Christchurch City Council

South-West Stormwater Management Plan Surface Water Quality Monitoring January – December 2013

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South-West Stormwater Management Plan
Surface Water Quality Monitoring
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1 Introduction

The resource consent for the South-West Christchurch Stormwater Management Plan (South-West SMP; CRC120223) was granted on 17 April 2012 and included conditions relating to the monitoring of surface water quality. This report summarises the results of this monitoring for the year 2013 (January to December). The monitoring program involves monthly collection and analysis of water quality samples from ten sites in the south-west area of Christchurch.

2 Methods

2.1 Sites and Sample Collection

Seven of the sites are located in the Heathcote River catchment and three sites are located in the Halswell River catchment (Table 1, Figure 1). 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 in the South-West SMP area with respect to Environment Canterbury's 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.

Table 1. Surface water quality monitoring sites of the South-West Stormwater Management Plan

Catchment	Site	Easting	Northing	pLWRP classification
Heathcote	Heathcote River at Templetons Road	2475913	5738508	Spring-fed – plains – urban
	Heathcote River at Rose Street	2478700	5737528	Spring-fed – plains – urban
	Heathcote River at Ferniehurst Street	2479157	5737222	Spring-fed – plains – urban
	Haytons Drain at Retention Basin outlet	2476019	5739207	Spring-fed – plains – urban
	Curletts Road Drain	2476927	5739322	Spring-fed – plains – urban
	Cashmere Stream at Sutherlands Road	2476084	5735598	Not classified
	Cashmere Stream at Worsleys Road	2479030	5736765	Banks Peninsula
Halswell	Nottingham Stream at Candys Road	2474530	5734689	Spring-fed – plains
	Knights Stream at Sabys Road	2473720	5734461	Spring-fed – plains
	Halswell River at Akaroa Highway	2474444	5733330	Spring-fed – plains

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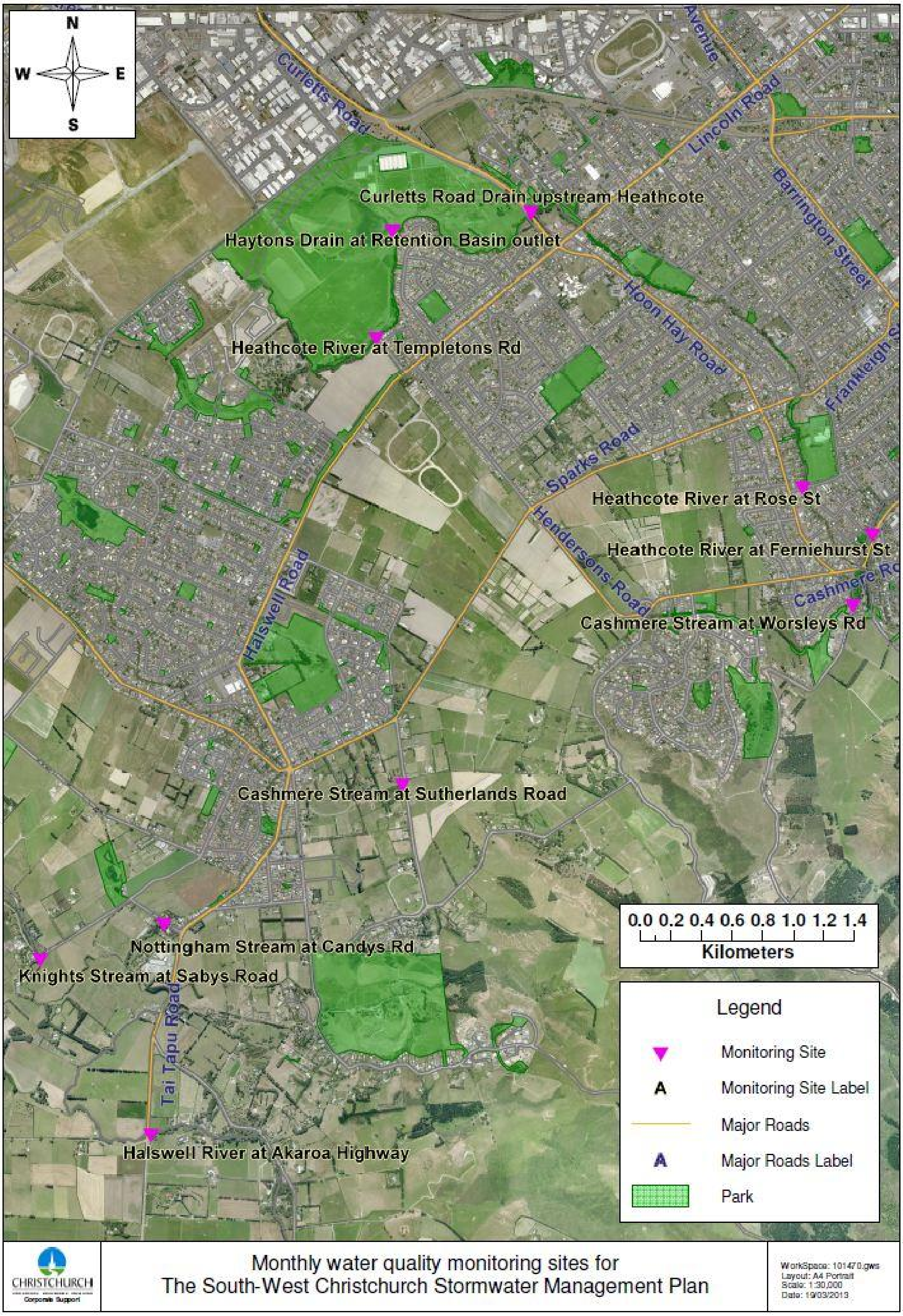

Figure 1. Surface water quality monitoring sites in the South-West Christchurch Stormwater Management Plan area

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 all the waterways in the South-West SMP 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 Environment Canterbury do not consider this guideline value is useful, due to natural variations in levels (Abigail Bartram, Environment Canterbury, 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). 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). ANZECC (2000) provides a guideline of 5.6 Nephelometric Turbidity Units (NTU) for turbidity in 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 is 70% for 'spring-fed – plains' and 'spring-fed – plains – urban' streams, and 90% for Banks Peninsula streams (i.e. Cashmere Stream in this area).

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 minimum 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 values of BOD_5 indicate the potential for bacteria to deplete oxygen levels in the water. The Ministry for the Environment (1992) guideline level for BOD_5 for waterways 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). However, the pLWRP has a set value (0.32 mg/L) for Banks Peninsula streams that is not adjusted according to measured pH levels; this value was therefore used for the Cashmere Stream site. The water quality standard for the other sites was adjusted based on the median pH levels for all sites (minus the Cashmere Stream site) being 7.5 for the monitoring period, resulting in a ammonia standard of 1.75 mg/L.

The water samples were analysed for nitrate and nitrite, but guidelines only exist for the sum of these parameters, *Nitrate Nitrite Nitrogen* (NNN); therefore, this parameter only is presented in this monitoring report. Elevated concentrations of 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. 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).

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' and 'spring-fed – plains – urban' waterways is 0.016 mg/L. For waterways in the Banks Peninsula water quality class (i.e. Cashmere Stream), the pLWRP standard is 0.025 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.

Table 2. Water quality parameters analysed for sites within the South-West Stormwater Management Plan area

Parameter	Units of measurement
Total and dissolved copper	µg/L
Total and dissolved lead	µg/L
Total and dissolved zinc	µg/L
pH	
Electrical conductivity	µS/cm
Total Suspended Solids (TSS)	mg/L
Turbidity	NTU
Dissolved oxygen	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
Dissolved Reactive Phosphorus (DRP)	mg/L
Escherichia coli	CFU/100 mL
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 from January to December 2013 were analysed using IBM® SPSS® Statistics 20. To allow analysis, water quality values that were less than the 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 top and bottom 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 have been measured since 2007 and continue to be sampled, but these are not presented in this report, as dissolved metals are considered to be more relevant because they constitute the bioavailable 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 reported below the LOD, therefore analyses were unable to be undertaken for dissolved copper and lead. 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 the last monitoring report, as flow data was not available for all sites, flow from one site in the Heathcote River at Ferniehurst Street was used across all Heathcote River sites, and the previous 24-hour total rainfall amount was used for the Halswell River catchment sites. However, it is now considered that this non site-specific approach could introduce biases into the analyses. For example, the Ferniehurst site receives tributary input from Cashmere Stream, whereas the Templetons and Rose Street sites upstream are headwater sites and therefore have less flow input; this may mean that the level of dilution is overestimated at these two sites if the Ferniehurst flow data is used. Rainfall data is also considered to only give an indication of the intensity of the event, not the site-specific dilution factor. Consequently, flow adjustment for the monitoring sites in this report was only undertaken for the one site that had flow data available – the Heathcote River at Ferniehurst Street. Flow was adjusted using the Locally Weighted Scatterplot Smoothing (LOWESS) method and flow adjusted data presented if flow explained a large proportion of the variation in the concentrations recorded. Given the large interval of monitoring (since 2007), it is hoped that variations in flow rates between sampling events will not strongly influence concentrations for the other sites, given most events will have been conducted during baseflow conditions.

