occasion (as shown by the outliers) within the Avon River catchment at Riccarton Main Drain, the Avon River at Manchester Street, Dudley Creek and the Avon River at Dallington Terrace. Addington Brook also recorded two sampling events above the trigger value, as shown by the interquartile range extending well above the guideline. The largest value recorded was at the Heathcote River Ferrymead Bridge site in May 2013 (0.0052 mg/L). There were no apparent upstream to downstream trends in concentrations, or differences between the Avon River mainstem and tributary sites. The Heathcote River catchment appeared to record higher levels compared to the Avon River catchment.

3.1.2 Dissolved Lead

The majority of sites recorded dissolved lead concentrations consistently below the LOD of 0.0015 mg/L (analysed as half this value, 0.00075 mg/L, to allow statistics to be undertaken), as shown by the medians being the same as the LOD and many sites exhibiting no interquartile ranges due to a lack of variation in the data (Figure 3). Levels above the LOD were recorded on many occasions at many sites throughout the monitoring period, but these concentrations were still well below the respective receiving water guidelines. There were no apparent differences between sites.

3.1.3 Dissolved Zinc

The median levels of dissolved zinc for the monitoring period were all below the respective water quality receiving guidelines (Figure 4). However, within the Avon River catchment, many tributary and mainstem sites exceeded the guideline level consistently, or at least on a few sampling occasions; the exception to this was the Avon River at Bridge Street site, which never recorded an exceedance. In the other catchments, the only site that recorded levels above the respective guideline was at the Heathcote River Opawa Road site on one occasion. Overall, Riccarton Main Drain recorded the highest concentration across all sites during the monitoring period (0.24 mg/L in December 2013). It was raining during this sampling event, so this high concentration is likely a result of zinc in stormwater from the contributing industrial/commercial catchment. Addington Brook recorded more variation in concentrations compared to the other sites, again likely due to the influence of varying stormwater events. In the Avon River, there were no apparent trends between

tributaries and mainstem sites, or upstream to downstream. In the Heathcote River catchment, concentrations appeared to decrease downstream based on the median levels recorded, although due to the substantial overlap in variation between the three sites, this trend is likely not significant. The Avon River catchment appeared to record higher levels compared to the Heathcote River catchment.

3.1.4 pH

Median pH levels for all river sites were within the lower and upper guideline levels (Figure 5). However, pH levels were below the guideline level on one sampling event at each of the following sites: Wairarapa Stream, Waimairi Stream, the Avon River at Mona Vale, Riccarton Main Drain and Addington Brook. These values were all relatively low (i.e. acidic), the lowest being pH of 5.5 in Addington Brook in May 2013. While it was not raining during this latter sampling event, it had been within the previous 24-hours. It is therefore likely that this result is due to stormwater input from the contributing industrial catchment. In addition, the Avon River at Avondale Road and Heathcote River at Ferrymead bridge sites both recorded levels above the upper limit on one sampling occasion (both recording a pH of 8.6). It was raining during sampling for the Avondale Road site, so this result is also likely due to stormwater inputs. However, it was not raining during the Ferrymead Bridge sampling, so the reason for this high level is unclear; the concentration is likely not due to tidal influences, which usually do not result in a pH of greater than 8.4 (Lesley Bolton-Ritchie, Environment Canterbury, person communication). In the Avon River catchment, pH levels appeared to increase downstream. In the Heathcote River mainstem, there were no trends downstream. Levels were similar between the Avon and Heathcote mainstems.

The stormwater basin sites recorded significantly higher pH levels compared to the river sites, and more variation in concentrations throughout the monitoring period. The highest level recorded at these two sites was pH 10.7 at the inlet in June 2013. It is unclear what the reason was for this basic pH level, but it was likely not due to stormwater, as it was not raining at the time of sampling and it had not rained the 24-hours previous. Median pH levels were lower at the outlet, although there was a large variation in values recorded, as shown by the long interquartile range. This suggests an increase in water quality due to the basin.

3.1.5 Conductivity

Conductivity levels varied across sites, with the tidal sites generally showing the most variation and the highest values (e.g. the Avon River at Pages Road/Seaview Bridge and Bridge Street, the Heathcote River at Tunnel Road and the Ferrymead Bridge, and the City Outfall Drain; Figure 6). This is likely due to salinity influences, rather than the presence of contaminants. The highest value recorded was at the Ferrymead Bridge in December 2013 (22500 µS/cm). Apart from the tidal influence, there appeared to be no substantial differences downstream for sites, or between the Avon River mainstem and tributaries, or between the Avon River and Heathcote River mainstems.

The two Halswell Retention Basin sites generally recorded lower conductivity levels than the river sites. Median levels were slightly lower at the outlet, suggesting an increase in water quality due to the basin.

3.1.6 Total Suspended Solids

Overall, the majority of river sites recorded medians below the TSS guideline level, with the exception of the Heathcote River Tunnel Road and Ferrymead Bridge sites (Figure 7). However, there were a number of events that exceeded this value throughout the monitoring period, as shown by the outliers and interquartile ranges extending past this value. The Heathcote River Ferrymead Bridge site recorded the highest concentration of all river sites of 130 mg/L in May 2013. There appeared to be a general increase in concentrations downstream in both the Avon and Heathcote mainstems, and the Heathcote River mainstem recorded higher levels than the Avon River sites. The Avon River tributaries generally recorded higher levels than the mainstem, potentially causing the increase in concentrations downstream in the mainstem.

The Halswell Retention Basin recorded values similar to the Heathcote River sites. However, the inlet recorded a very large and significantly higher value than any of the river sites in September 2013 of 600 mg/L. It was raining at the time of sampling and during the 24-hours previous, so it is likely that this high level was due to stormwater input. The outlet recorded lower levels than the inlet, suggesting a removal of sediment within the basin.

3.1.7 Turbidity

Median turbidity concentrations for all sites were below the guideline level, with the exception of the Horseshoe Lake discharge, Avon River at Bridge Street, Heathcote River at Opawa Road, Heathcote River at Tunnel Road, Heathcote River at Ferrymead Bridge, and the City Outfall Drain (Figure 8). However, most sites recorded values above the guideline throughout the monitoring period, except for Waimairi Stream and the Otukaikino River at Groynes Inlet. The highest value recorded across all sites was 120 NTU at the Heathcote River Ferrymead Bridge site in May 2013. It was raining at the time of this sampling, as well as during the 24-hour period previous; therefore, it is likely this high level was due to stormwater input. This site recorded relatively large variations in concentrations throughout the monitoring period compared to the other sites. Consistent with TSS, levels increased downstream in both the Avon and Heathcote mainstems, the Heathcote generally recorded higher levels than the Avon, and the Avon tributaries recorded higher levels than the mainstem.

3.1.8 Dissolved Oxygen

The majority of river sites recorded medians above the minimum guideline value of 70% saturation (Figure 9). However, two sites recorded median levels below this value: the Horseshoe Lake discharge and the City Outfall Drain. The low levels recorded in the City Outfall Drain are likely due to the high levels of salinity at this point. Whereas, the low levels in Horseshoe Lake may be due to a lack of flushing through the system (i.e. flow) or high levels of organic matter, possibly due to faecal matter from the high number of waterfowl present in the lake and leaf fall from deciduous trees. The Avon River tributaries generally recorded lower DO levels than the Avon River mainstem, and levels were similar between the Avon and Heathcote River mainstems. There was no apparent trend downstream for either the Avon or Heathcote River mainstems.

The Halswell Retention Basin sites recorded levels similar to the river sites, although lower DO levels were recorded on occasion (the lowest value recorded was 40%

saturation in November 2013) and there was more variation during the monitoring period (resulting in long interquartile ranges). Again, these low DO values are likely due to the lack of flow and retention design of the pond. However, overall the outlet recorded higher median DO levels than the inlet, suggesting an increase in water quality due to the basin.

3.1.9 Water temperature

The temperature of the water at all the river sites throughout the monitoring period was below the guideline value of 20ºC, the exception being the City Outfall Drain, which recorded a temperature above this value (22 ºC) on one occasion in October 2013 (Figure 10). Temperatures were generally similar across sites, although the upper Avon River catchment sites appeared to record less variation throughout the monitoring period, with less incidence of lower temperatures. The two Halswell Retention Basin sites recorded similar levels to the river sites, and temperatures were similar between the inlet and the outlet.

3.1.10 Biochemical Oxygen Demand

Median BOD_5 levels for all river sites were below the guideline level of 2 mg/L, with many equalling the laboratory LOD (Figure 11). However, this guideline level was exceeded on at least one occasion at the following sites (as shown by the outliers and interquartile ranges): Waimairi Stream, Riccarton Main Drain, Avon River at Manchester Street, Dudley Creek, City Outfall Drain and the Heathcote River at Bowenvale Avenue, McKenzie Avenue, Tunnel Road and the Ferrymead Bridge. In addition, Addington Brook exceeded the guideline on a number of occasions (as shown by the extent of the 75% interquartile ranges). These high levels are all likely due to poor water quality within these catchments. The highest level recorded in the river sites was 6 mg/L in the Riccarton Main Drain in December 2013. Exceedances were predominantly recorded in spring and summer, when higher water temperatures and lower water depth would be expected to decrease oxygen levels. There were no apparent trends from upstream to downstream, or between the Avon and Heathcote mainstems, but tributary sites in the Avon River appeared to record high median and outlier events compared to the mainstem.

The two Halswell Retention Basin sites recorded significantly higher concentrations than the river sites, with the maximum value recorded at the outlet in October 2013 (9 mg/L). These levels are likely due to the high level of organic matter in the ponds compared to the river sites. The outlet recorded substantially lower median levels than the inlet, suggesting better water quality at this location. However, this was variable, with higher levels recorded on occasion at this site, as shown by the long interquartile range.

3.1.11 Total Ammonia (Ammoniacal Nitrogen)

Total ammonia levels at all river sites were well below the receiving water quality guideline, with no events throughout the monitoring period exceeding this value (Figure 12). Addington Brook, Dudley Creek and the City Outfall Drain recorded higher levels and more variation in concentrations compared to the other river sites. Levels appeared to increase downstream in both the Avon and Heathcote River mainstems, although this relationship may not be statistically significant due to overlapping

variation between sites. Concentrations were generally similar between these two catchments. The Avon tributaries generally recorded higher concentrations than the mainstem.

The two Halswell Retention Basin sites recorded significantly higher levels than the river sites. These higher levels may be due to bacterial composition of organic matter, such as faeces from fish and waterfowl, dead algae and aquatic plants. Median ammonia levels were lower at the outlet, suggesting better water quality at this location. However, there was much variation throughout the monitoring period at this site (as shown by the long interquartile range), with high ammonia levels recorded on occasion (consistent with that recorded at the inlet).

3.1.12 Nitrate

All sites recorded median nitrate concentrations substantially below the grading guideline value of 3.8 mg/L and 95% percentiles below the surveillance guideline value of 5.6 mg/L[8] (Figure 13). Large variations in concentrations were recorded at the Avon River Mona Vale and Carlton Mill Corner sites. The Mona Vale site recorded the top five highest nitrate concentrations during the monitoring period, recording a maximum of 3.8 mg/L in January 2014. This site is just downstream of the Wairarapa and Waimairi Streams discharge points, and these catchments likely have a cumulative effect on the concentration of DIN at this sampling point. Concentrations decreased downstream in both the Avon and Heathcote mainstems. These higher levels upstream are hypothesised to be due to the influence of nitrogen-rich groundwater entering the waterways via springs in the upper reaches. The CCC is currently undertaking a survey at present to ascertain if this is the case. The Heathcote River mainstem sites, which are located in the mid to lower reaches of this waterway, recorded concentrations similar to the mid to the lower reach Avon River sites. Levels appeared to be lower in the Avon River tributaries than the mainstem, but this trend may not be significant due to overlapping variance.

The two Halswell Retention Basin sites recorded nitrate levels within the range of that recorded for the river sites, although these sites generally recorded more variation. Median concentrations at the outlet were slightly lower than the inlet, suggesting some treatment of this parameter.

3.1.13 Nitrate Nitrite Nitrogen

The majority of sites recorded median NNN concentrations substantially higher than the guideline value of 0.444 mg/L (Figure 14). The exception to this was Dudley Creek, Horseshoe Lake, Otukaikino at Groynes Inlet and the City Outfall Drain; although the Horseshoe Lake and Otukaikino River sites recorded many events during the monitoring period above the guideline. Levels recorded were similar to that for nitrate, due to NNN typically being dominated by this parameter. Specifically, large variations in concentrations were recorded at the Avon River Mona Vale and Carlton Mill Corner sites. The Mona Vale site recorded the top five highest concentrations of NNN for any site during the monitoring period, peaking with 3.8 mg/L in January 2014. Again, NNN levels appeared to decrease downstream in both the Avon and Heathcote catchments. The Heathcote River mainstem sites, which are located in the mid to lower reaches of

[8] Although the box-plots only show 25% and 75% percentiles, and not 95% percentiles, no events recorded values equivalent to the 5.6 mg/L guideline value at any of the sites.

this waterway, recorded concentrations similar to the mid to the lower reach Avon River sites. The Avon River tributaries appeared to record lower concentrations than the mainstem, although there was substantial overlap in the values recorded.

The stormwater basin sites recorded nitrogen within the same range of concentrations as the river sites, although more variation was generally recorded at these two sites. Median levels at the outlet were lower than the inlet, indicating an increase in water quality due to the basin.

3.1.14 Dissolved Inorganic Nitrogen

Median levels of DIN exceeded the guideline level at half of the Avon River catchment sites and all of the Heathcote River sites, but not at the Outukaikino River and City Outfall Drain sites (Figure 15). Consistent with NNN, concentrations notably decreased downstream in the Avon River and appeared to do the same in the Heathcote River, although this latter trend may not be statistically significant given the overlap in variation between sites. The Avon River tributary sites appeared to recorded lower concentrations that the mainstem sites. The highest levels of DIN recorded were at the Avon River Mona Vale site; the highest concentration at this site was recorded in January 2014 (3.8 mg/L).

The two stormwater basin sites recorded substantially higher concentrations than the river sites, likely driven by the high total ammonia levels recorded at these sites. The outlet recorded lower DIN levels than the inlet, suggesting that the basin increased water quality.

3.1.15 Dissolved Reactive Phosphorus

The majority of river sites recorded median concentrations above the guideline level (Figure 16). The exceptions to this were Wairarapa Stream, Waimairi Stream, Otukaikino River at Groynes Inlet, and the Avon River at Mona Vale, Carlton Mill Corner and Manchester Street. The City Outfall Drain recorded substantially higher concentrations than the other river sites. Concentrations generally increased downstream in both the Avon and Heathcote River mainstems, suggesting cumulative effects downstream. The Avon River tributaries recorded higher concentrations than the mainstem. Levels were similar between the Avon and the Heathcote.

The stormwater basin sites recorded much higher concentrations of DRP and more variation in levels throughout the monitoring period, compared to the river sites. This might be another result of faecal input from waterfowl using the basin. The outlet recorded substantially lower concentrations than the inlet, indicating that water quality was better at this location.

3.1.16 *Escherichia coli*

The ECan guideline states that 95% of *E. coli samples* should be below 550 CFU/100ml (Environment Canterbury, 2012). Therefore comparison against the T-bars of the box-plot graph is more appropriate than comparing against medians, as the T-bars show the approximate location of 95% of the data. *E. coli* concentrations were above the guideline level at all sites, except Waimairi Stream, although the guideline

value was exceeded at this site on two individual sampling events during the monitoring period (Figure 17). One of these events resulted in the highest value recorded at any of the sites during the monitoring period (24000 CFU/100ml in December 2013); Addington Brook also recorded the same concentration in July 2013. This latter site recorded the highest concentrations and variation of all sites. There were no obvious trends in concentrations between sites.

The stormwater basin sites recorded similar concentrations to the river sites and the outlet recorded lower levels compared to the inlet. This suggests that the basin provided some treatment of this parameter.

