Christchurch City Council
City Environment Group

South-West Stormwater Management Plan
Surface Water Quality Monitoring
Annual Results Summary
January – December 2012

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1 South-West Surface Water Quality Monitoring Programme

1.1 Sample Collection Methods

Surface water samples are collected as part of the 'Monitoring Programme for South-West Christchurch Stormwater Management Plan' from ten sites in the south-west of Christchurch City (Table 1, Figure 1).

Table 1. Surface water quality monitoring sites in the South-West SMP area.

Catchment	Site Description	Easting	Northing	NRRP classification (ECan 2011)
Heathcote	Heathcote River at Templetons Rd	2475913	5738508	Spring-fed plains - Urban
	Heathcote River at Rose St	2478700	5737528	Spring-fed plains - Urban
	Heathcote River at Ferniehurst St	2479157	5737222	Spring-fed plains - Urban
	Haytons Drain at Retention Basin outlet	2476019	5739207	Spring-fed plains - Urban
	Curletts Road Drain US Heathcote	2476927	5739322	Spring-fed plains - Urban
	Cashmere Stream at Sutherlands Road	2476084	5735598	Not classified
	Cashmere Stream at Worsleys Rd	2479030	5736765	Banks Peninsula
Halswell	Nottingham Stream at Candys Rd	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

1.2 Water Quality Parameters

Water samples are collected monthly by the Christchurch City Council laboratory and analysed for the parameters listed in Table 2.

Table 2. Water quality parameters analysed for sites within the South-West SMP 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 (BOD5)	mg/L
Ammonia 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/m3 as calcium carbonate