3 Results

3.1 Summary Statistics and Comparison to Guidelines

3.1.1 Dissolved Copper

The concentrations of dissolved copper for a significant proportion of samples were below the LOD of 0.002 mg/L (recorded as half this value, 0.001 mg/L, to allow analyses to be undertaken), as shown by the medians for every site being equivalent to this value (Figure 2). All concentrations for all sites during the monitoring period were below their respective trigger values. The exception to this was two outlier events at the Cashmere Stream at Worsleys Road site (recording values of 0.0031 mg/L in May and 0.0037 mg/L in June) and one outlier event at the Curletts Road Drain site (recording a value of 0.006 mg/L in June). There were no apparent upstream to downstream trends in concentrations.

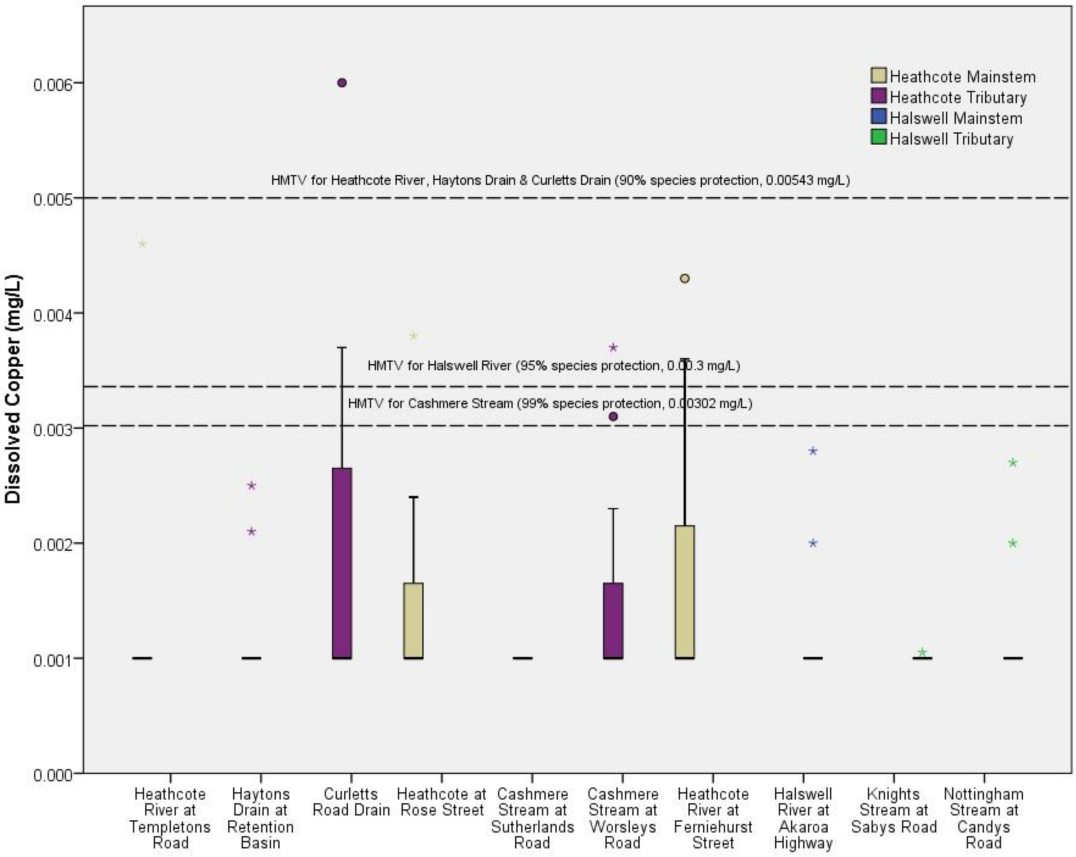

Figure 2. Dissolved copper levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values (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 – recorded as half this value (0.001 mg/L) to allow analyses to be undertaken.

3.1.2 Dissolved Lead

The majority of samples recorded dissolved lead concentrations below the LOD of 0.0015 mg/L (recorded as half this value, 0.00075 mg/L, to allow analyses to be undertaken), as shown by the medians all being the same as the LOD and no interquartile ranges being recorded due to a lack of variation in the data (Figure 3). Levels above the LOD were recorded on a number of sampling occasions at various sites, but these concentrations were still well below the respective receiving water guidelines (see the figure caption for these guideline levels). No particular site appeared to have higher or lower levels recorded compared to the other sites.

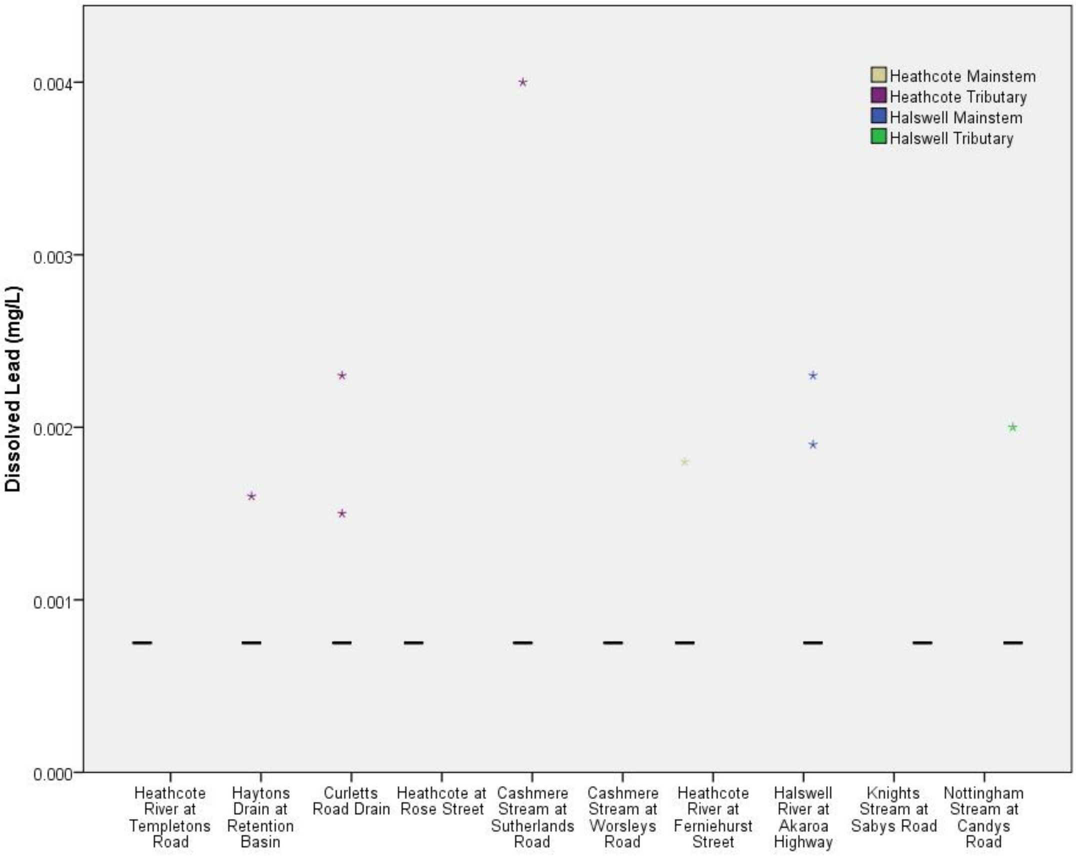

Figure 3. Dissolved lead levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The Proposed Canterbury Land and Water Regional Plan trigger values (Environment Canterbury, 2012), modified to account for water hardness as per the ANZECC (2000) guidelines methodology, are not included as they are well above the scale of the graph. These trigger values are: Heathcote River, Haytons Drain & Curletts Road Drain = 0.02916 mg/L for 90% species protection; Cashmere Stream = 0.00521 mg/L for 99% species protection; and Halswell River = 0.01257 for 95% species protection. The Laboratory Limit of Detection was 0.0015 mg/L – recorded as half this value (0.00075 mg/L) to allow analyses to be undertaken.

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, many samples during the monitoring period were above these guideline levels for a number of sites within the Heathcote River catchment. Nottingham Stream in the Halswell catchment also recorded many samples above its respective guideline level. The Curletts Road Drain recorded the highest concentration across all sites during the monitoring period (0.2300 mg/L in June). Based on medians, zinc concentrations decreased downstream in the Heathcote River mainstem, although due to the substantial overlap in variation between the three sites, this trend is likely not significant.