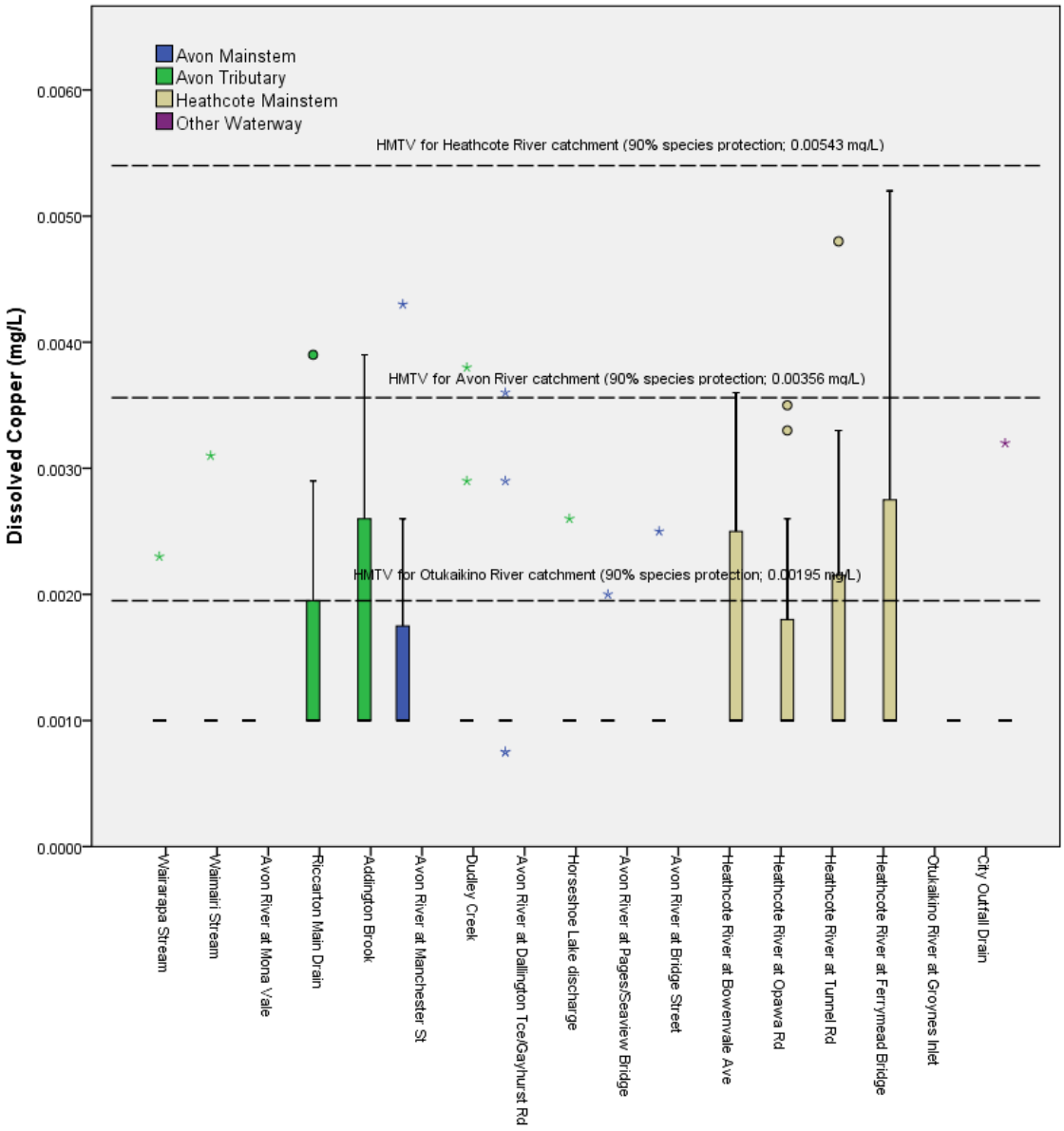

Figure 2. Dissolved copper levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (for only seventeen river sites, as not all sites were tested for this parameter). Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values (Environment Canterbury, 2012), which have been modified to account for water hardness (Hardness Modified Trigger Value = HMTV), as per the ANZECC (2000) guidelines methodology. The Laboratory Limit of Detection was 0.002 mg/L – analysed as half this value (0.001 mg/L) to allow statistics to be undertaken.

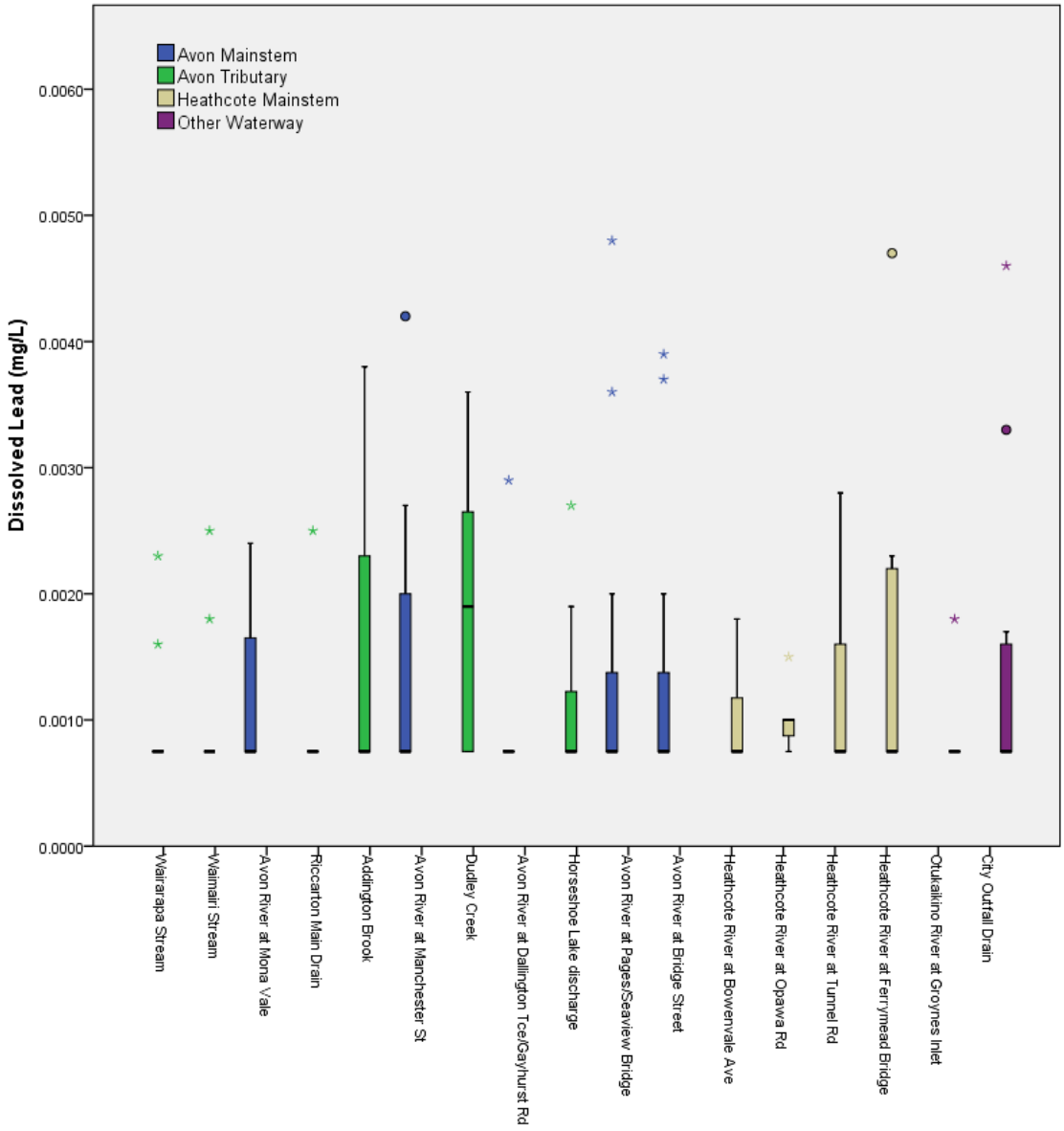

Figure 3. Dissolved lead levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (for only seventeen river sites, as not all sites were tested for this parameter). Sites are ordered from upstream to downstream (left to right). The Proposed Canterbury Land and Water Regional Plan trigger values (Environment Canterbury, 2012), which have been modified to account for water hardness, as per the ANZECC (2000) guidelines methodology, are not shown on this graph as the scale bar does not extend this far. These trigger values are: Heathcote River = 0.02916 mg/L for 90% species protection; Avon River = 0.01554 mg/L for 90% species protection; and Otukaikino River = 0.00632 for 90% species protection. The Laboratory Limit of Detection was 0.0015 mg/L – analysed as half this value (0.00075 mg/L) to allow statistics to be undertaken.

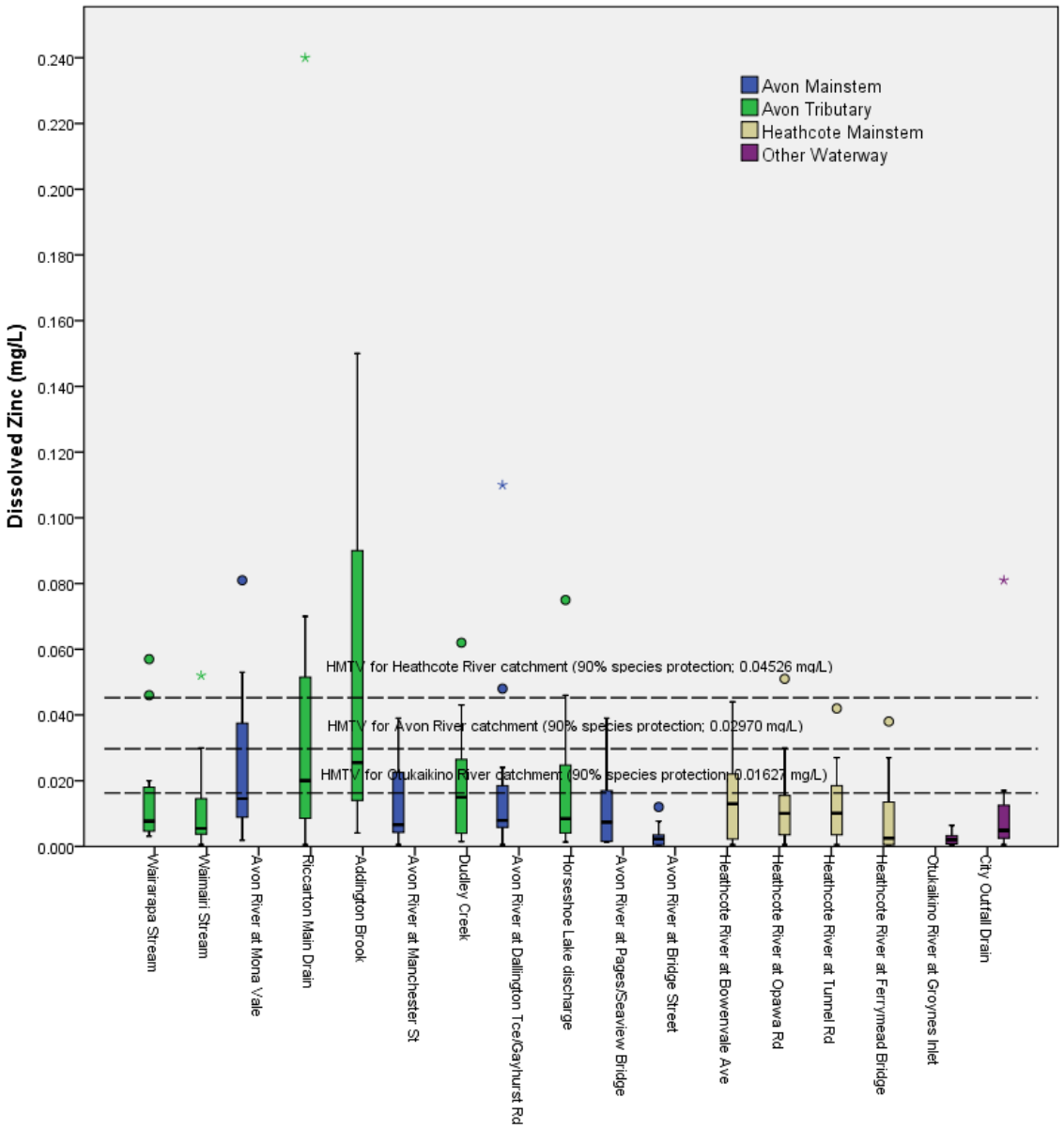

Figure 4. Dissolved zinc levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (for only seventeen river sites, as not all sites were tested for this parameter). Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values (Environment Canterbury, 2012), which have been modified to account for water hardness (Hardness Modified Trigger Value = HMTV), as per the ANZECC (2000) guidelines methodology. The Laboratory Limit of Detection was 0.0010 mg/L – analysed as half this value (0.0005 mg/L) to allow statistics to be undertaken.

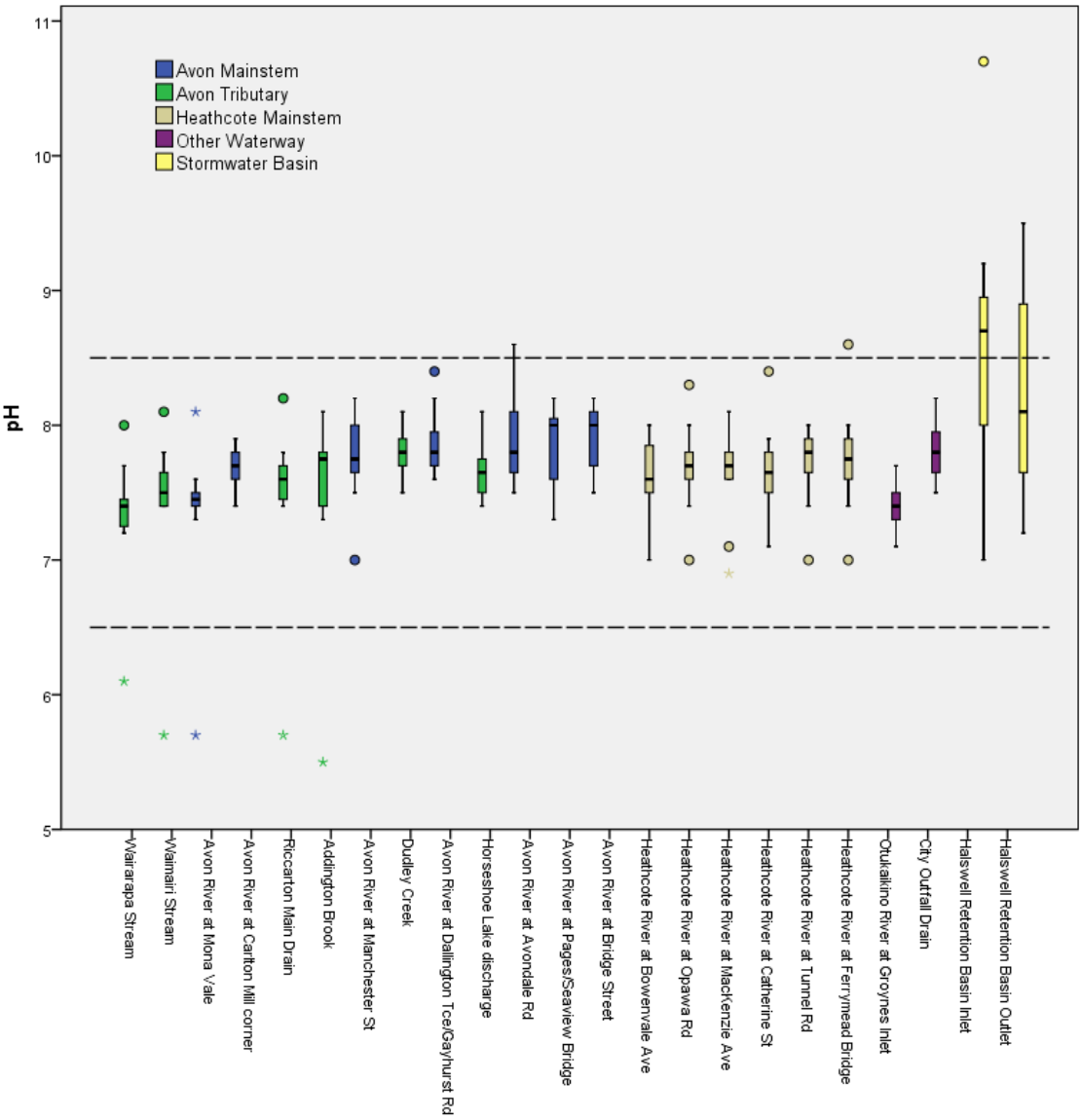

Figure 5. pH levels of water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan lower (6.5) and upper (8.5) limits (Environment Canterbury, 2012).

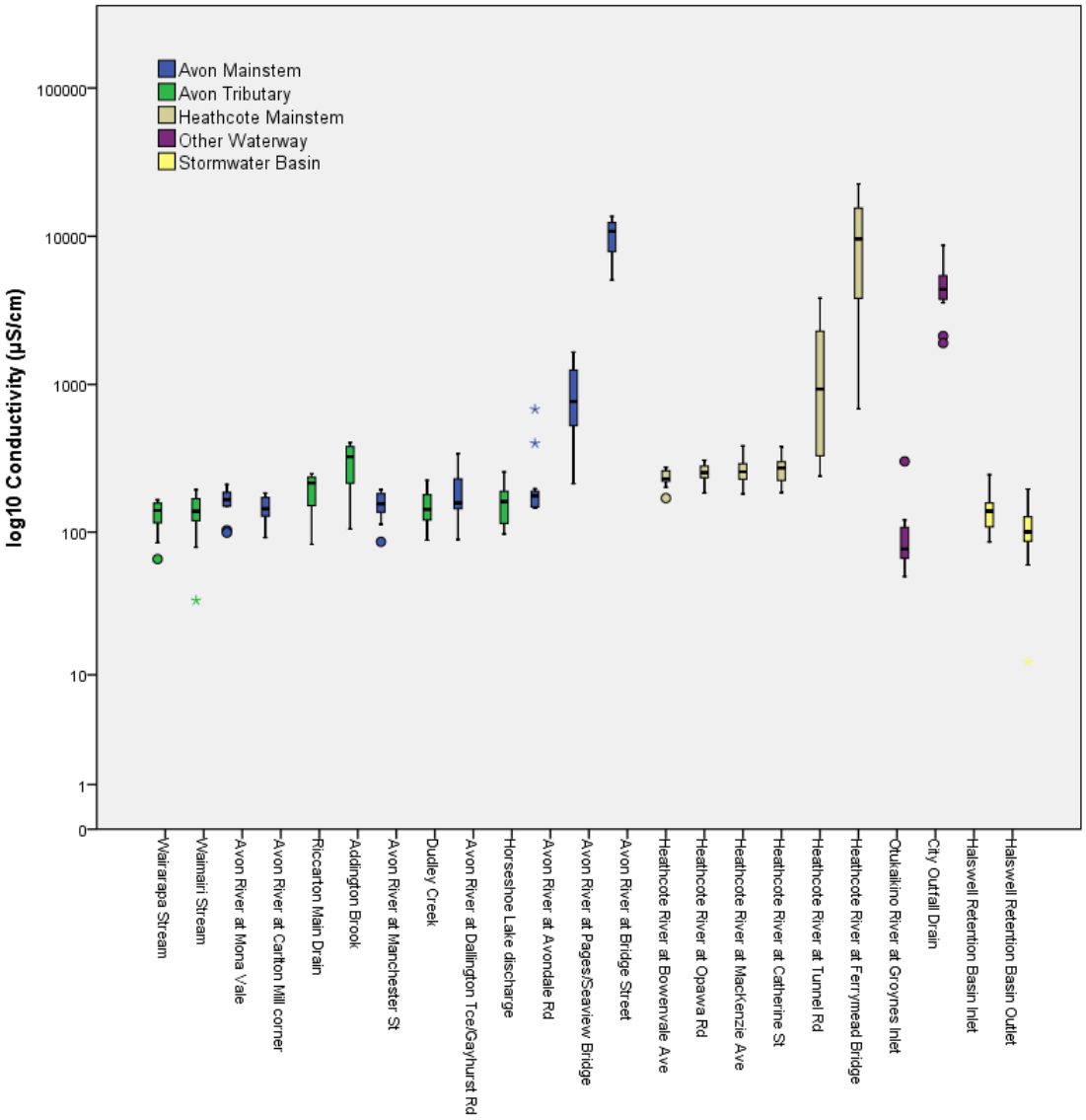

Figure 6. Conductivity levels of water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). Given the large differences in values between sites, a $\log_{10}$ scale was used to allow the data to be viewed on the same graph.