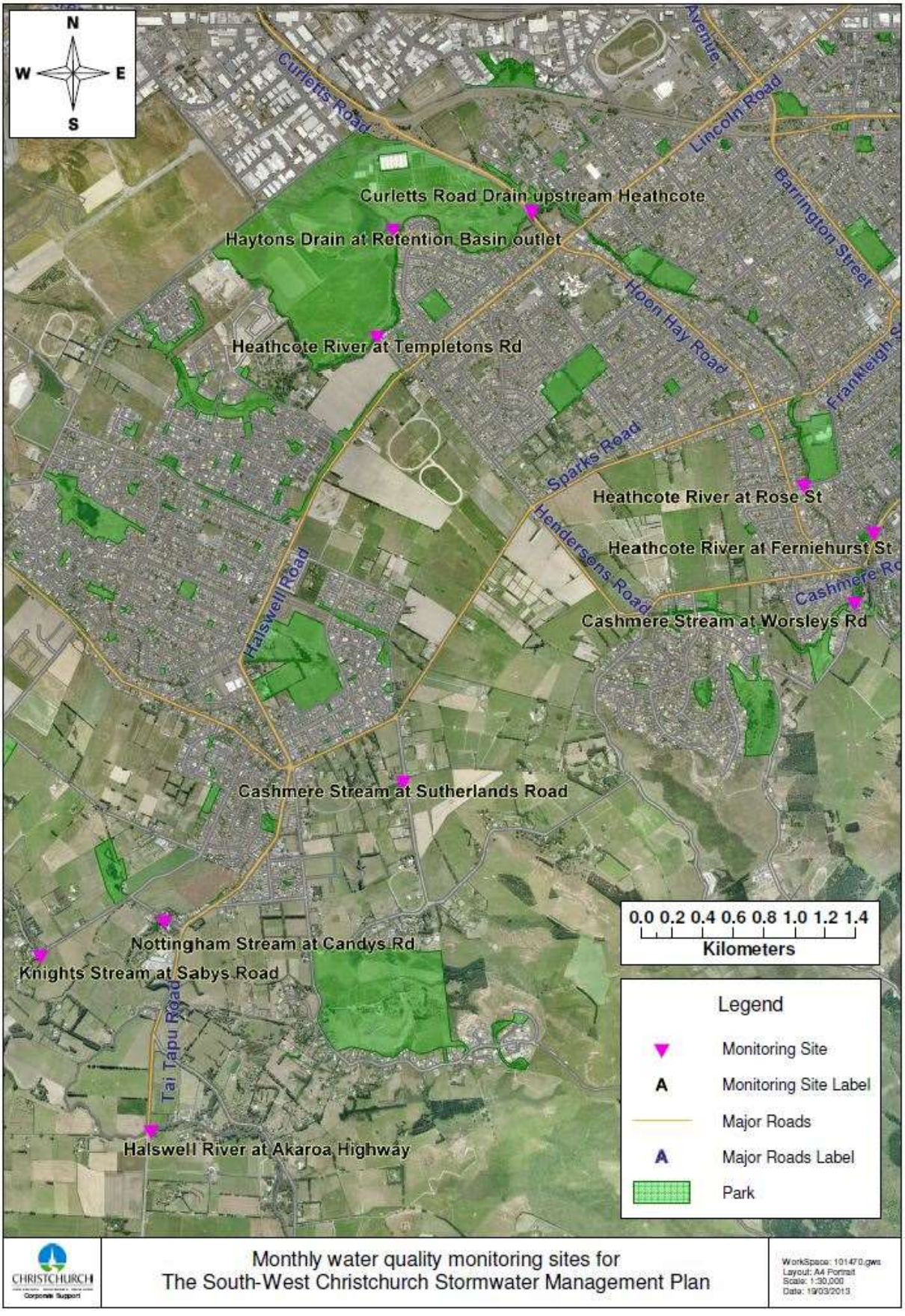


Figure 1. Surface water quality monitoring sites in South-West Christchurch SMP area.

1.3 Methods for Data Analysis

1.3.1 Summary Statistics

Water quality parameters for each site were summarised by the median, minimum and maximum values of 12 monthly samples collected between January 2012 and December 2012. Median values for each site were displayed on a bar graph for each parameter.

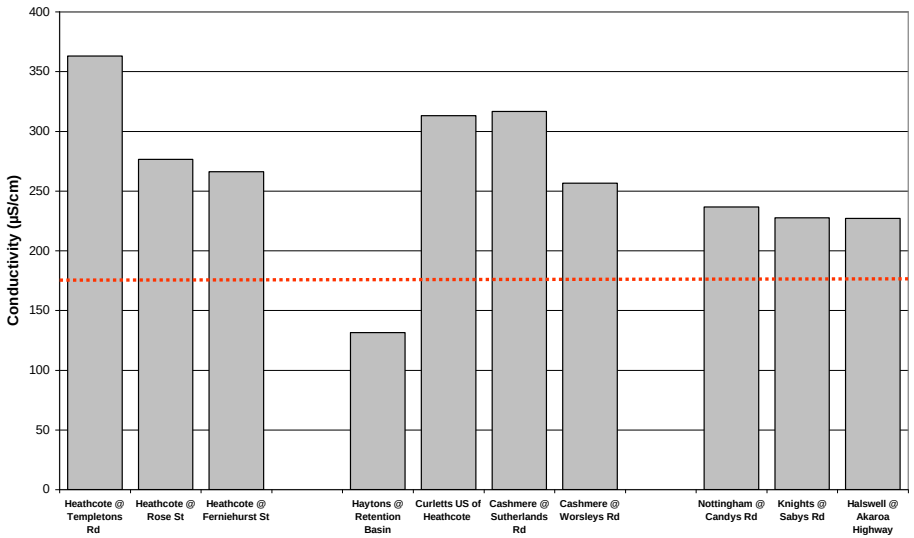
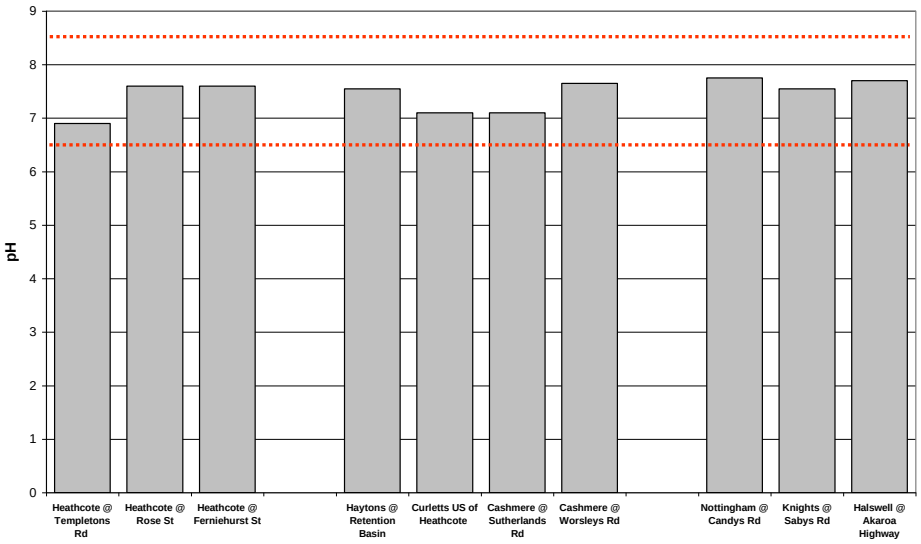
For the purpose of calculating summary statistics, where water quality results were reported by the laboratory as 'less than' the lower detection limit, the data were converted to a value equal to half of the reported detection limit.