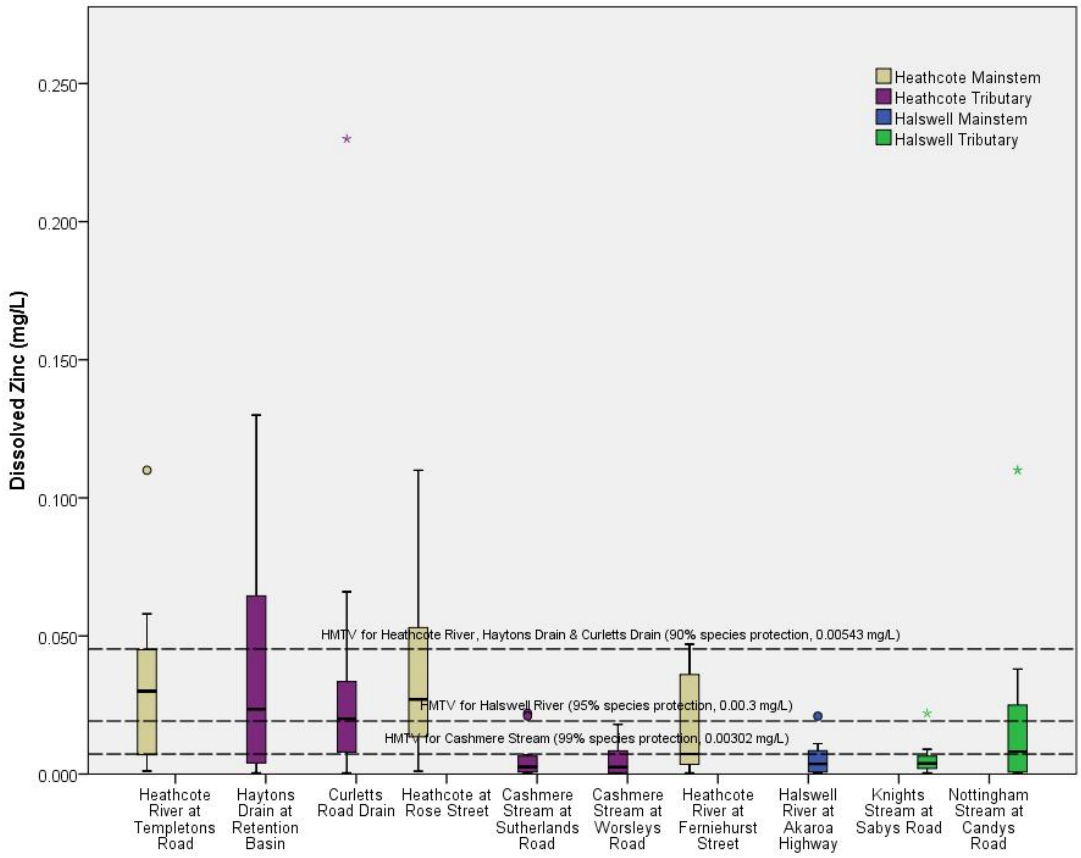

Figure 4. Dissolved zinc levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values (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 – recorded as half this value (0.0005 mg/L) to allow analyses to be undertaken.

3.1.4 pH

None of the samples during the monitoring period recorded pH levels below the lower guideline limit (Figure 5). However, a significant number of samples recorded pH levels above the upper guideline limit. In particular, median levels above this limit were recorded at Haytons Drain, the Halswell River at Akaroa Highway and Nottingham Stream. The highest pH level was recorded at Curletts Road Drain (pH of 8.7 in November). Based on medians, pH levels appeared to increase downstream in the Heathcote River mainstem; however, as there was overlapping variation in the datasets at the two downstream sites, this trend is likely not significant. The headwater site of Templetons Road had considerably lower pH levels than the other two sites.

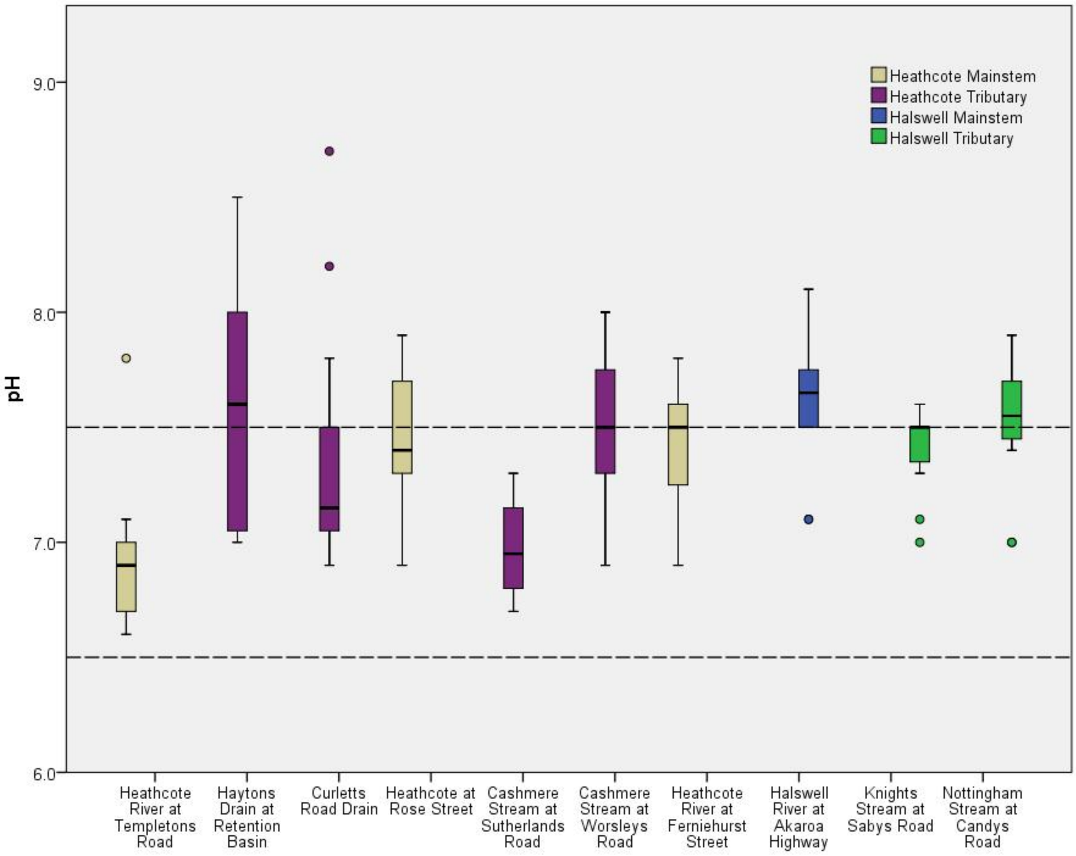

Figure 5. pH levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan lower (6.5) and upper (8.5) limits (Environment Canterbury, 2012).

3.1.5 Conductivity

Conductivity levels varied across sites, with some sites (e.g. Haytons Drain, Curletts Road and Heathcote River at Rose Street) showing more variation than others (Figure 6). Curletts Road Drain recorded particularly high conductivity on two sampling occasions compared to the other sites (469 µS/cm in March and 482 µS/cm in June). There was a slight decrease in conductivity downstream in the Heathcote mainstem, although due to the overlapping variation in the datasets at the two downstream sites, this trend is likely not significant. This similar trend to pH may be related in part to the relationship between these two parameters.

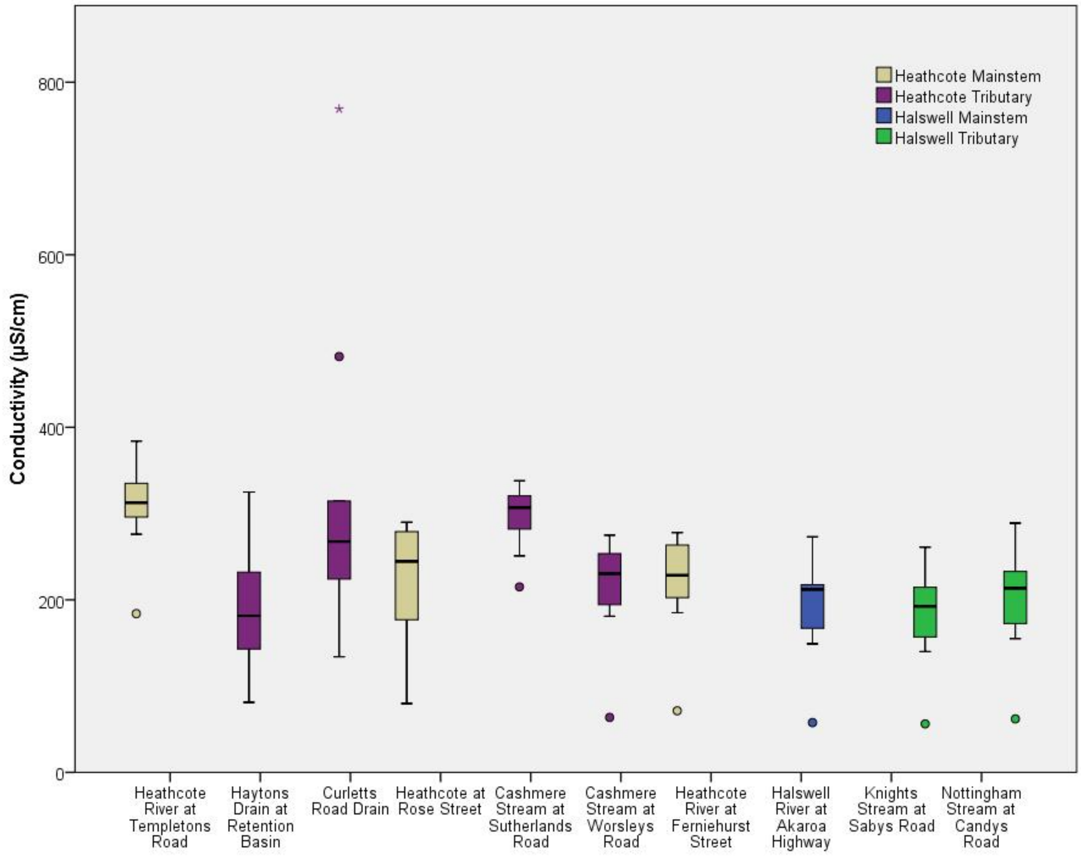

Figure 6. Conductivity levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right).

3.1.6 Total Suspended Solids

Overall, the majority of sampling events were below the TSS guideline level, with median levels well below this value (Figure 6). However, there were a number of events that exceeded this value, likely attributed to rainfall. High levels in particular were recorded in the Heathcote River Templetons Road (150 mg/L in October) and Ferniehurst Street sites (84 mg/L in April and 59 mg/L in May), and the Cashmere Stream at Worsleys Road site (140 mg/L in April and 80 mg/L in May). The Ferniehurst Street site is downstream of the confluence with Cashmere Stream and therefore these high levels are probably due to the high sediment loads from Cashmere Stream, as this waterway is known to have large loads of sediment due to runoff from the surrounding hills (McMurtrie & James, 2013). The Cashmere Stream at Sutherlands Road site recorded concentrations predominantly below the LOD. There appeared to be a slight increase in concentrations downstream in the Heathcote mainstem, but due to overlapping variation between sites, this relationship is unlikely to be significant.