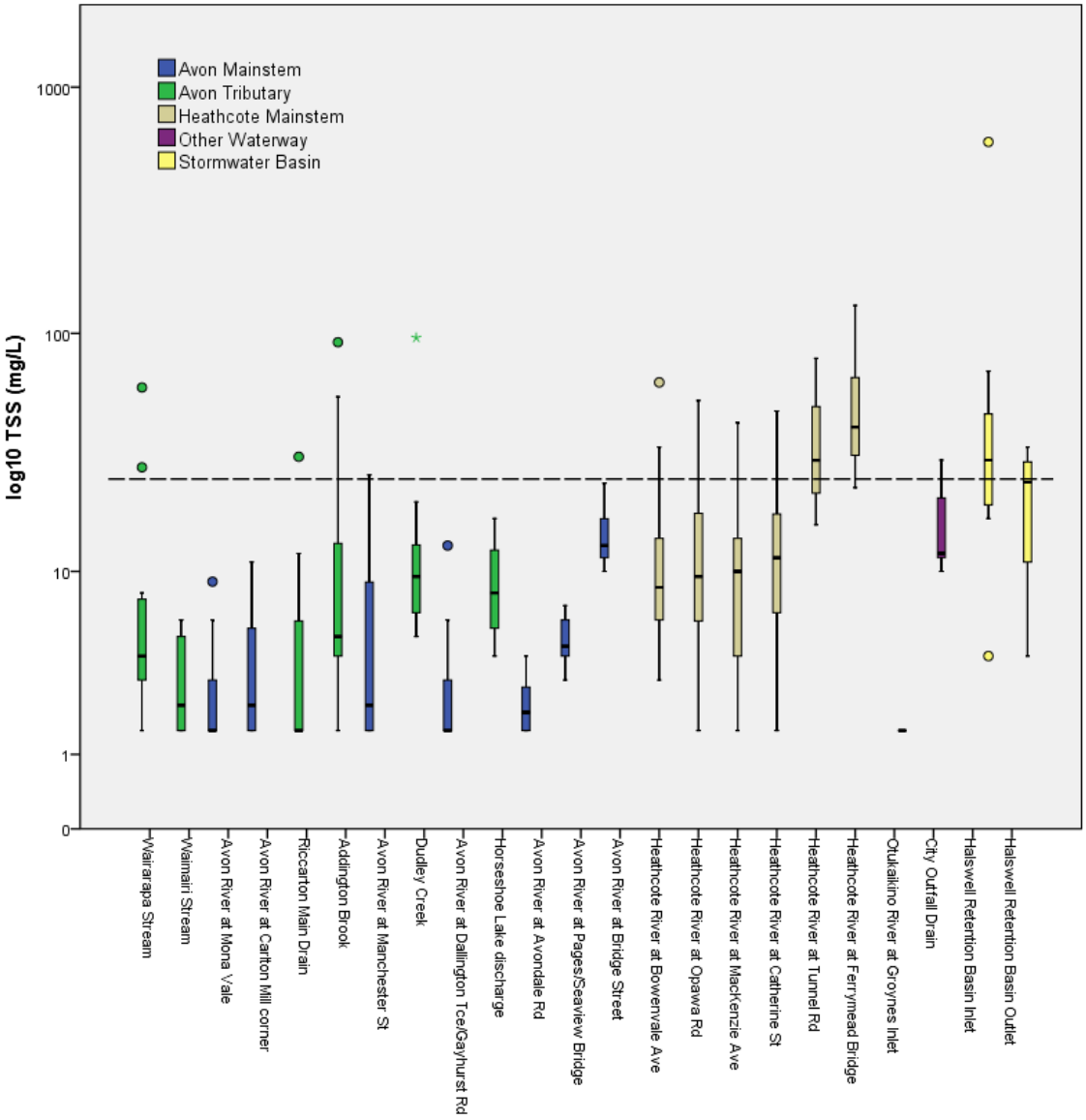

Figure 7. Total Suspended Solid (TSS) levels of water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Ryan (1991) guideline value of 25 mg/L. The Laboratory Limit of Detection was 5.0 mg/L – analysed as half this value (2.5 mg/L) to allow statistics to be undertaken. Given the large differences in values between sites, a $\log_{10}$ scale was used to allow the data to be viewed on the same graph.

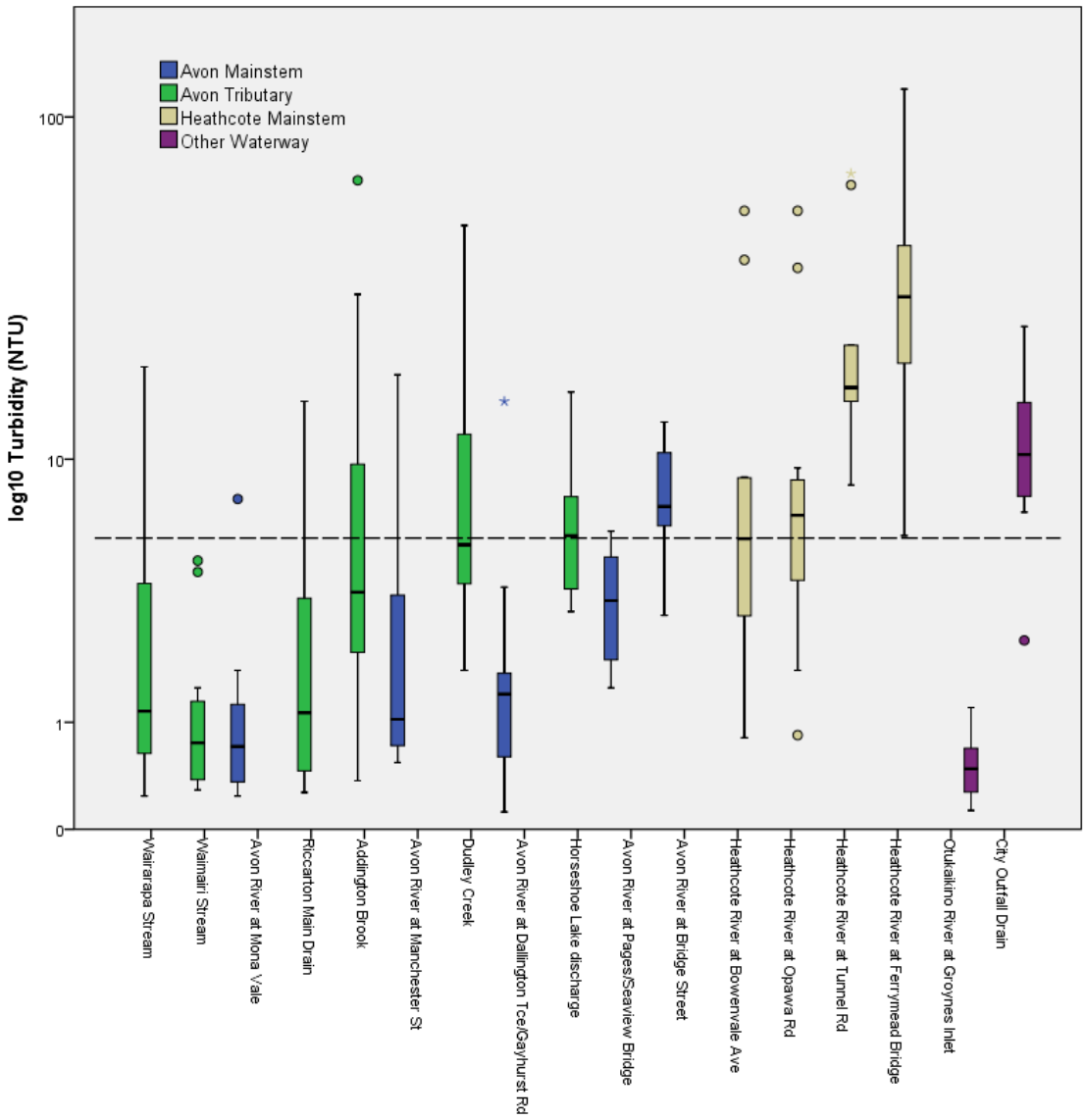

Figure 8. Turbidity levels of water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (for only seventeen river sites, as not all sites were tested for this parameter). Sites are ordered from upstream to downstream (left to right). The dotted line represents the ANZECC (2000) guideline value of 5.6 Nephelometric Turbidity Units (NTU). All values were above the Laboratory Limit of Detection of 0.7 NTU. Given the large differences in values between sites, a $\log_{10}$ scale was used to allow the data to be viewed on the same graph.

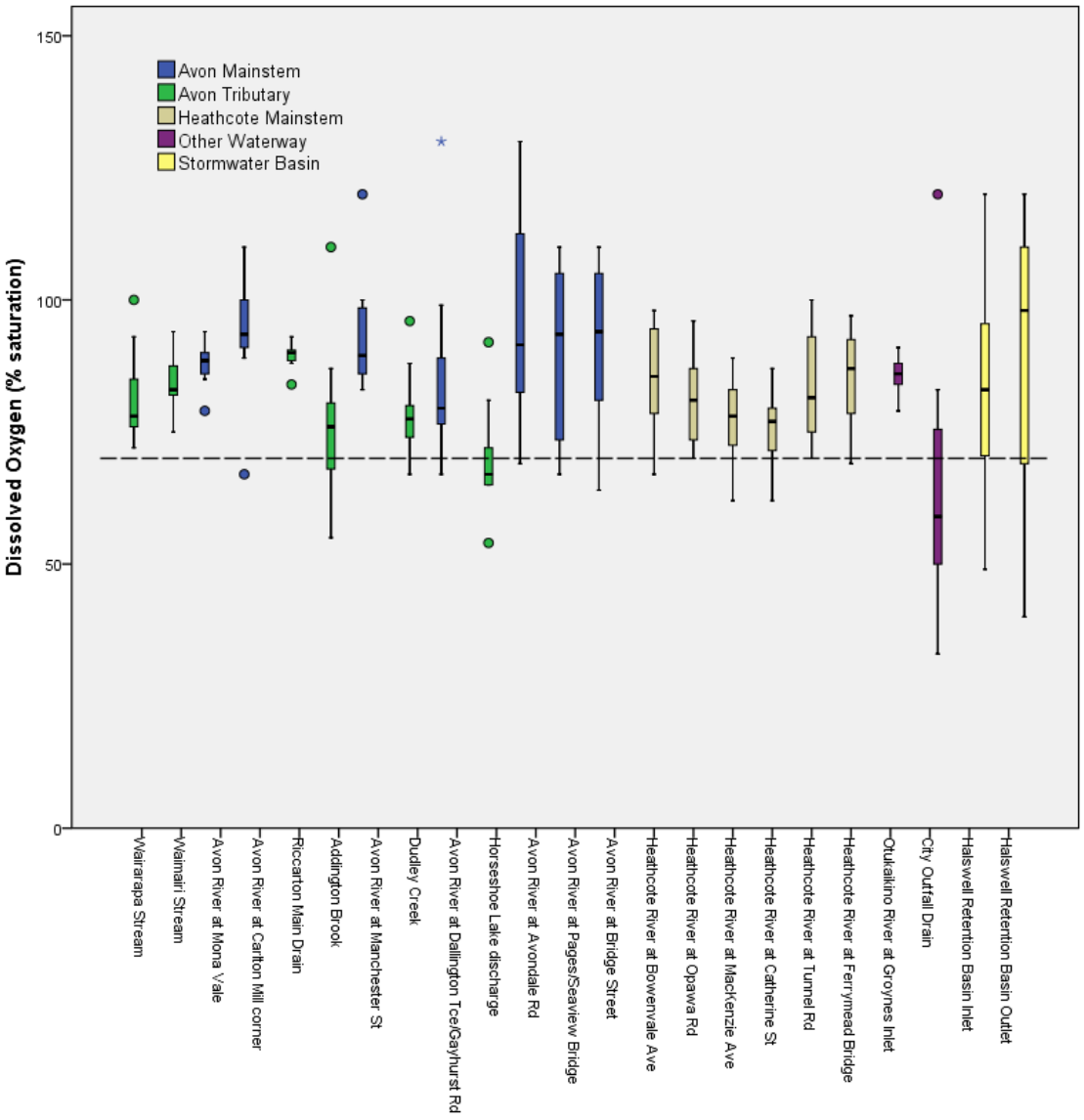

Figure 9. Dissolved oxygen levels of water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan minimum guideline value (70%, Environment Canterbury, 2012).

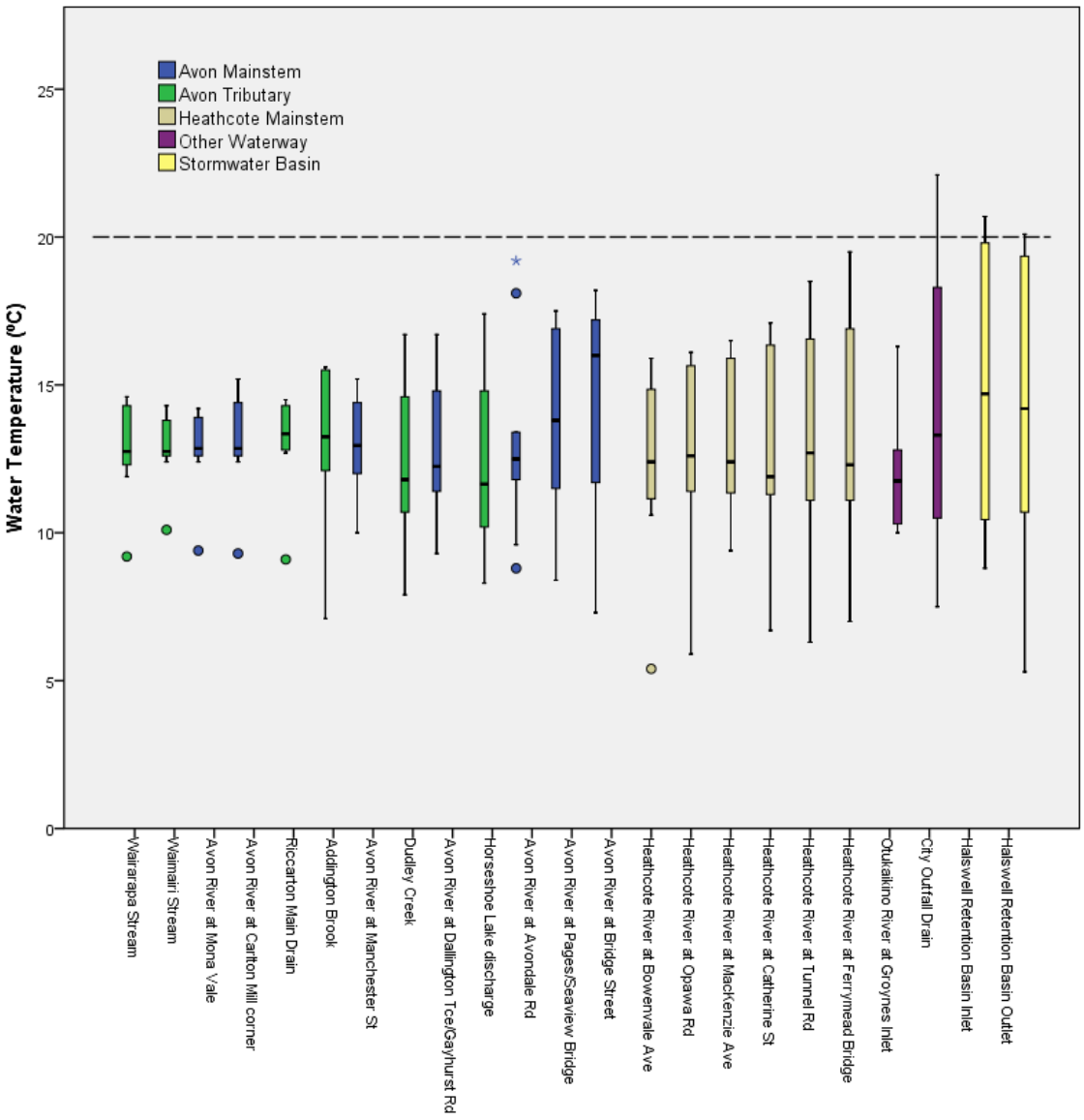

Figure 10. Temperature of the water at the time of sampling for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan maximum guideline value (20ºC, Environment Canterbury, 2012).

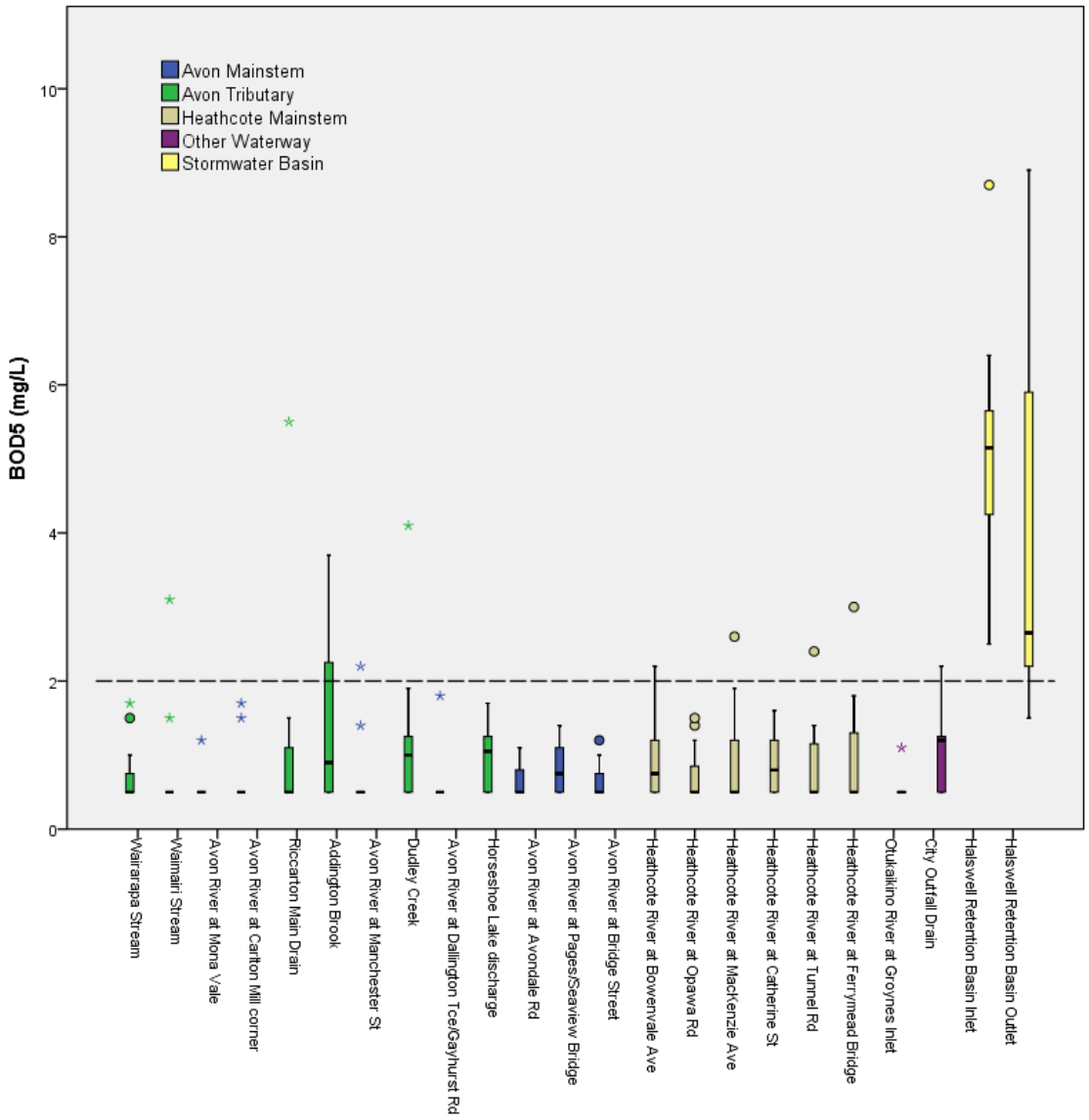

Figure 11. Biochemical Oxygen Demand (BOD_5) levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Ministry for the Environment guideline value (2 mg/L; Ministry for the Environment, 1992). The Laboratory Limit of Detection was 1.0 mg/L, analysed as half this value (0.5 mg/L) to allow statistics to be undertaken.

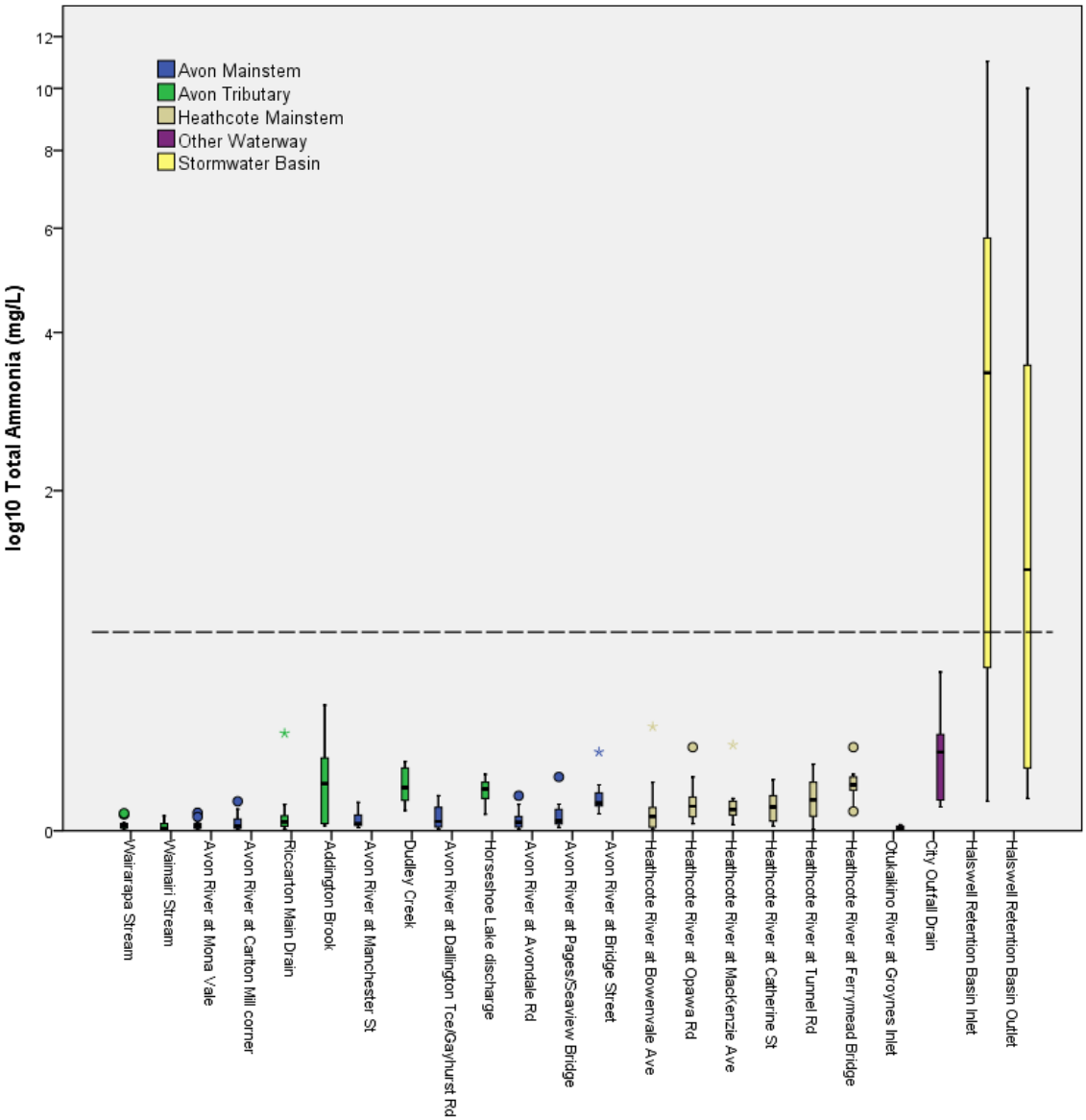

Figure 12. Total ammonia levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan trigger value adjusted in accordance with median pH levels (8.0) for the monitoring period, as per the guidelines (Environment Canterbury, 2012). Given the large differences in values between river and basin sites, a $\log_{10}$ scale was used to allow the data to be viewed on the same graph.

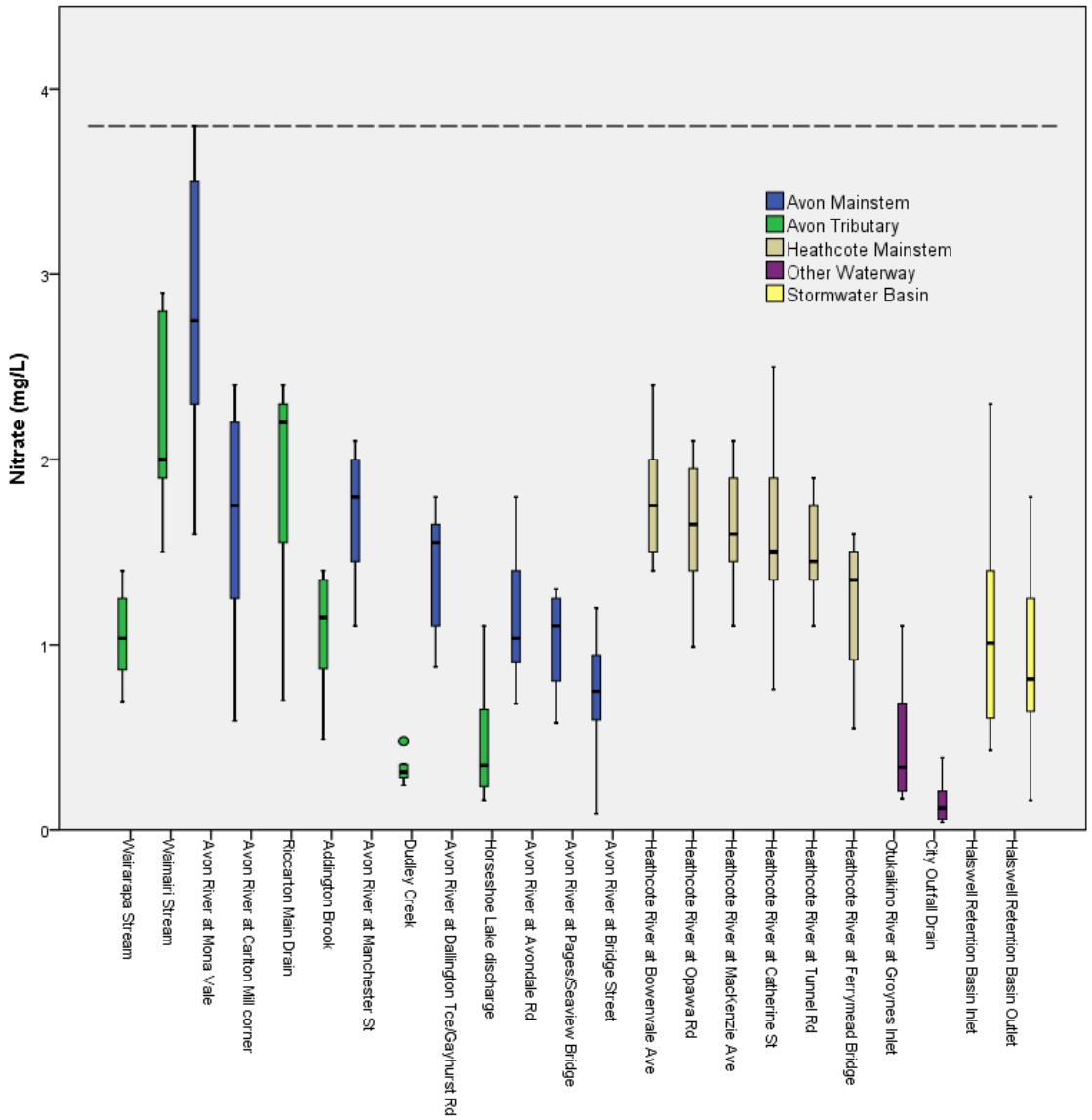

Figure 13. Nitrate levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Hickey (2013) grading guideline level. The surveillance guideline level (5.6 mg/L) is not shown on the graph, as the y-axis scale does not extend this far.

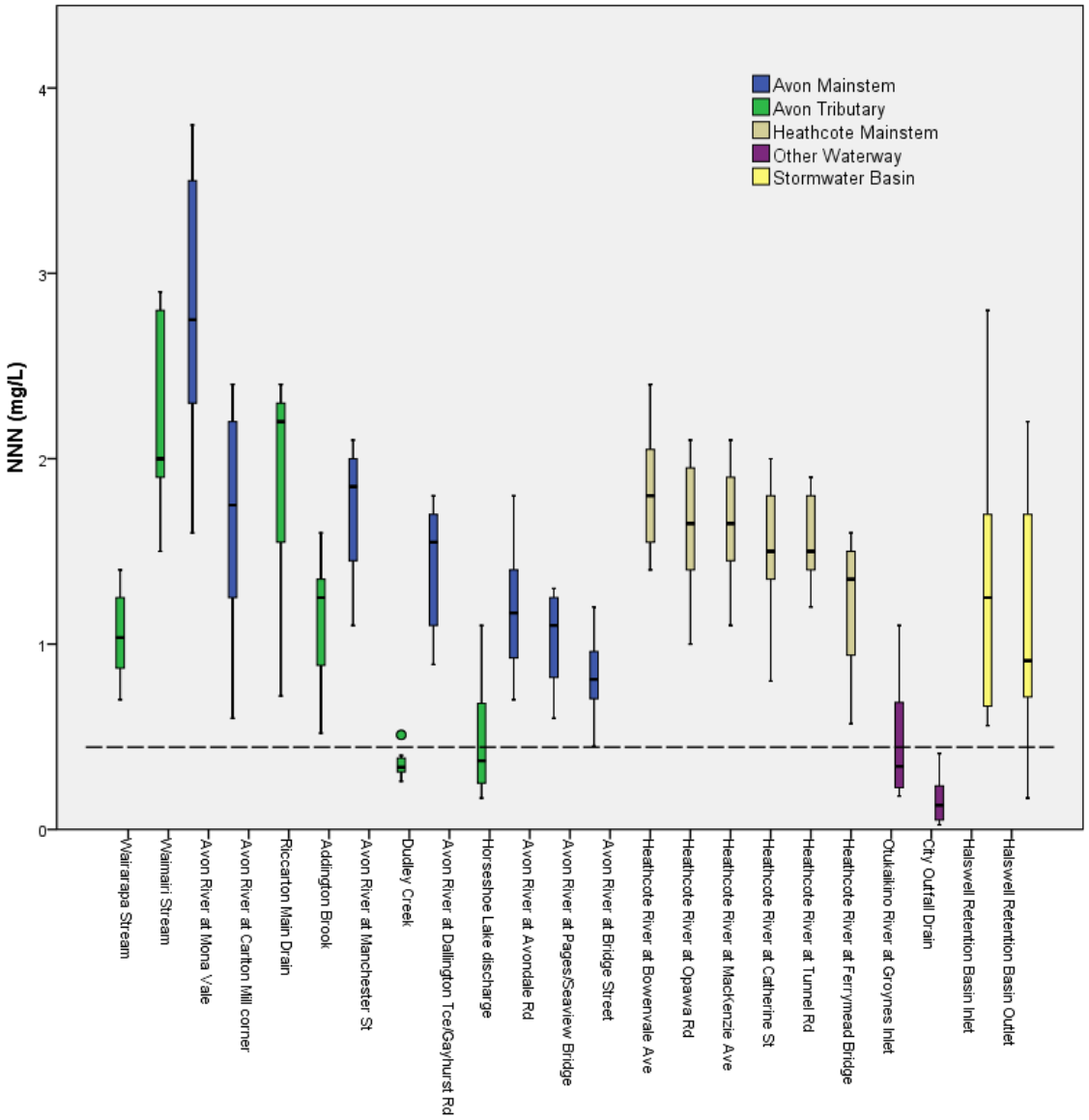

Figure 14. Nitrate Nitrite Nitrogen (NNN) levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the ANZECC water quality guideline (0.444 mg/L; ANZECC, 2000).

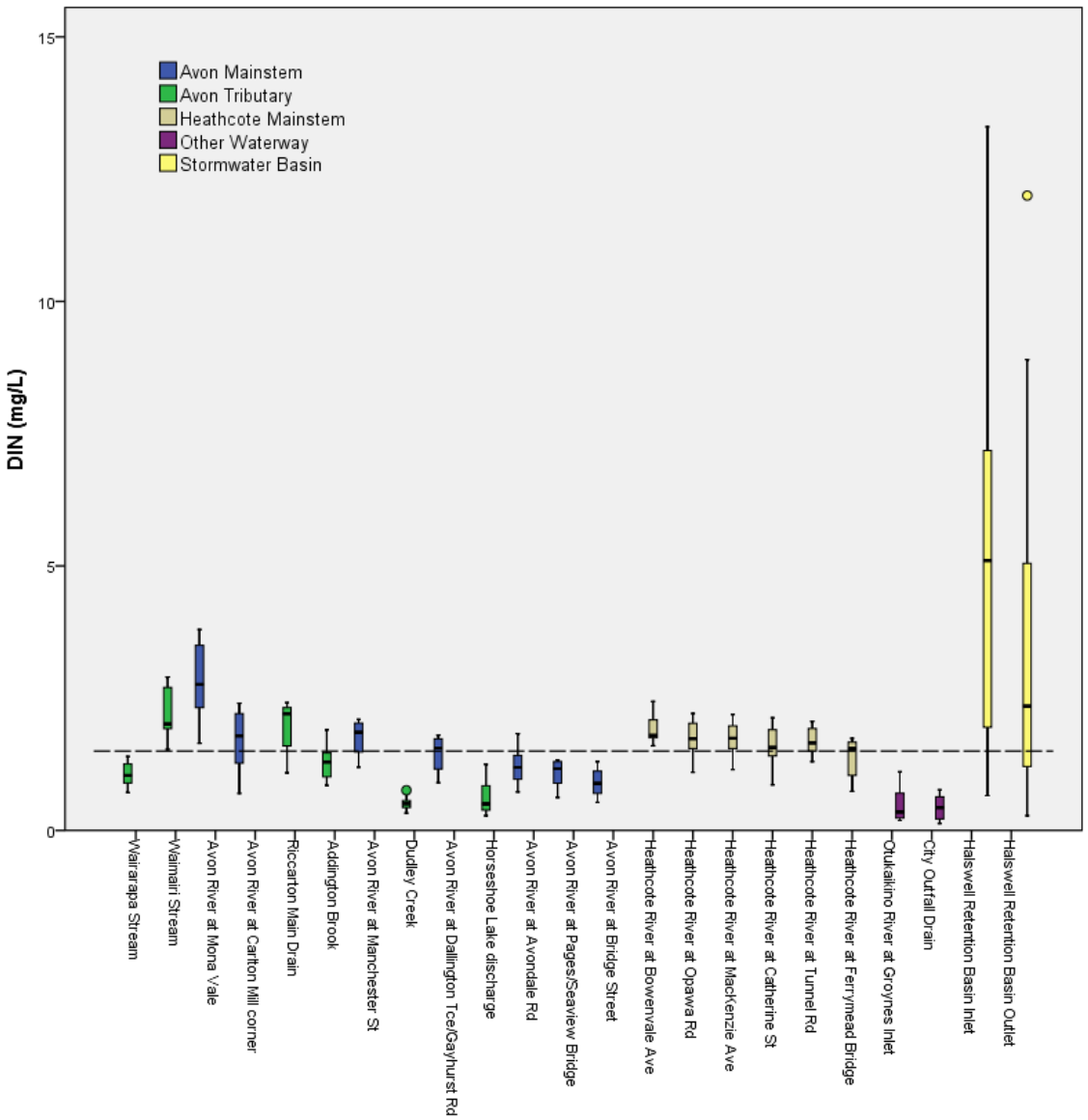

Figure 15. Dissolved Inorganic Nitrogen (DIN) levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan trigger value (Environment Canterbury, 2012).