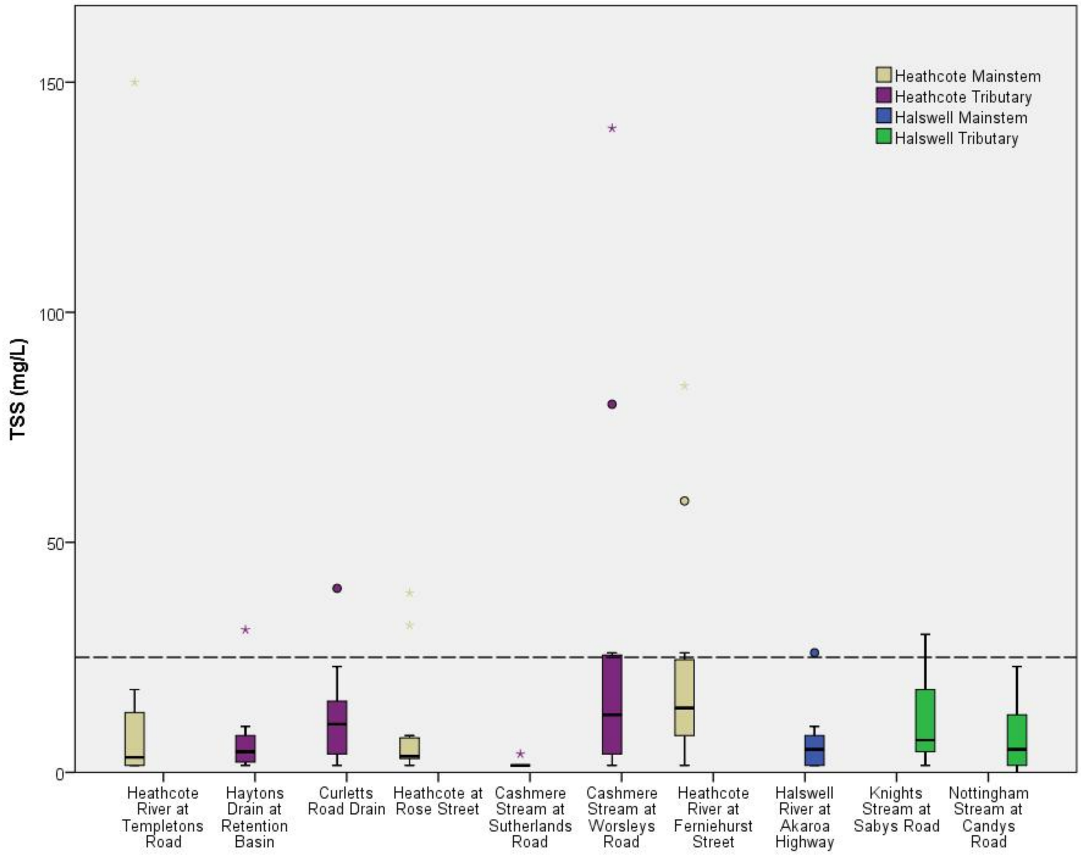

Figure 7. Total Suspended Solid (TSS) levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the Ryan (1991) guideline value of 25 mg/L. The Laboratory Limit of Detection was 5.0 mg/L – recorded as half this value (2.5 mg/L) to allow analyses to be undertaken.

3.1.7 Turbidity

Median turbidity concentrations for all sites were below the guideline level, with the exception of the Cashmere Stream at Worsleys Road and Heathcote River at Ferniehurst Street sites (Figure 8). These two sites recorded many values above this guideline level, with the highest value across all sites recorded at the Worsleys Road in April (79 NTU). Again, the high levels at Ferniehurst Street are likely due to sediment input from Cashmere Stream. Higher one-off events were also recorded at many of the other sites, as shown by the high number of outliers in the dataset. Turbidity levels increased downstream in the Heathcote mainstem, consistent with that observed for TSS.

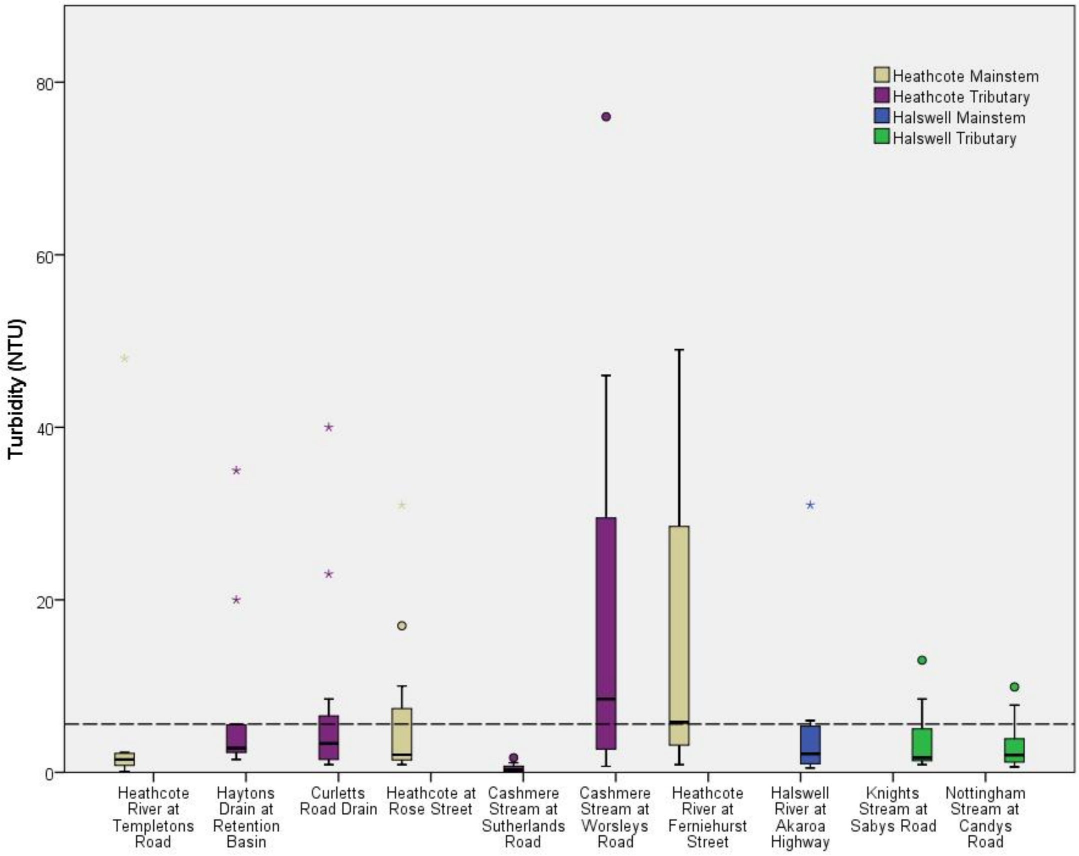

Figure 8. Turbidity levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the ANZECC (2000) guideline value of 5.6 Nephelometric Turbidity Units (NTU). All values were above the Laboratory Limit of Detection of 0.7 NTU.

3.1.8 Dissolved Oxygen

The majority of sites recorded medians above the minimum guideline value of 70% saturation (Figure 9). However, two sites recorded median levels below this value: Heathcote River at Templetons Road and Cashmere Stream at Sutherlands Road. Curletts Road Drain also recorded lots of variation throughout the year, with high and low DO levels, resulting in a very long interquartile range for this site. There was no apparent trend in DO levels downstream in the Heathcote River mainstem.