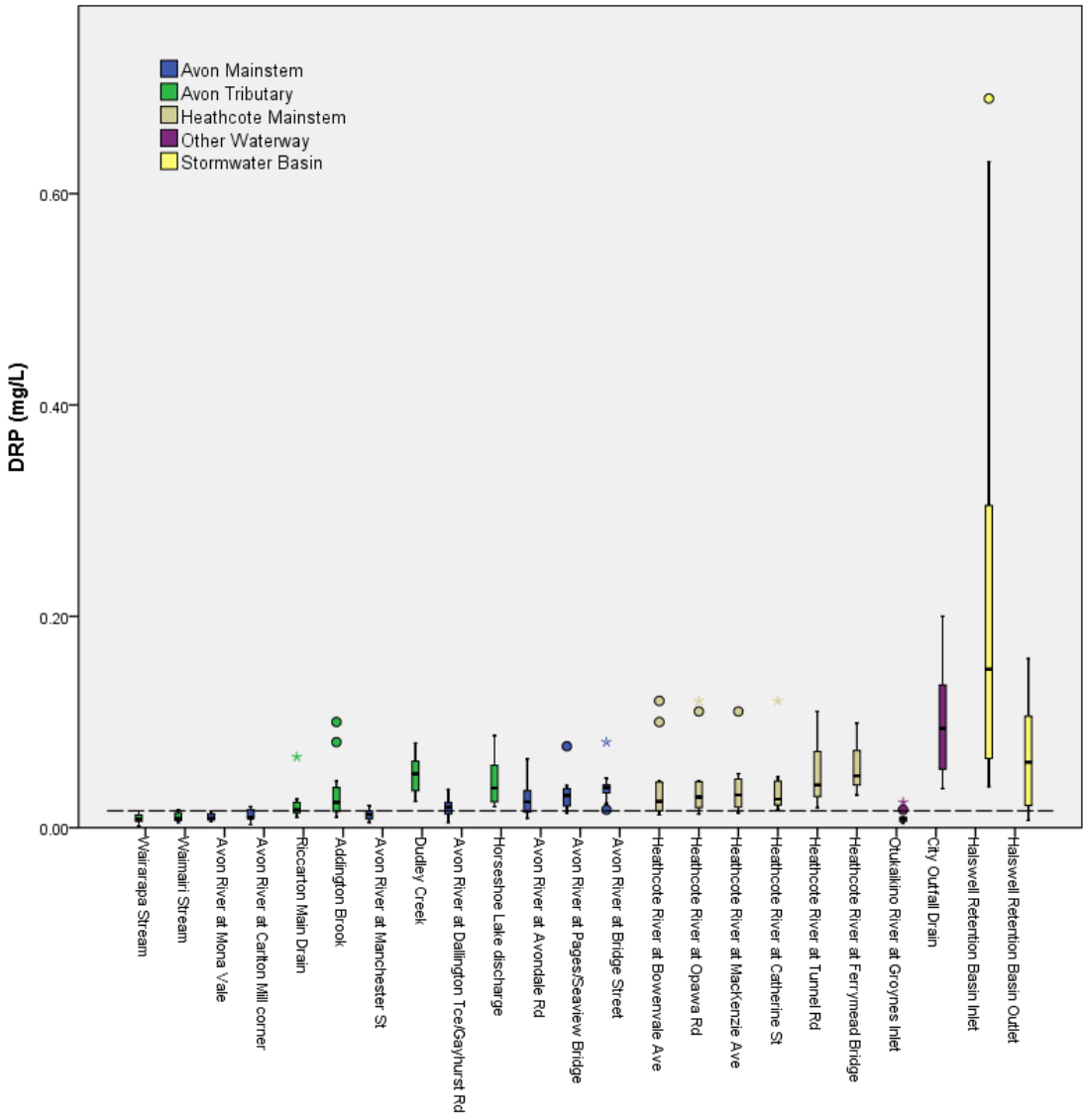

Figure 16. Dissolved Reactive Phosphorous (DRP) levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan trigger value (Environment Canterbury, 2012). The Laboratory Limit of Detection was 0.01 mg/L, analysed as half this value (0.005 mg/L) to allow statistics to be undertaken.

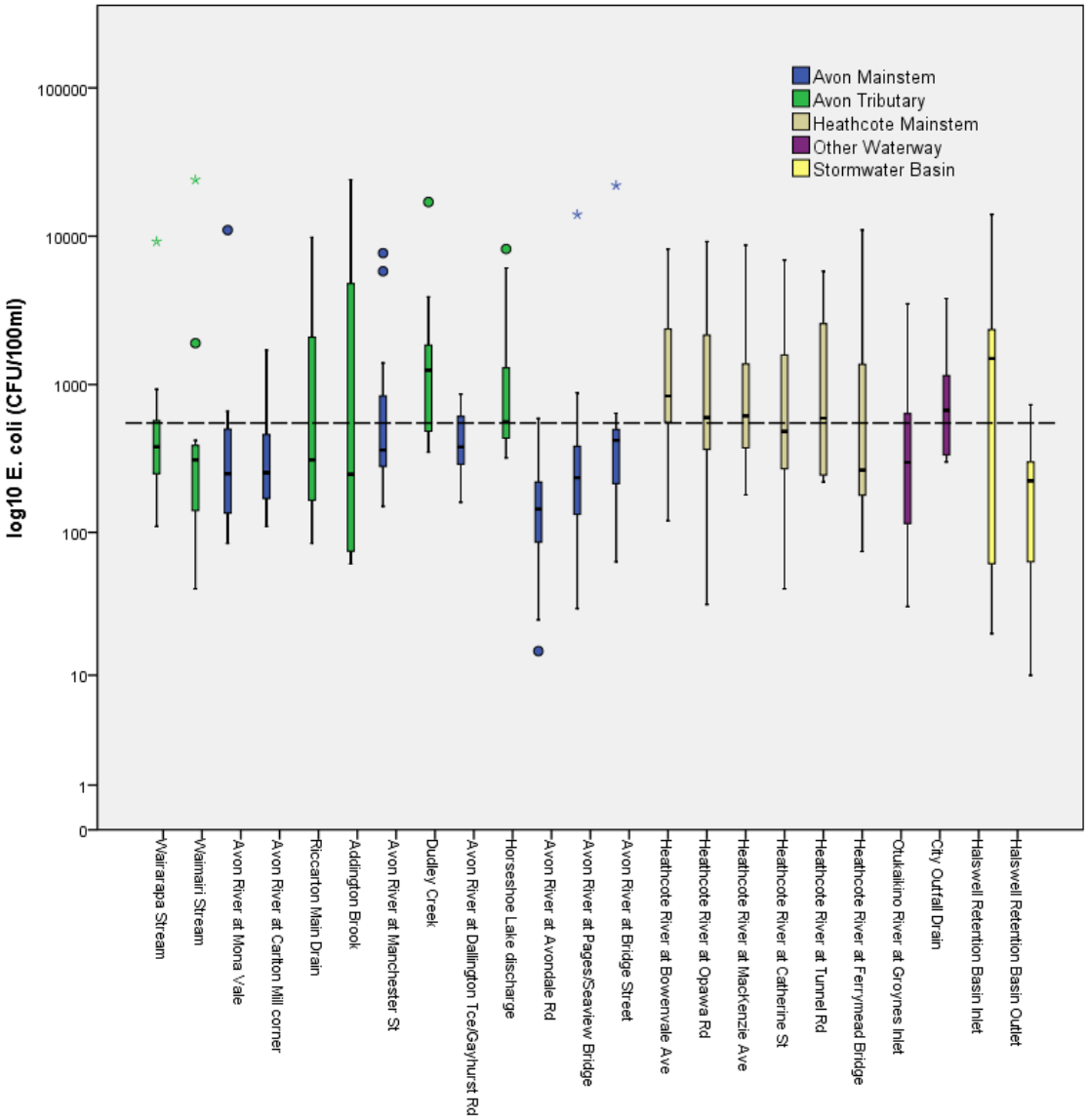

Figure 17. *Escherichia coli* levels in water samples for the monitoring period May 2013 to April 2014 at the Interim Global Stormwater Consent monitoring sites (twenty-one river sites and two stormwater basin sites). Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan trigger value of 550 CFU/100ml for 95% of samples (Environment Canterbury, 2012). Given the large differences in values between sites, a $\log_{10}$ scale was used to allow the data to be viewed on the same graph.

3.2 Temporal Trends

The majority of parameters across all sites had no significant upwards or downwards trends in concentrations, meaning that parameter levels remained static between years (151 incidences; Table 3). However, a number of sites recorded significant upward (47 incidences) and downward (45 incidences) trends in concentrations. The largest increase (by 33%) was for conductivity at the Avon River Bridge Street site (Figure 18). This increase may be related to salinity variations at this tidal site, potentially related to changes in estuary bathymetry or tidal extent due to the earthquakes, as the change in conductivity appears to occur around the time of seismic activity and now looks to have stabilised. Other notable increases were conductivity at the City Outfall Drain (again likely related to changes in salinity; Figure 19) and *E. coli* at the Halswell Retention Basin inlet (both by 23%). Increases were also recorded across most sites for pH, but these increases were only by 1-3%. Furthermore, these pH increases may not necessarily result in adverse effects, as increases to a certain limit may be beneficial if a site has pH tending towards acidic. The comparison to guidelines in the earlier section suggests that increases are not generally resulting in exceedances and are potentially needed for some of the Avon River sites that recorded acidic pH on some occasions (Waimairi Stream, Riccarton Main Drain, Addington Brook and Avon River at Mona Vale). The largest decrease was for turbidity in the Otukaikino River site (26%; Figure 20), which is likely due to a gradual decline since high levels in 2009. This is potentially due to improved land use practices in the catchment that have been instigated by Christchurch City Council rangers, such as fencing to keep out stock.

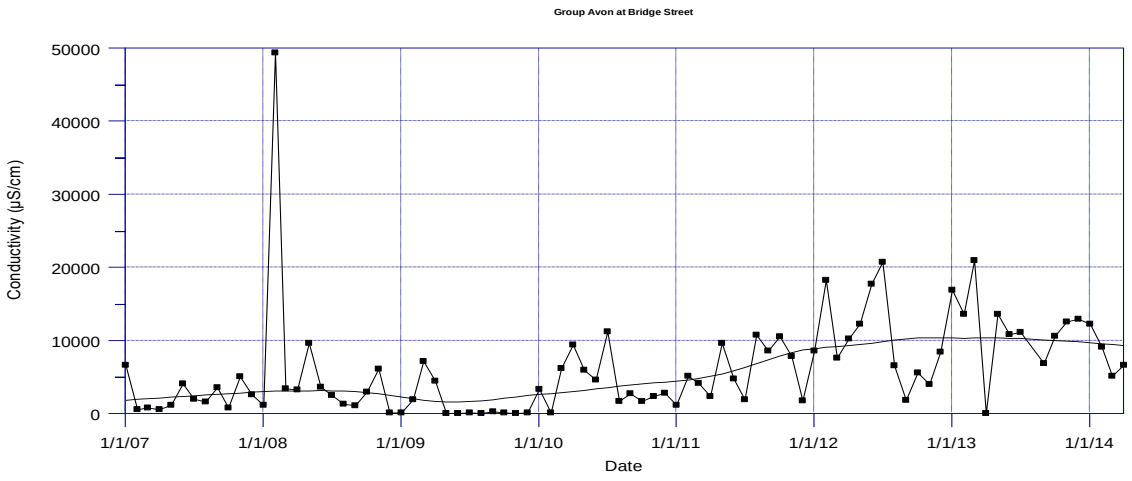

Figure 18. Conductivity levels at the Avon River Bridge Street site for the monitoring period January 2007 to April 2014. Squares indicate individual sampling events. The trendline was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

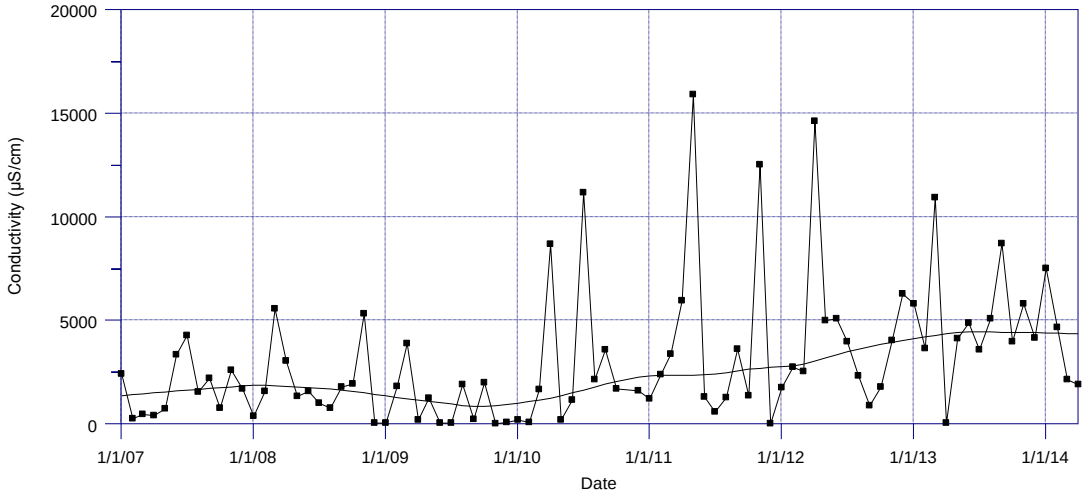

Figure 19. Conductivity levels at the City Outfall Drain site for the monitoring period January 2007 to April 2014. Squares indicate individual sampling events. The trendline was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

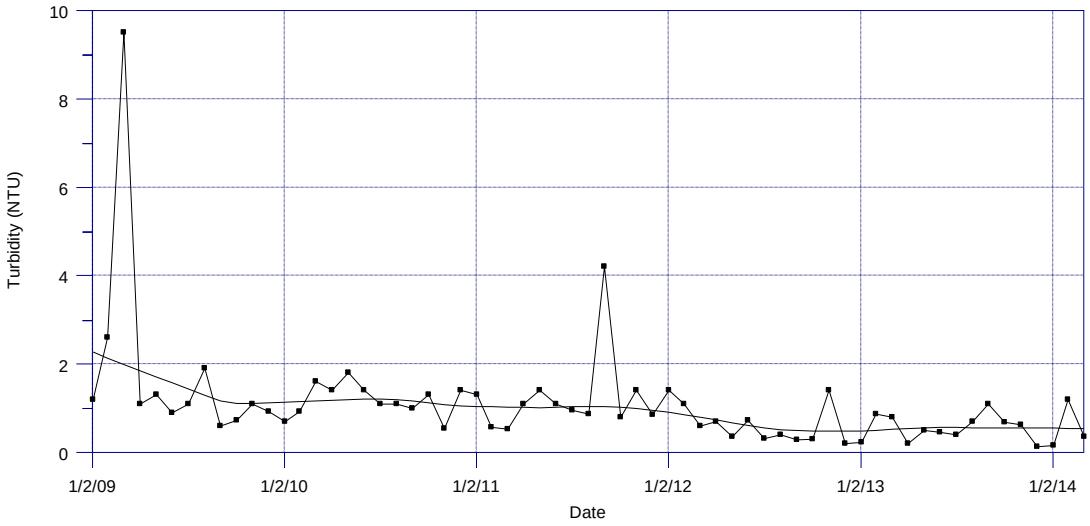

Figure 20. Turbidity levels at the Outukaikino at Groynes Inlet site for the monitoring period January 2007 to April 2014. Squares indicate individual sampling events. The trendline was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

Table 3. Direction of significant trends ($p<0.05$) for a range of parameters at the Interim Global Stormwater Consent water quality monitoring sites, calculated from monthly sampling conducted during January 2007 to April 2013. EC = Electrical Conductivity, TSS = Total Suspended Solids, DO = Dissolved Oxygen, Temp = Temperature; BOD_5 = Biochemical Oxygen Demand, NNN = Nitrate Nitrite Nitrogen and DIN = Dissolved Inorganic Nitrogen.