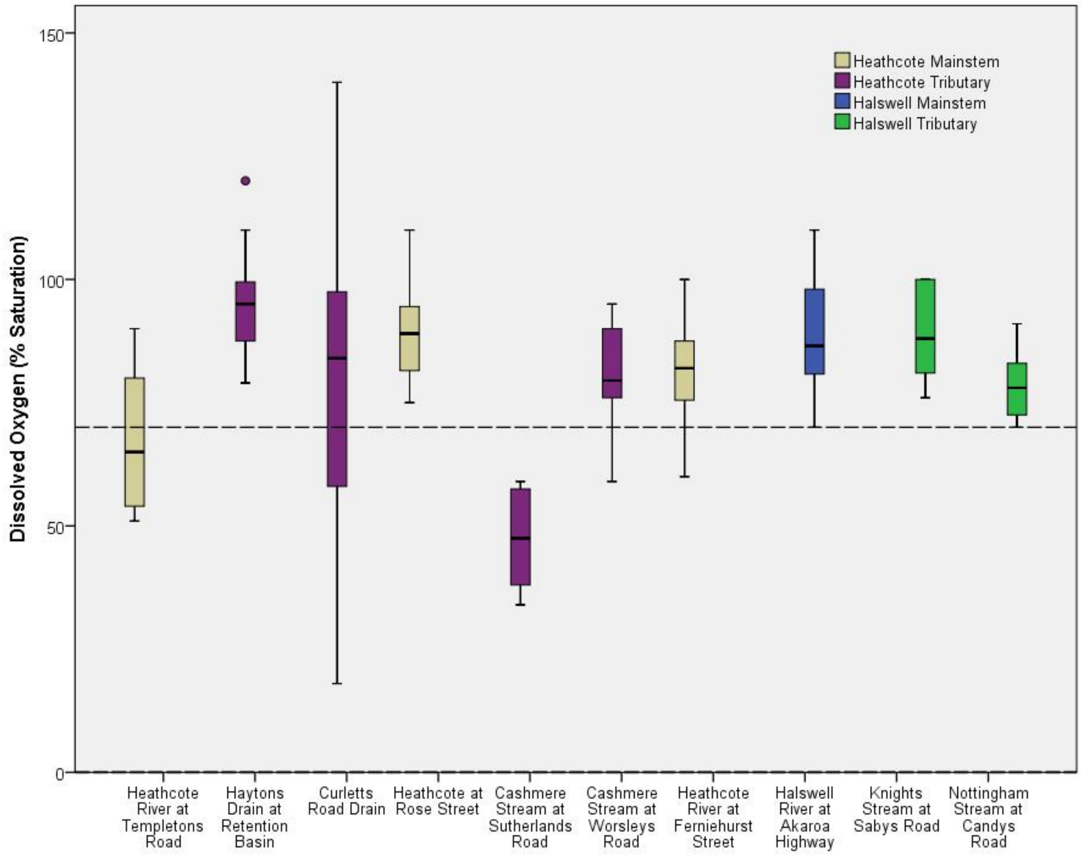

Figure 9. Dissolved oxygen levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan minimum guideline value (70%, Environment Canterbury, 2012).

3.1.9 Water temperature

The temperature of the water samples were all below the guideline value of 20ºC, with no samples at any of the sites during the monitoring period recording temperatures above this value (Figure 10). Temperatures were generally similar across sites and higher during the summer months as expected. Relatively large variations in temperature were recorded at the Haytons Drain site.

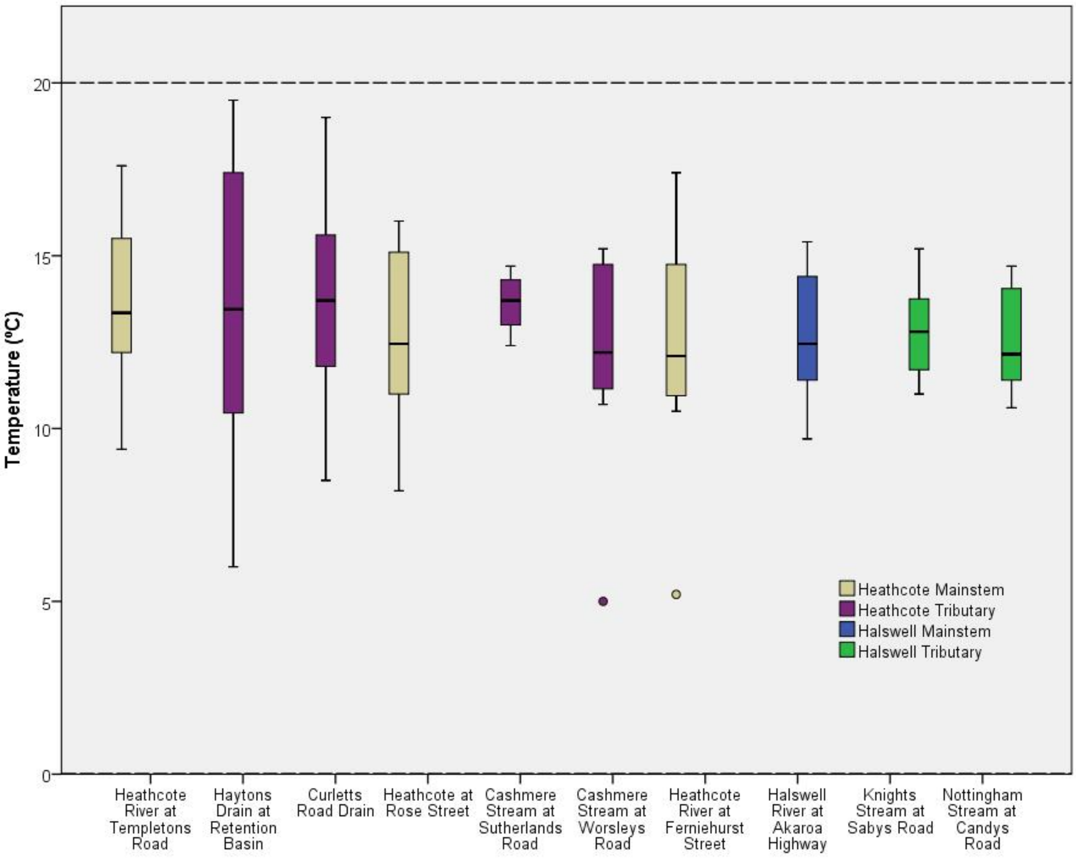

Figure 10. Water temperature for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan maximum guideline value (20ºC, Environment Canterbury, 2012).

3.1.10 Biochemical Oxygen Demand

Many of the levels of BOD_5 recorded in the samples during the monitoring period were below the LOD, with all sites except Curletts Road Drain, Haytons Drain and Nottingham Stream recording medians equivalent to the LOD (Figure 11). All medians were below the guideline level of 2 mg/L. However, a number of samples exceeded the guideline level at many of the sites, as shown by the high interquartile ranges and outliers. Particularly high values were recorded at the Heathcote River Templetons Road site (4.3 mg/L in October), Cashmere Stream at Sutherlands Road site (3.4 mg/L in January) and the Curletts Road Drain site (4.1 mg/L in May). Levels were generally similar across sites, with the exception of the outlier events.

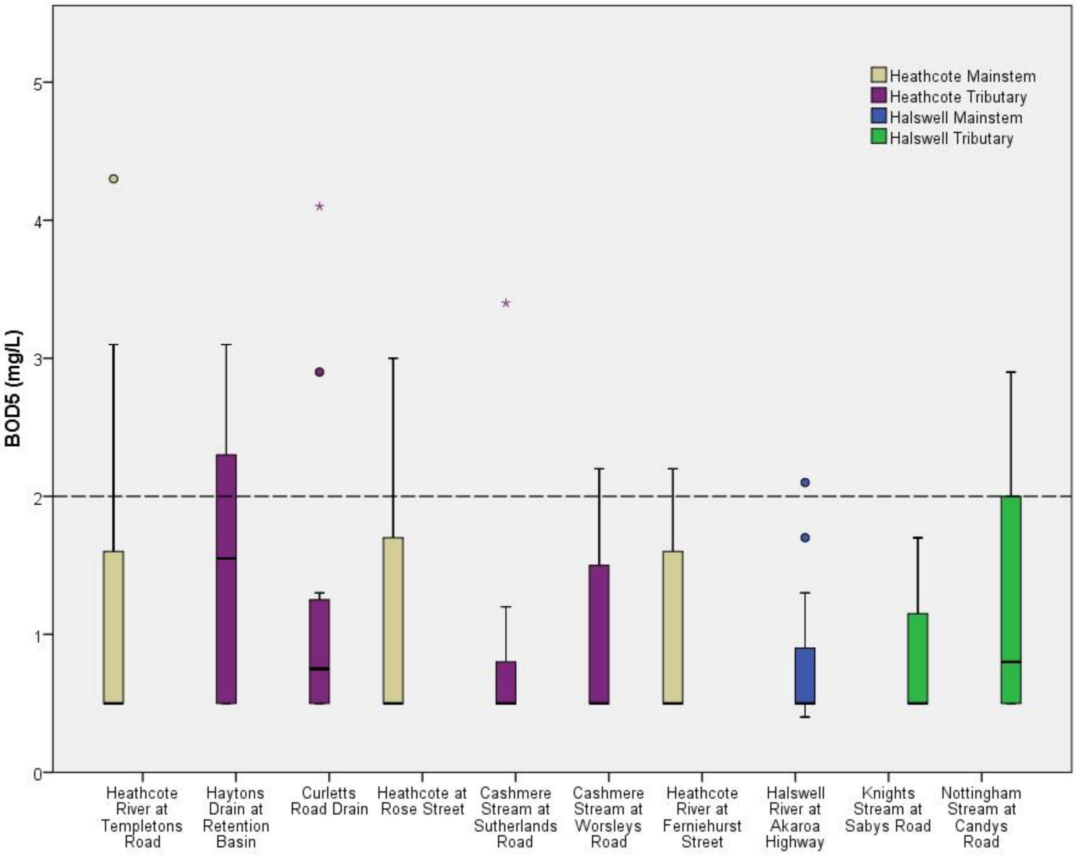

Figure 11. Biochemical Oxygen Demand (BOD_5) levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the Ministry for the Environment guideline value (2 mg/L; Ministry for the Environment, 1992). The Laboratory Limit of Detection was 1.0 mg/L, recorded as half this value (0.5 mg/L) to allow analyses to be undertaken.

3.1.11 Total Ammonia (Ammoniacal Nitrogen)

Total ammonia levels at all sites were well below their respective receiving water quality guidelines (Figure 12). However, one event at Haytons Drain did exceed the guideline in May, recording a value of 2.1 mg/L. The Curletts Road Drain also recorded a substantially higher value in May (1.6 mg/L) that was just below the guideline level of 1.61 mg/L. There was no apparent downstream trend in concentrations in the Heathcote River mainstem.