Catchment	Site	pH	EC	TSS	Turbidity	DO	Temp	BOD_5	Total Ammonia	NNN	DIN	*E. coli*
Avon	Wairarapa Stream		↓ 1%	↓ 4%								↑ 9%
	Waimairi Stream	↑ 1%	↓ 2%	↓ 7%	↓ 6%	↑ 1%						↑ 9%
	Avon River at Mona Vale	↑ 1%	↓ 1%	↓ 7%	↓ 10%							
	Avon River at Carlton Mill corner	↑ 1%	↓ 4%			↓ 1%				↓ 6%	↓ 6%	
	Riccarton Drain	↑ 1%	↑ 3%	↓ 4%			↑ 1%			↑ 8%	↑ 7%	
	Addington Brook	↑ 1%						↓ 8%				
	Avon River at Manchester St	↑ 1%	↓ 3%	↓ 5%								
	Dudley Creek	↑ 1%	↓ 5%	↑ 14%	↑ 13%				↑ 14%	↓ 8%		
	Avon River at Dallington Tce/Gayhurst Rd	↑ 1%		↓ 10%	↓ 11%		↑ 1%					
	Horseshoe Lake discharge	↑ 1%	↓ 5%						↑ 9%			↑ 18%
	Avon River at Avondale Rd			↓ 4%								
	Avon River at Pages/Seaview Bridge	↑ 1%	↑ 16%	↓ 5%	↓ 7%	↑ 2%	↑ 1%					↑ 19%
	Avon River at Bridge St	↑ 1%	↑ 33%	↓ 6%		↑ 2%				↓ 7%	↓ 5%	↑ 17%
Heathcote	Heathcote River at Bowenvale Ave	↑ 1%										
	Heathcote River at Opawa Rd/Clarendon Tce	↑ 1%		↓ 8%	↓ 11%			↓ 2%				
	Heathcote River at MacKenzie Ave	↑ 1%		↓ 10%				↓ 4%				
	Heathcote River at Catherine St	↑ 1%										
	Heathcote River at Tunnel Rd	↑ 1%		↓ 4%	↓ 8%				↓ 13%			
	Heathcote River at Ferrymead Bridge					↑ 2%		↓ 3%	↓ 16%			
Halswell	Halswell Retention Basin inlet	↑ 3%					↑ 3%	↓ 9%		↑ 20%	↑ 13%	↑ 23%
	Halswell Retention Basin outlet	↑ 2%	↓ 6%					↓ 12%				
Otukaikino	Otukaikino at Groynes inlet			↓ 13%	↓ 26%	↓ 1%						
City Outfall	City Outfall Drain	↑ 1%	↑ 23%	↑ 13%				↓ 7%		↓ 18%		↑ 12%

4 Discussion

There were a number of parameters that consistently met the relevant receiving water guidelines for the 2013-2014 monitoring period and are therefore unlikely to be having adverse effects on the waterways. These were dissolved lead, pH, temperature, total ammonia and nitrate. However, there were a number of parameters that recorded values well above the guidelines across most sites: NNN, DIN, DRP and *E. coli*. This indicates that these waterways are subjected to contaminated input, potentially from stormwater, wastewater and other discharges (i.e. waterfowl faeces). These parameters may be having adverse effects on biota (i.e. DIN), may encourage the proliferation of aquatic plants and/or algae (i.e. NNN and DRP), and may indicate human health risks from contact recreation (i.e. *E. coli*). These parameters are usually the ones of concern across all Christchurch waterways. There were also some parameters that generally recorded levels within the guidelines, but on a number of occasions recorded concentrations outside these values: dissolved copper, dissolved zinc, TSS, turbidity, dissolved oxygen and BOD_5. These occurrences are likely related to the discharge of stormwater during rain events and may result in short-term adverse effects on biota.

Notable spatial trends recorded during this monitoring period were:

1. TSS and turbidity: levels increased downstream in both the Avon and Heathcote catchments, levels in the Heathcote mainstem were higher than the Avon mainstem, and the Avon tributaries recorded higher levels than the mainstem. These trends are likely due to more sediment input occurring in the less urban upper reaches, and cumulative effects as flows travel downstream and receive more stormwater input.
2. DO and BOD_5: levels in the Avon tributaries were worse than the mainstem, most likely due to poor water quality within these catchments (e.g. Riccarton Main Drain, Addington Brook and Dudley Creek).
3. Nitrogen (nitrate, NNN and DIN): concentrations decreased downstream in all catchments, which is a trend that has been observed for many years across Christchurch's rivers. This phenomenon has often been attributed to nitrogen-rich spring input in the upper catchment (due to rural land use practices), with levels diluted as the waterways flow downstream. Consequently, the Council has recently instigated an investigation into nitrogen input into waterways from instream springs, starting with the Avon River catchment.

River sites that consistently recorded parameters well above the guideline levels and/or recorded a number of high one-off events compared to other sites were: Addington Brook for the Avon catchment (e.g. for dissolved copper, dissolved lead, dissolved zinc, TSS, DO, BOD_5, total ammonia and *E. coli*), the Heathcote River at the Ferrymead Bridge for the Heathcote catchment (e.g. for dissolved copper, dissolved lead, TSS and turbidity) and the City Outfall Drain (e.g. for DO, temperature, total ammonia and DRP). The Addington Brook is well known for having poor water quality, due to the commercial and industrial nature of this catchment. Consequently, ECan is working with industries to identify and reduce the levels of contaminants in this waterway. This project also encompasses Riccarton Main Drain, which recorded concentrations above the respective guidelines for dissolved zinc, NNN, DIN, DRP and *E. coli* during this monitoring period. Both the Ferrymead Bridge and City Outfall sites are located at the bottom of the catchments, immediately upstream of the estuary. It is assumed that the

high level of contaminants recorded at these sites is due to site-specific inputs from the adjacent industrial/commercial land use, rather than cumulative effects down through the catchment, as increases downstream were not recorded for these parameters. The exception to this was DRP, which did increase downstream in both the Avon and Heathcote catchments. In contrast, the Otukaikino River site, and the Wairarapa and Waimairi Streams in the Avon catchment, recorded the best water quality out of all the monitoring sites.

Overall, the results of the temporal trends analysis showed that the majority of parameter concentrations for the sites have remained steady over time. However, some sites have increased and decreased in concentrations. Of note was a 33% and 23% increase in conductivity at the Avon River Bridge Street site and the City Outfall Drain, respectively. As discussed, this increase may be related to salinity variations at these sites, which might be related to changes due to the earthquakes, as the changes in conductivity appear to occur around the time of seismic activity and now look to have stabilised. A decrease in turbidity in the Otukaikino River site (by 26%) was also recorded, which is likely due to a gradual decline since high levels in 2009. As mentioned previously, this is potentially due to improved land use practices that have been instigated in the catchment, such as fencing to keep out stock.

ECan has recently also undertaken temporal trend analyses of Avon River water quality, using the same data used in this report, although only using data up until the end of 2012 (Environment Canterbury, 2014). This ECan report is more detailed, analysing a larger number parameters and the influence of seismic activity. Analyses were conducted in the ECan report using the same methodology as that in this report. Consistent trends were generally shown between the two monitoring reports[9]. However, the ECan report identified some trends that were not shown to either decrease or increase significantly in this report[10]. These differences between reports are likely due to the extra year and a half of data analysed in this report, as the same base data and methodology was employed in both reports.

With respect to the Halswell Retention Basin inlet and outlet, these sites generally recorded much higher levels than the river sites. This is to be expected given the predominantly stormwater input into the basins and that the rivers are also subjected to dilution from baseflow. These basin sites also appeared to record more variability in concentrations, possibly due to variable levels of parameters in stormwater and/or the treatment ability of the basin. The outlet recorded lower median concentrations that the inlet for all parameters, indicating that overall there was an improvement in water quality due to the basin.

In summary, the water quality at the majority of IGSC sites has not degraded further in the last monitoring year and has even increased at some sites. In particular, the Otukaikino Groynes site notably recorded good water quality (with the exception of *E.*

[9] Namely, (1) an increase in ammonia in Dudley Creek, (2) an increase in NNN and DIN in Riccarton Main Drain, (3) a decrease in NNN in the Avon River at Bridge Street and Carlton Mill Corner, (4) an increase in *E. coli* in the Avon River at Pages Road, the Avon River at Bridge Street and at Horseshoe Lake, (5) a decrease in BOD_5 in Addington Brook, (6) an increase in DO in the Avon River at Bridge Street, (7) an increase in TSS at Dudley Creek, (8) a decrease in TSS at the Avon River Bridge Street site, (9) a decrease in turbidity in the Avon River at Dallington Terrace, the Avon River at Mona Vale and in Waimairi Stream, and (10) an increase in turbidity in Dudley Creek.

[10] These included (1) an increase in ammonia in the Avon River at Carton Mill Corner, (2) a decrease in NNN in the Avon River at Pages/Seaview Bridge, the Avon River at Manchester Street and in Waimairi Stream, (3) an increase in *E. coli* in the Avon River at Carlton Mill Corner and (4) a decrease in DO in the Avon River at Avondale Road. This report also recorded 1-3% increases in pH across all sites, but the ECan report only recorded an increase in pH in the Avon River at Dallington Terrace, the Avon River at Manchester Street and in Horseshoe Lake.

coli levels). However, the water quality at some sites has reduced and many of the guideline levels are still not being met. In particular, there are still consistently high levels of NNN, DIN, DRP and *E. coli*. at many sites that could be causing adverse effects on biota, proliferation of aquatic plants and algae, and contact recreation human health risks. Therefore these parameters should be a focus of treatment throughout these catchments. Locations recording particularly high levels of parameters included Addington Drain, the Heathcote River at the Ferrymead Bridge and the City Outfall Drain. Water quality in most of these catchments should improve over time with the instigation of the Christchurch City Council's Avon Stormwater Management Plan and the ECan catchment pollution projects. Improvements in water quality of the Avon and Heathcote Rivers will then most likely also result in an improvement in the water quality of the estuary.

5 References

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6 Appendix A: Metal Hardness Modified Trigger Values

1. Introduction

The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC, 2000) provides a set of default guideline trigger values for metals, with which to compare measured contaminant concentrations. These trigger values represent concentrations below which there is considered to be a low risk of adverse biological effects (ANZECC, 2000). The guidelines also provide a process for modifying the given trigger values for local environmental conditions. If measured concentrations of toxicants are below default trigger values, then there is a low risk of adverse effects. However, if measured concentrations exceed these guidelines, then it is possible to consider site specific factors that may modify the trigger values, to gain a better understanding of whether a real risk exists. If measured concentrations also exceed modified trigger values, then the next step would be to directly assess biological effects.

Christchurch City Council has measured concentrations of metals (total cadmium, total copper, total lead, total zinc) in water samples from 33 river monitoring sites across the city since 2008. Measured concentrations vary widely across the monitoring sites, and there are several sites where values often exceed guideline trigger values. In fresh waters, the hardness, pH and alkalinity of the water can alter the toxicity of metals and hence the risk of adverse biological effects (ANZECC, 2000). The default guideline trigger values for metals assume that water is soft (with a hardness value of between 0 and 59 mg/L as CaCO3), but as water hardness increases, the toxicity of some metals decreases and therefore the trigger value may increase, without increasing the risk of adverse biological effects.

To make an informed assessment of the real risks associated with exceeding the default trigger values, additional monitoring for water hardness has been included at sites within each catchment for the purpose of calculating appropriate hardness modified trigger values (HMTV) for Christchurch rivers using the water hardness dependent algorithms provided in the ANZECC (2000) guidelines.

2. Sites and sampling regime

Water samples are collected monthly at sites across the five main catchments within Christchurch City (Avon, Heathcote, Styx, Halswell, Otukaikino). These samples are analysed at the Christchurch City Council laboratory for a range of physical and chemical characteristics, including temperature, nutrients, microbiological indicators and metals. Since December 2010, samples from the eight sites listed in Table 1 have also been analysed for water hardness measured in mg/L as $CaCO_3$. Routine water quality monitoring was disrupted on several occasions during 2011, by the significant earthquakes experienced in the city. Despite this, each of the sites had between 9 and 12 water hardness measures recorded by March 2012 and the results were relatively consistent over time for each site.

Table 1. Sampling sites for water hardness investigation (December 2010 to March 2012)

Site Description	Easting	Northing	Number of water hardness samples
Otukaikino at Groynes Inlet	2477878	5750484	11
Styx River at Gardiners Road	2476786	5748821	12
Styx River at Marshland Road bridge	2482356	5749417	12
Avon River at Mona Vale	2478279	5742653	9
Avon River at Gayhurst Road	2483549	5742827	9
Heathcote River at Templetons Road	2475913	5738516	12
Heathcote at Opawa Road/Clarendon Terrace	2483072	5739226	12
Halswell River at Akaroa Highway	2474427	5733346	9

3. Results

3.1. Water Hardness by catchment

Sites on the Styx and Otukaikino rivers had median hardness values within the 'soft' water category, the Avon and Halswell river sites were within the 'moderate' hardness category and the Heathcote sites had 'moderate' to 'hard' water (Figure 1). For the Heathcote River, the Templetons Road site had a number of low hardness outlier values, but median water hardness was higher at the upstream site (Templetons Road) than the downstream site (Opawa Road).

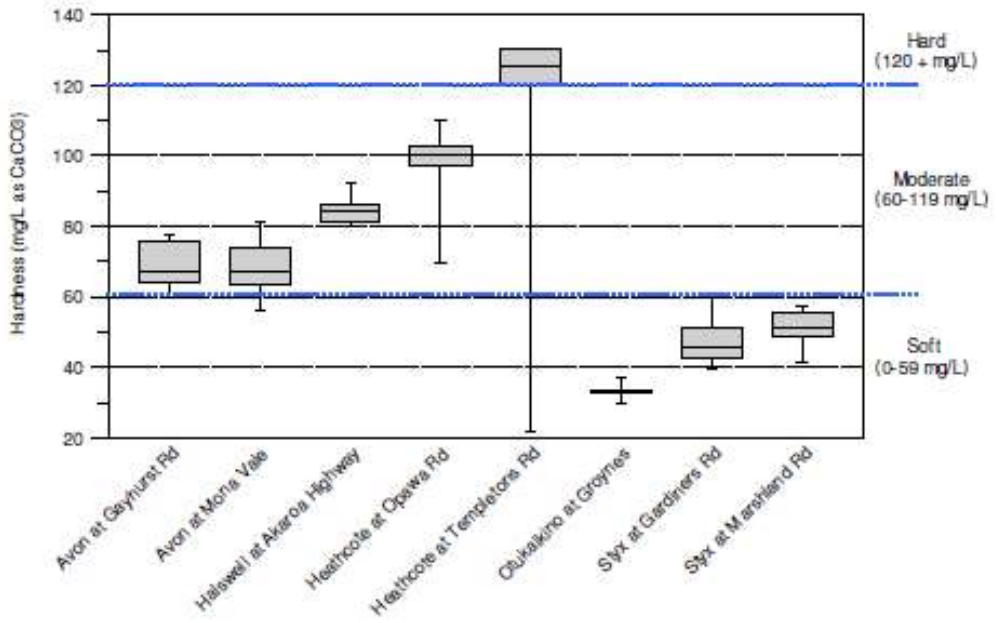

Figure 1 Box plots displaying median (and upper, lower quartiles, max and min) water hardness values for monitoring sites on the Avon, Heathcote, Halswell, Styx and Otukaikino rivers between December 2010 and March 2012.

3.2. Hardness Modified Trigger Values (HMTV)

Hardness modified trigger values (HMTV) are greater than default trigger values in each of the rivers in Christchurch (Table 1). This is because the default values assume that water is in the 'soft' category and this provides trigger values to conservatively protect aquatic ecosystems values in the absence of further information to refine these values.

Table 2 Default and HMTV for metals in the Avon, Heathcote, Halswell, Styx and Otukaikino rivers, based on 99, 95 and 90% levels of species protection as described by ANZECC (2000).

		Default trigger values (µg/L) (ANZECC, 2000)			Hardness modified trigger values (µg/L)		
Level of species protection		**99%**	**95%**	**90%**	**99%**	**95%**	**90%**
Avon	Cadmium	0.06	0.20	0.40	0.12	0.41	0.82
	Copper	1.00	1.40	1.80	1.98	2.77	3.56
	Lead	1.00	3.40	5.60	2.77	9.43	15.54
	Zinc	2.40	8.00	15.00	4.75	15.84	29.70
Heathcote	Cadmium	0.06	0.20	0.40	0.19	0.64	1.27
	Copper	1.00	1.40	1.80	3.02	4.22	5.43
	Lead	1.00	3.40	5.60	5.21	17.71	29.16
	Zinc	2.40	8.00	15.00	7.24	24.14	45.26
Halswell	Cadmium	0.06	0.20	0.40	0.15	0.50	1.00
	Copper	1.00	1.40	1.80	2.40	3.36	4.32
	Lead	1.00	3.40	5.60	3.70	12.57	20.71
	Zinc	2.40	8.00	15.00	5.76	19.19	35.99
Styx	Cadmium	0.06	0.20	0.40	0.09	0.31	0.62
	Copper	1.00	1.40	1.80	1.52	2.12	2.73
	Lead	1.00	3.40	5.60	1.86	6.34	10.44
	Zinc	2.40	8.00	15.00	3.64	12.14	22.76
Otukaikino	Cadmium	0.06	0.20	0.40	0.07	0.22	0.44
	Copper	1.00	1.40	1.80	1.08	1.52	1.95
	Lead	1.00	3.40	5.60	1.13	3.84	6.32
	Zinc	2.40	8.00	15.00	2.60	8.68	16.27

4. References

ANZECC (Australian and New Zealand Environment and Conservation Council), 2000. Australian and New Zealand guidelines for fresh and marine water quality.

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7 Appendix B: Summary Data

Site		Total Ammonia (mg/L)	BOD5 (mg/L)	Total Cadmium (mg/L)	Dissolved Cadmium (mg/L)	Conductivity (µS/cm)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Dissolved Oxygen Saturation (%)	Dissolved Oxygen (mg/L)	Dissolved Organic Carbon (mg/L)	E. coli (CFU/100ml)
Addington Brook	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.2	0.9		0.0001	325		0.0010	76	8	3.0	280
	Mean	0.2	1.5		0.0001	293		0.0020	76	8	4.5	5014
	Std. Error of Mean	0.0	0.3		0.0000	31		0.0005	4	1	1.0	2582
	Minimum	0.0	0.5		0.0001	105		0.0010	55	6	1.8	61
	Maximum	0.5	3.7		0.0001	404		0.0071	110	12	14.0	24000
Avon River at Avondale Rd	N	12.0	12.0			12			12	12		12
	Median	0.0	0.5			177			92	10		145
	Mean	0.0	0.7			229			96	10		175
	Std. Error of Mean	0.0	0.1			46			6	0		44
	Minimum	0.0	0.5			145			69	7		15
	Maximum	0.1	1.1			680			130	13		590
Avon River at Bridge Street	N	11.0	11.0		11.0000	11		11.0000	11	11	11.0	11
	Median	0.1	0.5		0.0001	10800		0.0010	94	9	1.4	420
	Mean	0.1	0.7		0.0001	10112		0.0011	92	9	1.7	2309
	Std. Error of Mean	0.0	0.1		0.0000	862		0.0001	5	0	0.3	1970
	Minimum	0.1	0.5		0.0001	5070		0.0010	64	6	0.4	63
	Maximum	0.3	1.2		0.0003	13600		0.0025	110	11	4.5	22000
Avon River at Carlton Mill corner	N	12.0	12.0			12			12	12		12
	Median	0.0	0.5			144			94	10		255
	Mean	0.0	0.7			146			94	10		400
	Std. Error of Mean	0.0	0.1			9			3	0		125
	Minimum	0.0	0.5			92			67	7		110
	Maximum	0.1	1.7			184			110	11		1700
Avon River at Dallington Tce/Gayhurst Rd	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.5		0.0001	158		0.0010	80	9	0.8	380
	Mean	0.0	0.6		0.0001	185		0.0013	85	9	0.9	443
	Std. Error of Mean	0.0	0.1		0.0000	20		0.0003	5	0	0.1	63
	Minimum	0.0	0.5		0.0001	89		0.0008	67	7	0.6	160
	Maximum	0.1	1.8		0.0001	340		0.0036	130	13	1.7	860
Avon River at Manchester St	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.5		0.0001	156		0.0010	90	10	0.6	370
	Mean	0.0	0.7		0.0001	154		0.0015	93	10	0.9	1484
	Std. Error of Mean	0.0	0.2		0.0000	10		0.0003	3	0	0.2	726
	Minimum	0.0	0.5		0.0001	86		0.0010	83	9	0.4	150
	Maximum	0.1	2.2		0.0001	194		0.0043	120	12	2.7	7700
Avon River at Mona Vale	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12

Site		Total Ammonia (mg/L)	BOD5 (mg/L)	Total Cadmium (mg/L)	Dissolved Cadmium (mg/L)	Conductivity (µS/cm)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Dissolved Oxygen Saturation (%)	Dissolved Oxygen (mg/L)	Dissolved Organic Carbon (mg/L)	E. coli (CFU/100ml)
	Median	0.0	0.5		0.0001	166		0.0010	89	9	0.4	250
	Mean	0.0	0.6		0.0001	163		0.0010	88	9	0.5	1178
	Std. Error of Mean	0.0	0.1		0.0000	10		0.0000	1	0	0.1	895
	Minimum	0.0	0.5		0.0001	99		0.0010	79	8	0.1	84
	Maximum	0.1	1.2		0.0001	211		0.0010	94	10	1.1	11000
Avon River at Pages/Seaview Bridge	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.8		0.0001	767		0.0010	94	10	1.8	235
	Mean	0.1	0.8		0.0001	872		0.0011	90	9	2.4	1411
	Std. Error of Mean	0.0	0.1		0.0000	135		0.0001	5	0	0.4	1146
	Minimum	0.0	0.5		0.0001	213		0.0010	67	7	0.8	30
	Maximum	0.2	1.4		0.0001	1650		0.0020	110	11	4.5	14000
City Outfall Drain	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.3	1.2		0.0001	4395		0.0010	59	6	3.6	670
	Mean	0.3	1.1		0.0001	4695		0.0012	64	7	3.5	1048
	Std. Error of Mean	0.1	0.1		0.0000	565		0.0002	6	1	0.2	312
	Minimum	0.1	0.5		0.0001	1900		0.0010	33	3	2.3	300
	Maximum	0.7	2.2		0.0002	8690		0.0032	120	11	4.5	3800
Dudley Creek	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.2	1.0		0.0001	143		0.0010	78	8	2.7	1250
	Mean	0.2	1.2		0.0001	148		0.0014	79	8	3.0	2575
	Std. Error of Mean	0.0	0.3		0.0000	12		0.0003	2	0	0.5	1342
	Minimum	0.1	0.5		0.0001	88		0.0010	67	7	1.1	350
	Maximum	0.3	4.1		0.0001	225		0.0038	96	10	6.7	17000
Halswell Retention Basin Inlet	N	12.0	12.0			12			12	12		11
	Median	3.4	5.2			139			83	9		1500
	Mean	3.6	5.2			142			82	8		2928
	Std. Error of Mean	1.0	0.4			14			6	1		1394
	Minimum	0.1	2.5			86			49	5		20
	Maximum	11.0	8.7			245			120	11		14000
Halswell Retention Basin Outlet	N	12.0	12.0			12			12	12		10
	Median	1.4	2.7			100			98	10		225
	Mean	2.5	3.9			104			90	9		253
	Std. Error of Mean	0.9	0.7			13			7	1		70
	Minimum	0.1	1.5			12			40	4		10
	Maximum	10.0	8.9			196			120	12		730
Heathcote River at Bowenvale Ave	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.8		0.0001	231		0.0010	86	9	3.0	850
	Mean	0.1	0.9		0.0001	235		0.0017	86	9	3.9	1923
	Std. Error of Mean	0.0	0.2		0.0000	9		0.0003	3	0	0.9	696

Site		Total Ammonia (mg/L)	BOD5 (mg/L)	Total Cadmium (mg/L)	Dissolved Cadmium (mg/L)	Conductivity (µS/cm)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Dissolved Oxygen Saturation (%)	Dissolved Oxygen (mg/L)	Dissolved Organic Carbon (mg/L)	E. coli (CFU/100ml)
	Minimum	0.0	0.5		0.0001	170		0.0010	67	8	1.1	120
	Maximum	0.4	2.2		0.0001	275		0.0036	98	10	10.0	8200
Heathcote River at Catherine St	N	12.0	12.0			12			12	12		12
	Median	0.1	0.8			272			77	8		485
	Mean	0.1	0.9			267			76	8		1289
	Std. Error of Mean	0.0	0.1			16			2	0		569
	Minimum	0.0	0.5			185			62	7		41
	Maximum	0.2	1.6			380			87	9		6900
Heathcote River at Ferrymead Bridge	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.2	0.5		0.0001	9605		0.0010	87	9	2.3	265
	Mean	0.2	1.0		0.0002	10666		0.0020	85	9	3.2	1741
	Std. Error of Mean	0.0	0.2		0.0001	2165		0.0004	3	0	0.9	939
	Minimum	0.1	0.5		0.0001	684		0.0010	69	7	0.3	74
	Maximum	0.3	3.0		0.0010	22500		0.0052	97	10	10.0	11000
Heathcote River at MacKenzie Ave	N	12.0	12.0			12			12	12		12
	Median	0.1	0.5			257			78	8		615
	Mean	0.1	1.0			264			77	8		1635
	Std. Error of Mean	0.0	0.2			15			2	0		721
	Minimum	0.0	0.5			182			62	7		180
	Maximum	0.3	2.6			384			89	9		8700
Heathcote River at Opawa Rd	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.1	0.5		0.0001	254		0.0010	81	9	2.6	605
	Mean	0.1	0.7		0.0001	255		0.0015	81	9	3.5	2074
	Std. Error of Mean	0.0	0.1		0.0000	10		0.0003	2	0	0.8	896
	Minimum	0.0	0.5		0.0001	184		0.0010	70	7	0.7	32
	Maximum	0.3	1.5		0.0001	307		0.0035	96	10	10.0	9200
Heathcote River at Tunnel Rd	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.1	0.5		0.0001	930		0.0010	82	9	2.9	605
	Mean	0.1	0.9		0.0001	1414		0.0021	84	9	3.7	1699
	Std. Error of Mean	0.0	0.2		0.0000	346		0.0007	3	0	0.8	601
	Minimum	0.0	0.5		0.0001	240		0.0010	70	7	0.3	220
	Maximum	0.2	2.4		0.0002	3830		0.0083	100	10	9.9	5800
Horseshoe Lake discharge	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.1	1.1		0.0001	161		0.0010	67	7	4.3	560
	Mean	0.1	1.0		0.0001	161		0.0011	70	7	5.6	1738
	Std. Error of Mean	0.0	0.1		0.0000	14		0.0001	3	0	0.9	747
	Minimum	0.1	0.5		0.0001	97		0.0010	54	6	1.8	320
	Maximum	0.2	1.7		0.0001	256		0.0026	92	9	9.8	8200
Otukaikino River at Groynes Inlet	N	12.0	12.0	1.0000	12.0000	12	3.0000	12.0000	12	12	12.0	12

Site		Total Ammonia (mg/L)	BOD5 (mg/L)	Total Cadmium (mg/L)	Dissolved Cadmium (mg/L)	Conductivity (µS/cm)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Dissolved Oxygen Saturation (%)	Dissolved Oxygen (mg/L)	Dissolved Organic Carbon (mg/L)	E. coli (CFU/100ml)
	Median	0.0	0.5	0.0001	0.0001	77	0.0010	0.0010	86	9	0.8	300
	Mean	0.0	0.6	0.0001	0.0001	100	0.0009	0.0010	86	9	0.9	652
	Std. Error of Mean	0.0	0.1		0.0000	19	0.0001	0.0000	1	0	0.1	285
	Minimum	0.0	0.5	0.0001	0.0001	50	0.0008	0.0010	79	8	0.1	31
	Maximum	0.0	1.1	0.0001	0.0001	302	0.0010	0.0010	91	10	1.8	3500
Riccarton Main Drain	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.5		0.0001	216		0.0010	90	9	0.9	320
	Mean	0.1	1.1		0.0001	193		0.0022	90	9	1.4	1806
	Std. Error of Mean	0.0	0.4		0.0000	16		0.0008	1	0	0.6	841
	Minimum	0.0	0.5		0.0001	83		0.0010	84	9	0.3	84
	Maximum	0.4	5.5		0.0001	249		0.0100	93	10	7.5	9800
Waimairi Stream	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.5		0.0001	139		0.0010	83	9	0.4	310
	Mean	0.0	0.8		0.0001	137		0.0012	84	9	0.7	2361
	Std. Error of Mean	0.0	0.2		0.0000	13		0.0002	1	0	0.3	1972
	Minimum	0.0	0.5		0.0001	34		0.0010	75	8	0.1	41
	Maximum	0.0	3.1		0.0001	194		0.0031	94	10	4.3	24000
Wairarapa Stream	N	12.0	12.0		12.0000	12		12.0000	12	12	12.0	12
	Median	0.0	0.5		0.0001	141		0.0010	78	8	0.5	380
	Mean	0.0	0.7		0.0001	132		0.0011	81	9	0.7	1143
	Std. Error of Mean	0.0	0.1		0.0000	9		0.0001	2	0	0.1	735
	Minimum	0.0	0.5		0.0001	65		0.0010	72	8	0.3	110
	Maximum	0.1	1.7		0.0001	166		0.0023	100	11	1.5	9200
Total	N	275.0	275.0	1.0000	203.0000	275	3.0000	203.0000	275	275	203.0	272
	Median	0.1	0.5	0.0001	0.0001	194	0.0010	0.0010	84	9	1.4	405
	Mean	0.3	1.2	0.0001	0.0001	1319	0.0009	0.0014	84	9	2.4	1624
	Std. Error of Mean	0.1	0.1		0.0000	202	0.0001	0.0001	1	0	0.2	221
	Minimum	0.0	0.5	0.0001	0.0001	12	0.0008	0.0008	33	3	0.1	10
	Maximum	11.0	8.9	0.0001	0.0010	22500	0.0010	0.0100	130	13	14.0	24000

Site		Faecal Coliforms (CFU/100ml)	Total Lead (mg/L)	Dissolved Lead (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrate - Nitrite (mg/L)	Dissolved Inorganic Nitrogen (mg/L)	pH	Dissolved Reactive Phosphorus (mg/L)	Total Phosphorus (mg/L)
Addington Brook	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	250		0.0008	1.15	0.03	1.3	1.3	7.8	0.024	0.078
	Mean	2776		0.0015	1.08	0.03	1.1	1.3	7.5	0.034	0.139
	Std. Error of Mean	1362		0.0003	0.10	0.01	0.1	0.1	0.2	0.008	0.052
	Minimum	60		0.0008	0.49	0.02	0.5	0.9	5.5	0.010	0.029
	Maximum	14000		0.0038	1.40	0.09	1.6	1.9	8.1	0.100	0.680
Avon River at Avondale Rd	N	12			12.00	12.00	12.0	12.0	12.0	12.000	
	Median	115			1.04	0.02	1.2	1.2	7.8	0.025	
	Mean	146			1.15	0.03	1.2	1.2	7.9	0.028	
	Std. Error of Mean	39			0.10	0.01	0.1	0.1	0.1	0.005	
	Minimum	20			0.68	0.01	0.7	0.7	7.5	0.009	
	Maximum	530			1.80	0.17	1.8	1.8	8.6	0.065	
Avon River at Bridge Street	N	11		11.0000	11.00	11.00	11.0	11.0	11.0	11.000	11.000
	Median	400		0.0008	0.75	0.02	0.8	0.9	8.0	0.038	0.062
	Mean	2187		0.0014	0.75	0.02	0.8	0.9	7.9	0.039	0.077
	Std. Error of Mean	1882		0.0004	0.09	0.00	0.1	0.1	0.1	0.005	0.011
	Minimum	50		0.0008	0.09	0.01	0.5	0.5	7.5	0.017	0.046
	Maximum	21000		0.0039	1.20	0.02	1.2	1.3	8.2	0.081	0.180
Avon River at Carlton Mill corner	N	12			12.00	12.00	12.0	12.0	12.0	12.000	
	Median	380			1.75	0.01	1.8	1.8	7.7	0.010	
	Mean	503			1.71	0.01	1.7	1.7	7.7	0.012	
	Std. Error of Mean	100			0.17	0.00	0.2	0.2	0.0	0.002	
	Minimum	100			0.59	0.01	0.6	0.7	7.4	0.003	
	Maximum	1200			2.40	0.01	2.4	2.4	7.9	0.020	
Avon River at Dallington Tce/Gayhurst Rd	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	275		0.0008	1.55	0.01	1.6	1.6	7.8	0.020	0.032
	Mean	386		0.0009	1.40	0.01	1.4	1.5	7.9	0.019	0.040
	Std. Error of Mean	64		0.0002	0.09	0.00	0.1	0.1	0.1	0.003	0.006
	Minimum	150		0.0008	0.88	0.01	0.9	0.9	7.6	0.005	0.010
	Maximum	800		0.0029	1.80	0.02	1.8	1.8	8.4	0.036	0.080
Avon River at Manchester St	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	315		0.0008	1.80	0.01	1.9	1.9	7.8	0.013	0.021
	Mean	947		0.0014	1.71	0.01	1.7	1.7	7.8	0.013	0.028
	Std. Error of Mean	500		0.0003	0.10	0.00	0.1	0.1	0.1	0.001	0.007
	Minimum	170		0.0008	1.10	0.01	1.1	1.2	7.0	0.005	0.010
	Maximum	6300		0.0042	2.10	0.02	2.1	2.1	8.2	0.021	0.100
Avon River at Mona Vale	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	520		0.0008	2.75	0.01	2.8	2.8	7.5	0.009	0.010

Site		Faecal Coliforms (CFU/100ml)	Total Lead (mg/L)	Dissolved Lead (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrate - Nitrite (mg/L)	Dissolved Inorganic Nitrogen (mg/L)	pH	Dissolved Reactive Phosphorus (mg/L)	Total Phosphorus (mg/L)
	Mean	1051		0.0011	2.82	0.01	2.8	2.8	7.4	0.010	0.019
	Std. Error of Mean	556		0.0002	0.21	0.00	0.2	0.2	0.2	0.001	0.005
	Minimum	140		0.0008	1.60	0.01	1.6	1.6	5.7	0.006	0.010
	Maximum	7100		0.0024	3.80	0.01	3.8	3.8	8.1	0.016	0.073
Avon River at Pages/Seaview Bridge	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	190		0.0008	1.10	0.02	1.1	1.2	8.0	0.031	0.059
	Mean	1014		0.0014	1.03	0.03	1.0	1.1	7.8	0.032	0.064
	Std. Error of Mean	818		0.0004	0.07	0.01	0.1	0.1	0.1	0.005	0.010
	Minimum	10		0.0008	0.58	0.01	0.6	0.6	7.3	0.014	0.031
	Maximum	10000		0.0048	1.30	0.14	1.3	1.3	8.2	0.077	0.160
City Outfall Drain	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	565		0.0008	0.12	0.02	0.1	0.4	7.8	0.094	0.205
	Mean	811		0.0014	0.14	0.01	0.2	0.4	7.8	0.100	0.199
	Std. Error of Mean	186		0.0004	0.03	0.00	0.0	0.1	0.1	0.015	0.022
	Minimum	110		0.0008	0.04	0.01	0.0	0.1	7.5	0.037	0.053
	Maximum	2400		0.0046	0.39	0.02	0.4	0.8	8.2	0.200	0.320
Dudley Creek	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	1250		0.0019	0.32	0.02	0.3	0.5	7.8	0.051	0.098
	Mean	1749		0.0018	0.34	0.02	0.4	0.5	7.8	0.051	0.114
	Std. Error of Mean	538		0.0003	0.02	0.00	0.0	0.0	0.0	0.005	0.023
	Minimum	460		0.0008	0.24	0.01	0.3	0.3	7.5	0.025	0.053
	Maximum	7300		0.0036	0.48	0.03	0.5	0.8	8.1	0.080	0.340
Halswell Retention Basin Inlet	N	11			12.00	12.00	12.0	12.0	12.0	12.000	
	Median	1700			1.01	0.19	1.3	5.1	8.7	0.150	
	Mean	3748			1.07	0.26	1.3	5.0	8.6	0.228	
	Std. Error of Mean	2100			0.16	0.06	0.2	1.1	0.3	0.065	
	Minimum	20			0.43	0.02	0.6	0.7	7.0	0.039	
	Maximum	24000			2.30	0.81	2.8	13.3	10.7	0.690	
Halswell Retention Basin Outlet	N	10			12.00	12.00	12.0	12.0	12.0	12.000	
	Median	170			0.82	0.10	0.9	2.4	8.1	0.062	
	Mean	1458			0.93	0.18	1.1	3.7	8.3	0.066	
	Std. Error of Mean	1284			0.14	0.04	0.2	1.0	0.2	0.015	
	Minimum	10			0.16	0.02	0.2	0.3	7.2	0.007	
	Maximum	13000			1.80	0.47	2.2	12.0	9.5	0.160	
Heathcote River at Bowenvale Ave	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	700		0.0008	1.75	0.01	1.8	1.8	7.6	0.025	0.075
	Mean	1752		0.0010	1.80	0.02	1.8	1.9	7.6	0.039	0.078
	Std. Error of Mean	684		0.0001	0.09	0.00	0.1	0.1	0.1	0.010	0.015