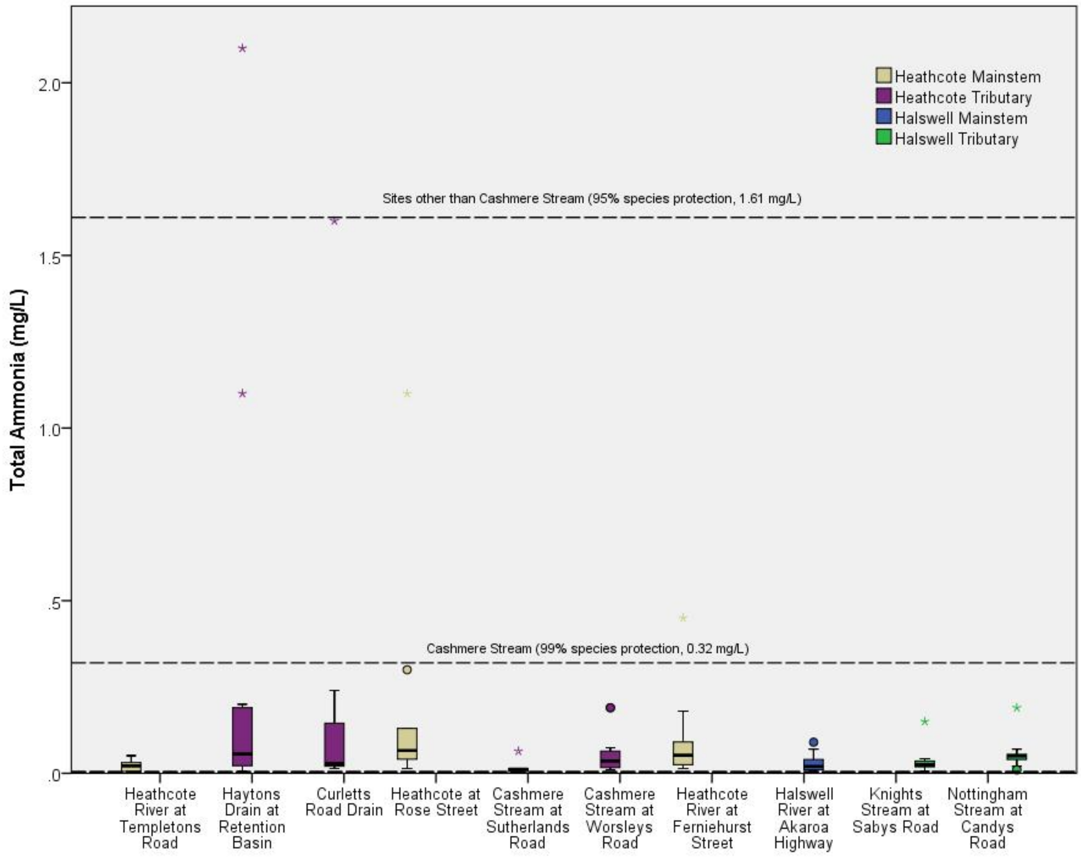

Figure 12. Total ammonia levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values; all sites except Cashmere Stream were adjusted in accordance with median pH levels (7.5) for the monitoring period, as per the guidelines (Environment Canterbury, 2012).

3.1.12 Nitrate Nitrite Nitrogen

The majority of sites recorded NNN concentrations substantially higher than the guideline value of 0.444 mg/L (Figure 13). The exception to this was Haytons Drain. NNN levels appeared to decrease downstream in the Heathcote mainstem.

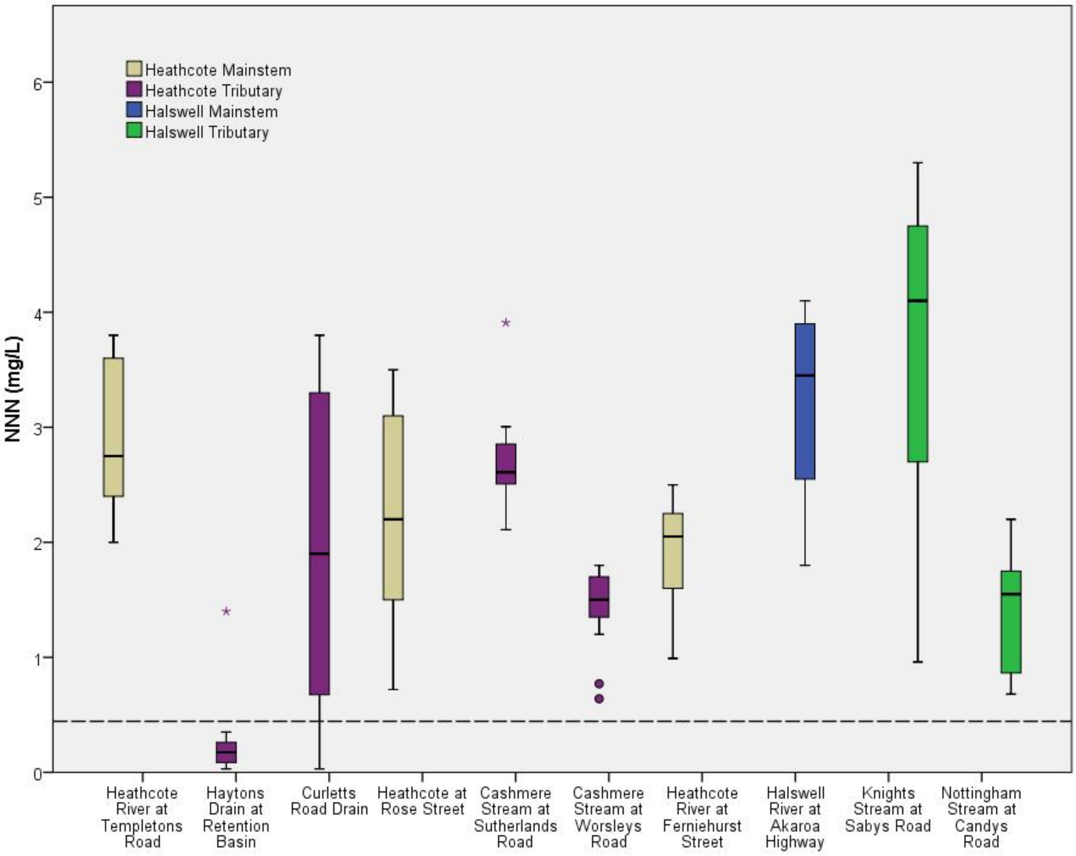

Figure 13. Nitrate Nitrite Nitrogen (NNN) levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the ANZECC water quality guideline (0.444 mg/L; ANZECC, 2000).

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3.1.13 Dissolved Inorganic Nitrogen

Median levels of DIN exceeded the respective guideline levels for all sites except Haytons Drain and the Heathcote River at Ferniehurst Street, although some sampling events in Haytons Drain and many at Ferniehurst Street exceeded this guideline (Figure 14). Concentrations appeared to decrease downstream in the Heathcote mainstem. The Cashmere Stream at Sutherlands Road site recorded considerably higher DIN levels compared to the other sites.

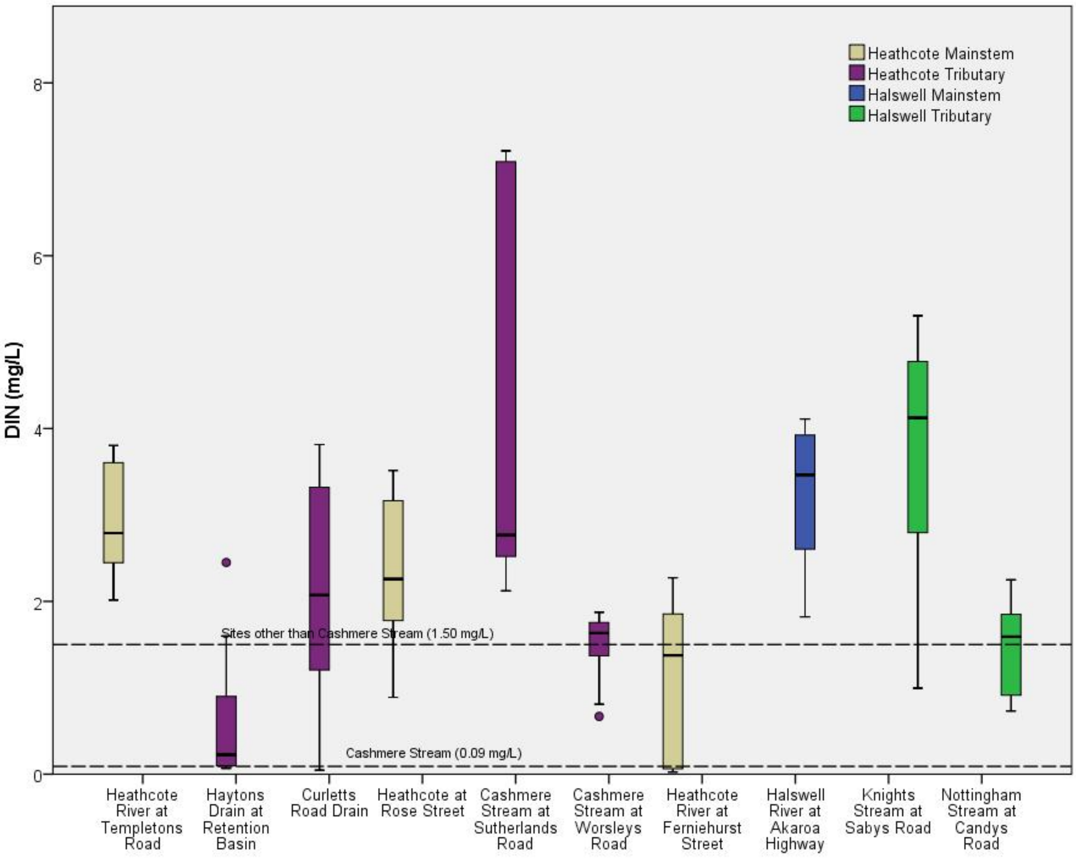

Figure 14. Dissolved Inorganic Nitrogen (DIN) levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values (Environment Canterbury, 2012).