Site		Faecal Coliforms (CFU/100ml)	Total Lead (mg/L)	Dissolved Lead (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrate - Nitrite (mg/L)	Dissolved Inorganic Nitrogen (mg/L)	pH	Dissolved Reactive Phosphorus (mg/L)	Total Phosphorus (mg/L)
	Minimum	250		0.0008	1.40	0.01	1.4	1.6	7.0	0.012	0.010
	Maximum	8200		0.0018	2.40	0.03	2.4	2.4	8.0	0.120	0.200
Heathcote River at Catherine St	N	12			12.00	12.00	12.0	12.0	12.0	12.000	
	Median	505			1.50	0.02	1.5	1.6	7.7	0.027	
	Mean	1150			1.60	0.02	1.5	1.6	7.7	0.037	
	Std. Error of Mean	482			0.13	0.00	0.1	0.1	0.1	0.008	
	Minimum	230			0.76	0.01	0.8	0.9	7.1	0.017	
	Maximum	6000			2.50	0.03	2.0	2.1	8.4	0.120	
Heathcote River at Ferrymead Bridge	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	245		0.0008	1.35	0.03	1.4	1.5	7.8	0.049	0.110
	Mean	1403		0.0015	1.20	0.03	1.2	1.4	7.8	0.056	0.120
	Std. Error of Mean	773		0.0003	0.10	0.00	0.1	0.1	0.1	0.006	0.017
	Minimum	40		0.0008	0.55	0.01	0.6	0.7	7.0	0.031	0.051
	Maximum	9200		0.0047	1.60	0.04	1.6	1.7	8.6	0.099	0.260
Heathcote River at MacKenzie Ave	N	12			12.00	12.00	12.0	12.0	12.0	12.000	
	Median	470			1.60	0.02	1.7	1.7	7.7	0.031	
	Mean	1154			1.63	0.02	1.6	1.7	7.6	0.036	
	Std. Error of Mean	457			0.09	0.00	0.1	0.1	0.1	0.008	
	Minimum	190			1.10	0.01	1.1	1.2	6.9	0.014	
	Maximum	5600			2.10	0.04	2.1	2.2	8.1	0.110	
Heathcote River at Opawa Rd	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	530		0.0010	1.65	0.02	1.7	1.7	7.7	0.029	0.066
	Mean	1319		0.0010	1.64	0.02	1.7	1.7	7.7	0.042	0.078
	Std. Error of Mean	556		0.0001	0.09	0.00	0.1	0.1	0.1	0.010	0.015
	Minimum	140		0.0008	0.99	0.01	1.0	1.1	7.0	0.013	0.020
	Maximum	5800		0.0015	2.10	0.03	2.1	2.2	8.3	0.120	0.190
Heathcote River at Tunnel Rd	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	490		0.0008	1.45	0.02	1.5	1.7	7.8	0.041	0.105
	Mean	1013		0.0012	1.52	0.02	1.6	1.7	7.7	0.052	0.108
	Std. Error of Mean	280		0.0002	0.07	0.00	0.1	0.1	0.1	0.010	0.014
	Minimum	60		0.0008	1.10	0.01	1.2	1.3	7.0	0.019	0.042
	Maximum	2600		0.0028	1.90	0.04	1.9	2.1	8.0	0.110	0.230
Horseshoe Lake discharge	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	545		0.0008	0.35	0.02	0.4	0.5	7.7	0.038	0.110
	Mean	1281		0.0011	0.46	0.02	0.5	0.6	7.6	0.043	0.113
	Std. Error of Mean	500		0.0002	0.08	0.00	0.1	0.1	0.1	0.006	0.015
	Minimum	220		0.0008	0.16	0.01	0.2	0.3	7.4	0.020	0.039
	Maximum	5200		0.0027	1.10	0.03	1.1	1.3	8.1	0.087	0.210
Otukaikino River at Groynes Inlet	N	12	3.0000	12.0000	12.00	12.00	12.0	12.0	12.0	10.000	12.000

Site		Faecal Coliforms (CFU/100ml)	Total Lead (mg/L)	Dissolved Lead (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrate - Nitrite (mg/L)	Dissolved Inorganic Nitrogen (mg/L)	pH	Dissolved Reactive Phosphorus (mg/L)	Total Phosphorus (mg/L)
	Median	170	0.0016	0.0008	0.34	0.01	0.3	0.4	7.4	0.009	0.010
	Mean	386	0.0015	0.0008	0.47	0.01	0.5	0.5	7.4	0.010	0.020
	Std. Error of Mean	142	0.0004	0.0001	0.09	0.00	0.1	0.1	0.0	0.002	0.004
	Minimum	60	0.0008	0.0008	0.17	0.01	0.2	0.2	7.1	0.004	0.010
	Maximum	1500	0.0022	0.0018	1.10	0.01	1.1	1.1	7.7	0.024	0.045
Riccarton Main Drain	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	450		0.0008	2.20	0.01	2.2	2.2	7.6	0.017	0.029
	Mean	1281		0.0009	1.90	0.01	1.9	2.0	7.5	0.022	0.046
	Std. Error of Mean	498		0.0001	0.16	0.00	0.2	0.1	0.2	0.004	0.019
	Minimum	30		0.0008	0.70	0.01	0.7	1.1	5.7	0.010	0.010
	Maximum	5000		0.0025	2.40	0.02	2.4	2.4	8.2	0.067	0.250
Waimairi Stream	N	12		12.0000	12.00	12.00	12.0	11.0	12.0	12.000	12.000
	Median	355		0.0008	2.00	0.01	2.0	2.0	7.5	0.009	0.010
	Mean	812		0.0010	2.23	0.01	2.2	2.2	7.4	0.010	0.019
	Std. Error of Mean	369		0.0002	0.15	0.00	0.2	0.2	0.2	0.001	0.006
	Minimum	60		0.0008	1.50	0.01	1.5	1.5	5.7	0.005	0.010
	Maximum	4700		0.0025	2.90	0.01	2.9	2.9	8.1	0.017	0.085
Wairarapa Stream	N	12		12.0000	12.00	12.00	12.0	12.0	12.0	12.000	12.000
	Median	320		0.0008	1.04	0.01	1.0	1.0	7.4	0.008	0.010
	Mean	1077		0.0010	1.05	0.01	1.0	1.1	7.3	0.009	0.023
	Std. Error of Mean	722		0.0001	0.07	0.00	0.1	0.1	0.1	0.001	0.006
	Minimum	140		0.0008	0.69	0.01	0.7	0.7	6.1	0.002	0.010
	Maximum	9000		0.0023	1.40	0.01	1.4	1.4	8.0	0.016	0.068
Total	N	272	3.0000	203.0000	275.00	275.00	275.0	274.0	275.0	273.000	203.000
	Median	395	0.0016	0.0008	1.30	0.02	1.3	1.5	7.7	0.025	0.056
	Mean	1265	0.0015	0.0012	1.29	0.03	1.3	1.7	7.7	0.043	0.076
	Std. Error of Mean	166	0.0004	0.0001	0.04	0.00	0.0	0.1	0.0	0.004	0.006
	Minimum	10	0.0008	0.0008	0.04	0.01	0.0	0.1	5.5	0.002	0.010
	Maximum	24000	0.0022	0.0048	3.80	0.81	3.8	13.3	10.7	0.690	0.680

Site		Total Suspended Solids (mg/L)	Water Temperature (°C)	Total Nitrogen (mg/L)	Turbidity (NTU)	Total Zinc (mg/L)	Dissolved Zinc (mg/L)	Enterococci (MPN/100ml)
Addington Brook	N	12	10	12.0	12.0		12.000	
	Median	5	13	1.7	3.7		0.026	
	Mean	17	13	2.3	11.6		0.052	
	Std. Error of Mean	8	1	0.6	5.5		0.015	
	Minimum	2	7	1.0	0.4		0.004	
	Maximum	92	16	8.7	66.0		0.150	
Avon River at Avondale Rd	N	12	10					
	Median	2	13					
	Mean	2	13					
	Std. Error of Mean	0	1					
	Minimum	2	9					
	Maximum	4	19					
Avon River at Bridge Street	N	11	9	11.0	11.0		11.000	10
	Median	13	16	1.2	7.1		0.002	75
	Mean	15	14	1.2	8.1		0.003	222
	Std. Error of Mean	1	1	0.1	1.0		0.001	133
	Minimum	10	7	0.8	3.0		0.001	17
	Maximum	24	18	1.5	13.0		0.012	1400
Avon River at Carlton Mill corner	N	12	10					
	Median	2	13					
	Mean	4	13					
	Std. Error of Mean	1	1					
	Minimum	2	9					
	Maximum	11	15					
Avon River at Dallington Tce/Gayhurst Rd	N	12	10	12.0	12.0		12.000	
	Median	2	12	1.8	1.4		0.008	
	Mean	3	13	1.7	2.4		0.020	
	Std. Error of Mean	1	1	0.1	1.2		0.009	
	Minimum	2	9	1.4	0.1		0.001	
	Maximum	13	17	1.9	15.0		0.110	
Avon River at Manchester St	N	12	10	12.0	12.0		12.000	
	Median	2	13	2.1	1.0		0.007	
	Mean	7	13	2.0	3.5		0.012	
	Std. Error of Mean	2	1	0.1	1.5		0.004	
	Minimum	2	10	1.4	0.5		0.001	
	Maximum	26	15	2.2	18.0		0.039	
Avon River at Mona Vale	N	12	10	12.0	12.0		12.000	
	Median	2	13	3.7	0.7		0.015	

Site		Total Suspended Solids (mg/L)	Water Temperature (°C)	Total Nitrogen (mg/L)	Turbidity (NTU)	Total Zinc (mg/L)	Dissolved Zinc (mg/L)	Enterococci (MPN/100ml)
	Mean	3	13	3.5	1.3		0.025	
	Std. Error of Mean	1	0	0.3	0.6		0.007	
	Minimum	2	9	1.8	0.2		0.002	
	Maximum	9	14	6.0	7.5		0.081	
Avon River at Pages/Seaview Bridge	N	12	10	12.0	12.0		12.000	
	Median	5	14	1.4	3.4		0.007	
	Mean	5	14	1.4	3.5		0.011	
	Std. Error of Mean	0	1	0.1	0.5		0.003	
	Minimum	3	8	1.2	1.5		0.001	
	Maximum	7	18	1.8	5.9		0.039	
City Outfall Drain	N	12	10	12.0	12.0		12.000	11
	Median	12	13	0.7	10.4		0.005	500
	Mean	16	14	0.7	11.5		0.012	400
	Std. Error of Mean	2	2	0.0	1.7		0.006	95
	Minimum	10	8	0.6	2.4		0.001	19
	Maximum	30	22	1.0	25.0		0.081	1000
Dudley Creek	N	12	10	12.0	12.0		12.000	
	Median	10	12	0.7	5.4		0.015	
	Mean	17	12	0.8	10.8		0.019	
	Std. Error of Mean	7	1	0.1	3.8		0.005	
	Minimum	5	8	0.6	1.8		0.002	
	Maximum	96	17	1.4	49.0		0.062	
Halswell Retention Basin Inlet	N	12	12					
	Median	30	15					
	Mean	79	15					
	Std. Error of Mean	48	1					
	Minimum	4	9					
	Maximum	600	21					
Halswell Retention Basin Outlet	N	12	12					
	Median	25	14					
	Mean	21	14					
	Std. Error of Mean	3	1					
	Minimum	4	5					
	Maximum	34	20					
Heathcote River at Bowenvale Ave	N	12	11	12.0	12.0		12.000	
	Median	9	12	2.3	5.7		0.013	
	Mean	15	12	2.3	11.9		0.014	
	Std. Error of Mean	5	1	0.1	4.8		0.004	

Site		Total Suspended Solids (mg/L)	Water Temperature (°C)	Total Nitrogen (mg/L)	Turbidity (NTU)	Total Zinc (mg/L)	Dissolved Zinc (mg/L)	Enterococci (MPN/100ml)
	Minimum	3	5	1.9	0.8		0.001	
	Maximum	63	16	2.7	54.0		0.044	
Heathcote River at Catherine St	N	12	11					
	Median	12	12					
	Mean	15	13					
	Std. Error of Mean	4	1					
	Minimum	2	7					
	Maximum	48	17					
Heathcote River at Ferrymead Bridge	N	12	11	12.0	12.0		12.000	10
	Median	42	12	1.6	30.5		0.003	125
	Mean	52	14	1.6	38.2		0.009	843
	Std. Error of Mean	9	1	0.2	9.4		0.004	675
	Minimum	23	7	0.8	5.7		0.001	20
	Maximum	130	20	2.7	120.0		0.038	6900
Heathcote River at MacKenzie Ave	N	12	11					
	Median	10	12					
	Mean	12	13					
	Std. Error of Mean	3	1					
	Minimum	2	9					
	Maximum	43	17					
Heathcote River at Opawa Rd	N	12	11	12.0	12.0		12.000	
	Median	10	13	2.2	6.7		0.010	
	Mean	15	13	2.2	12.2		0.013	
	Std. Error of Mean	4	1	0.1	4.7		0.004	
	Minimum	2	6	1.7	0.8		0.001	
	Maximum	53	16	2.6	54.0		0.051	
Heathcote River at Tunnel Rd	N	12	11	12.0	12.0		12.000	
	Median	30	13	2.0	16.5		0.010	
	Mean	37	13	2.0	24.2		0.013	
	Std. Error of Mean	6	1	0.1	5.8		0.004	
	Minimum	16	6	1.5	8.3		0.001	
	Maximum	79	19	2.6	69.0		0.042	
Horseshoe Lake discharge	N	12	10	12.0	12.0		12.000	
	Median	8	12	0.9	5.7		0.008	
	Mean	9	12	1.0	6.6		0.018	
	Std. Error of Mean	1	1	0.1	1.1		0.007	
	Minimum	4	8	0.5	3.1		0.001	
	Maximum	17	17	2.0	16.0		0.075	
Otukaikino River at Groynes Inlet	N	12	10	11.0	12.0	3.000	12.000	

Site		Total Suspended Solids (mg/L)	Water Temperature (°C)	Total Nitrogen (mg/L)	Turbidity (NTU)	Total Zinc (mg/L)	Dissolved Zinc (mg/L)	Enterococci (MPN/100ml)
	Median	2	12	0.4	0.5	0.020	0.002	
	Mean	2	12	0.6	0.5	0.023	0.002	
	Std. Error of Mean	0	1	0.1	0.1	0.012	0.001	
	Minimum	2	10	0.3	0.1	0.003	0.001	
	Maximum	2	16	1.2	1.2	0.045	0.006	
Riccarton Main Drain	N	12	10	12.0	12.0		12.000	
	Median	2	13	2.6	1.1		0.020	
	Mean	6	13	2.4	3.4		0.043	
	Std. Error of Mean	3	1	0.1	1.5		0.019	
	Minimum	2	9	1.5	0.3		0.001	
	Maximum	31	15	2.7	15.0		0.240	
Waimairi Stream	N	12	10	12.0	12.0		12.000	
	Median	2	13	2.8	0.8		0.006	
	Mean	3	13	2.6	1.3		0.012	
	Std. Error of Mean	1	0	0.2	0.4		0.004	
	Minimum	2	10	1.6	0.3		0.001	
	Maximum	6	14	3.3	4.7		0.052	
Wairarapa Stream	N	12	10	12.0	12.0		12.000	
	Median	4	13	1.3	1.2		0.008	
	Mean	11	13	1.3	3.8		0.016	
	Std. Error of Mean	5	1	0.1	1.7		0.005	
	Minimum	2	9	0.9	0.2		0.003	
	Maximum	60	15	1.6	19.0		0.057	
Total	N	275	239	202.0	203.0	3.000	203.000	31
	Median	7	13	1.7	4.2	0.020	0.008	130
	Mean	16	13	1.8	9.1	0.023	0.017	485
	Std. Error of Mean	2	0	0.1	1.1	0.012	0.002	221
	Minimum	2	5	0.3	0.1	0.003	0.001	17
	Maximum	600	22	8.7	120.0	0.045	0.240	6900