3.1.14 Dissolved Reactive Phosphorus

Haytons Drain, Curletts Road Drain, Heathcote River at Rose Street and Nottingham Stream recorded median DRP levels above the respective guideline levels (Figure 15). Haytons Drain had considerably higher levels compared to the other sites. Heathcote River at Templetons Road and Cashmere Stream at Sutherlands Road recorded comparably lower levels of DRP. There was no trend downstream in the Heathcote River mainstem.

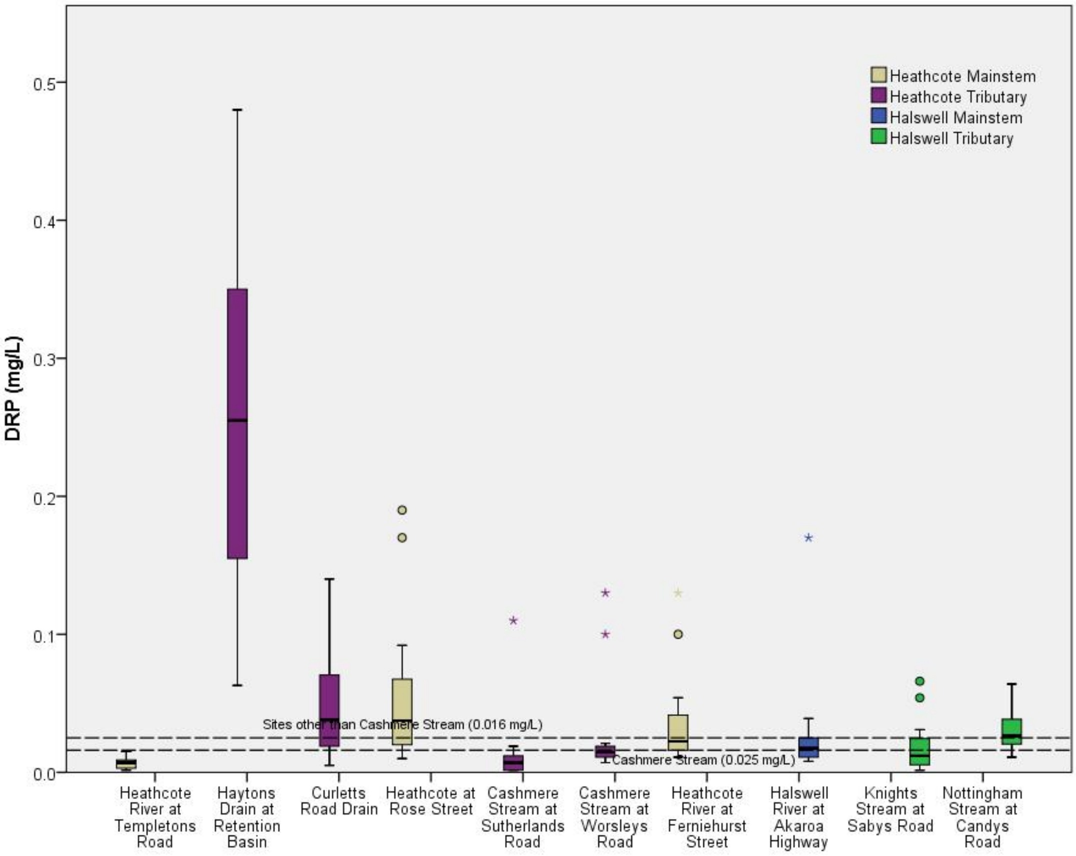

Figure 15. Dissolved Reactive Phosphorous (DRP) levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted lines represent the Proposed Canterbury Land and Water Regional Plan trigger values (Environment Canterbury, 2012). The Laboratory Limit of Detection was 0.01 mg/L, recorded as half this value (0.005 mg/L) to allow analyses to be undertaken.

3.1.15 *Escherichia coli*

The Environment Canterbury 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 the medians. With this in mind, *E. coli* concentrations were above the guideline level at all sites, except the two Cashmere Stream sites and the Halswell River at Akaroa Highway site (Figure 16). However, the Cashmere Stream at Worsleys Road and Halswell River at Akaroa Highway sites recorded concentrations above the guideline level on occasion; the only site where the guideline was never exceeded on any sampling occasion was Cashmere Stream at Sutherlands Road. The individual samples with the highest levels were from the Cashmere Stream at Worsleys Road and Heathcote River at Ferniehurst Street sites (both 11000 CFU/ml in May). There were no trends downstream in the Heathcote mainstem, although the headwater site of Templetons Road recorded lower *E. coli* levels than the other two sites.

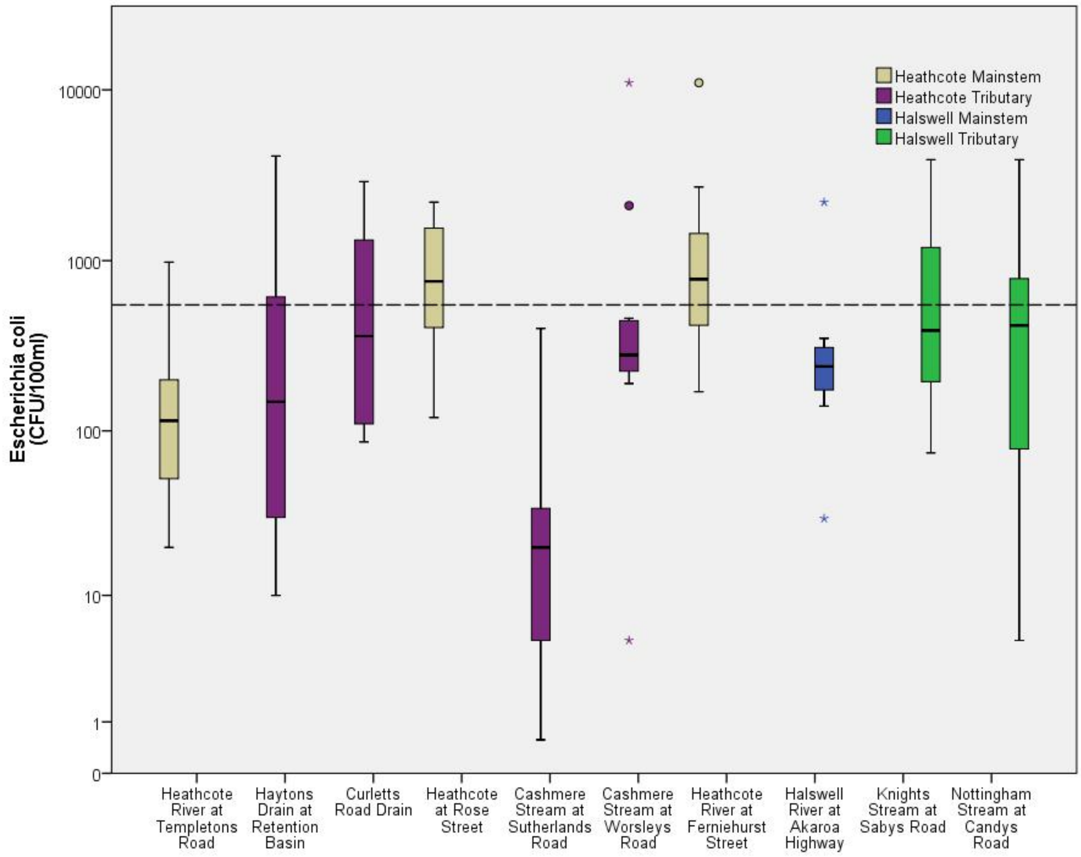

Figure 16. *Escherichia coli* levels for the monitoring period January to December 2013 at the seven Heathcote River and three Halswell River sites. Sites are ordered from upstream to downstream (left to right). The dotted line represents the Proposed Canterbury Land and Water Regional Plan trigger value of 550 CFU/100ml, for 95% of samples (Environment Canterbury, 2012). Note: the y-axis is on a $\log_{10}$ scale.

3.2 Temporal Trends

Flow adjusted data for the Heathcote River Ferniehurst Street site explained a large proportion of the variance in the data for only TSS and turbidity. Therefore, flow-adjusted data was used to assess trends for these two parameters. The majority of parameters across all sites had no significant upwards or downwards trends in concentrations, meaning that parameter levels remained static between years (Table 3). Two parameters recorded no trends across any of the sites: DO and *E. coli*. The largest trend was a 229% decrease in dissolved zinc at Curletts Road Drain (Figure 17). Other notable decreases occurred at Haytons Drain for total ammonia (33%), NNN (33%), DIN (33%) and DRP (26%), and Curletts Road Drain for TSS (22%). Increases were recorded across many sites for pH, conductivity and temperature, but these increases were only by 1-3%.

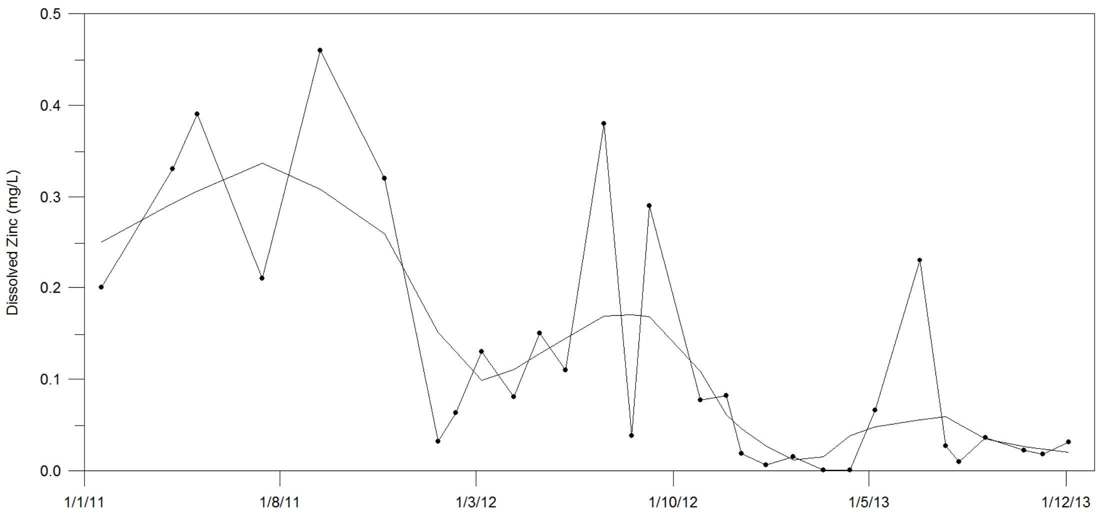

Figure 17. Dissolved zinc levels at Curletts Road Drain for the monitoring period January to December 2013. Circles indicate individual sampling events. The trendline was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

Table 3. Direction of significant trends ($p<0.05$) for a range of parameters at the South-West Stormwater Management Plan surface water quality monitoring sites, calculated from monthly sampling conducted during January 2007 to December 2013. Diss. Zinc = Dissolved Zinc, EC = Electrical Conductivity, TSS = Total Suspended Solids, Temp = Temperature; BOD_5 = Biochemical Oxygen Demand, NNN = Nitrate Nitrite Nitrogen and DRP = Dissolved Reactive Phosphorus. Dissolved oxygen and *Escherichia coli* are not presented in the table as no upward or downward trends were recorded.

Catchment	Site	Diss. Zinc	pH	EC	TSS	Turbidity	Temp	BOD_5	Total Ammonia	NNN	DIN	DRP
Heathcote	Heathcote River at Templetons Road			á 3%	â 7%		á 1%					
	Heathcote River at Rose Street		á 1%					â 11%		â 6%	â 7%	â 20%
	Heathcote River at Ferniehurst Street		á 1%				á 2%					
	Haytons Drain at Retention Basin outlet				â 13%	â 16%	á 3%	â 12%	â 33%	â 33%	â 33%	â 26%
	Curletts Road Drain	â 229%	á 1%		â 22%		á 3%					
	Cashmere Stream at Sutherlands Road											
	Cashmere Stream at Worsleys Road											
Halswell	Nottingham Stream at Candys Road		á 1%	â 8%						â 12%	â 10%	
	Knights Stream at Sabys Road											
	Halswell River at Akaroa Highway			â 3%			á 3%			â 5%	â 5%	

4 Discussion

There were a number of parameters that consistently met the relevant receiving water guidelines for the 2013 monitoring period and are therefore unlikely to be having adverse effects on the waterways. These were dissolved copper, dissolved lead, temperature and total ammonia. However, there were a number of parameters that recorded values well above the guidelines across most sites (pH, NNN, DIN, DRP and *E. coli*). This indicates that the waterways are subjected to contaminated input, potentially from stormwater, wastewater and other discharges. These parameters may be having adverse effects on biota (i.e. pH and DIN), may encourage the proliferation of aquatic plants or algae (i.e. NNN, DIN and DRP) and may indicate human health risks from contact recreation (i.e. *E. coli*). There were also some parameters that generally recorded levels within the guidelines, but on occasion had concentrations well outside the guidelines: dissolved zinc, TSS, turbidity, dissolved oxygen and BOD_5. There were no strong increases or decreases in the concentrations of parameters downstream in the Heathcote River mainstem. The exception to this was an increase in turbidity and nitrogen (NNN and DIN) downstream.

Sites that consistently recorded levels of parameters well above the guideline levels and/or recorded a number of high one-off events compared to other sites were Haytons (e.g. for dissolved zinc, pH and DRP) and Curletts Road Drains (e.g. for pH, conductivity, dissolved oxygen). These catchments are well known for having high concentrations of parameters due to high traffic loads and industrial activities that affect the quality of stormwater input into these waterways. The Haytons Drain catchment is part of an ongoing project to improve urban waterway health, including work by Environment Canterbury's pollution prevention team and industrial site audits to be undertaken as part of the implementation of the South-West SMP. In contrast, the Cashmere Stream at Sutherlands Road site generally recorded consistently low parameter levels compared to all other sites.

Overall, the results of the trends analysis was positive, with generally minor increases in pH and temperature across sites since 2007, and moderate decreases in TSS and nitrogen. Of note, was the large downwards trend in dissolved zinc at Curletts Road Drain. There was a significant amount of sites and parameters where concentrations have remained steady over this timeframe.

Specific issues identified from this monitoring year are:

1. Turbidity levels regularly substantially exceeded the guideline value at the Cashmere Stream at Worsleys Road and Heathcote River at Ferniehurst Street sites. High suspended sediment loads in Cashmere Stream are not a new issue and have been the subject of ongoing investigations by Environment Canterbury (James & McMurtrie, 2010; McMurtrie & James, 2013). It is likely that Cashmere Stream is contributing to the higher levels in the Heathcote River at Ferniehurst Street, as this site is downstream of the confluence of these two waterways.
2. Relatively low DO levels were recorded at the Cashmere Stream Sutherlands Road site compared to other sites. This also occurred during the last monitoring period and is likely due to this site being within the headwaters of this waterway and subsequently having low water levels.

3. Last year *E. coli* levels were often elevated within Nottingham Stream (median of 710 CFU/100ml), which was thought to be due to significant earthquake damage to the wastewater system in this area. However, this site recorded lower levels during this monitoring period (median of 420 CFU/100ml) that were similar to that recorded at the other sites. Repairs of this system have started, although not been completed, and this likely explains this decrease.
4. DIN levels appeared to decrease downstream in the Heathcote River mainstem, 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. Nitrogen input from springs might also explain the high DIN levels recorded at the headwater site of Cashmere Stream at Sutherlands Road and NNN levels at Knights Stream at Sabys Road, which is within a rural catchment. The Knights Stream nitrogen levels contrast the relatively low levels recorded in the adjacent Nottingham Stream, which flows through a predominantly urban catchment. However, direct runoff/discharge could also be the cause of the high nitrogen levels at the Knights Stream site.

In summary, it appears that the water quality at these South-West SMP sites has not degraded further in the last monitoring year and has even increased in quality in part. Notably, TSS and nitrogen levels have decreased across some sites, and there was a large decrease in zinc at Curletts Road Drain. However, there are still high levels of some contaminants (nitrogen, phosphorus *E. coli*, dissolved zinc and TSS) 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. The 'dirty' waterways still appear to be Curletts Road and Haytons Drain, and therefore these catchments should continue to be a priority for treatment.

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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).

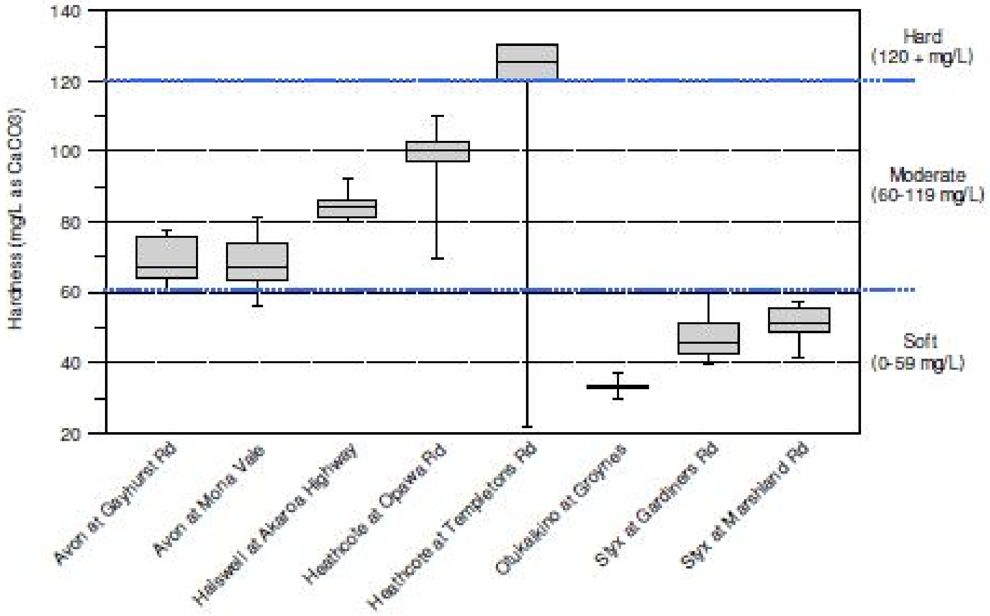

Figure 1 Box plots displaying median (and upper, lower quartiles, max and min) water hardness values for monitoring sites on the Avon, Heathcote, Halswell, Styx and Otukaikino rivers between December 2010 and March 2012.

Christchurch City Council

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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