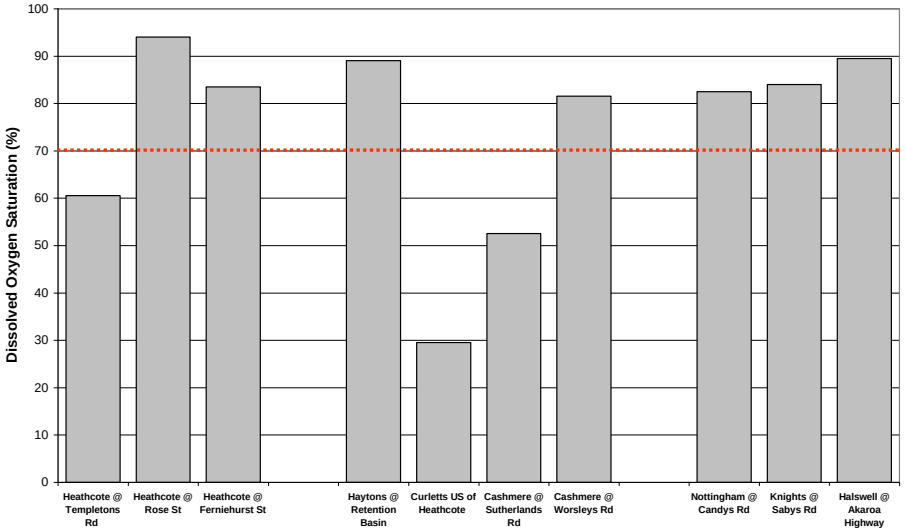
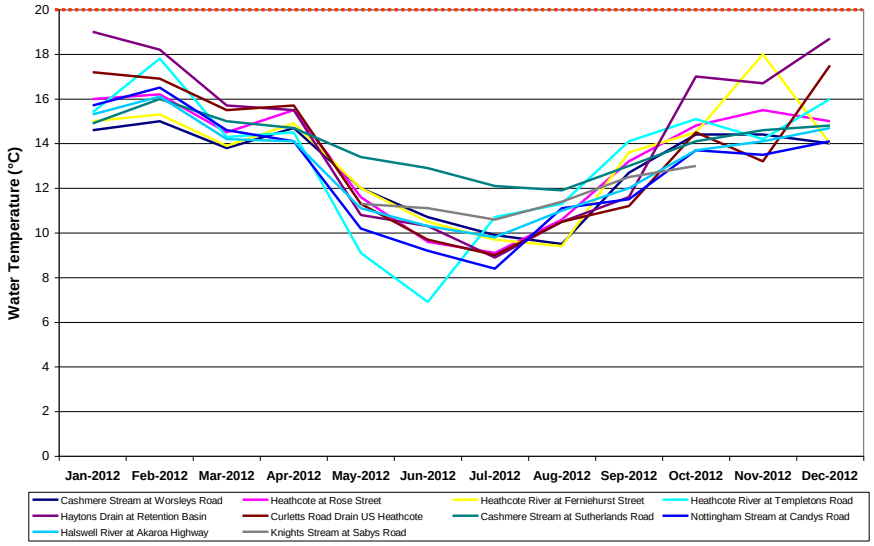
1.3.2 Trend Analysis

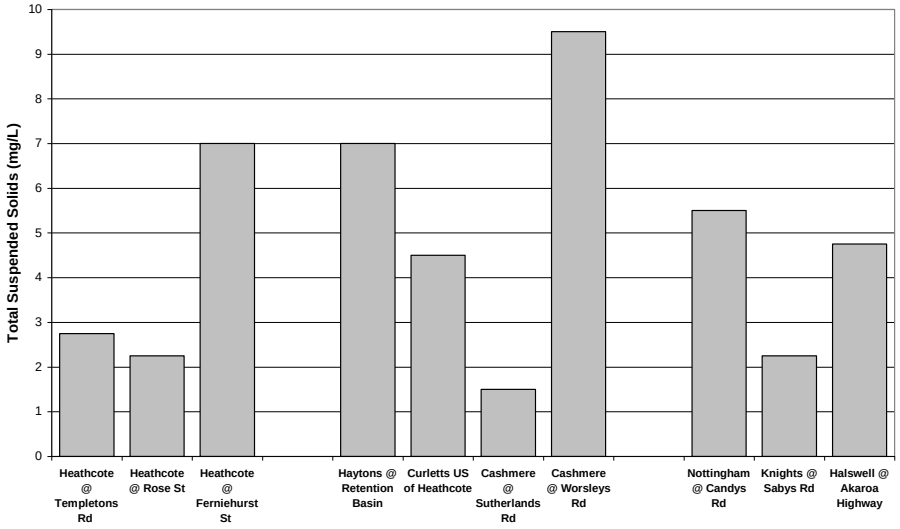
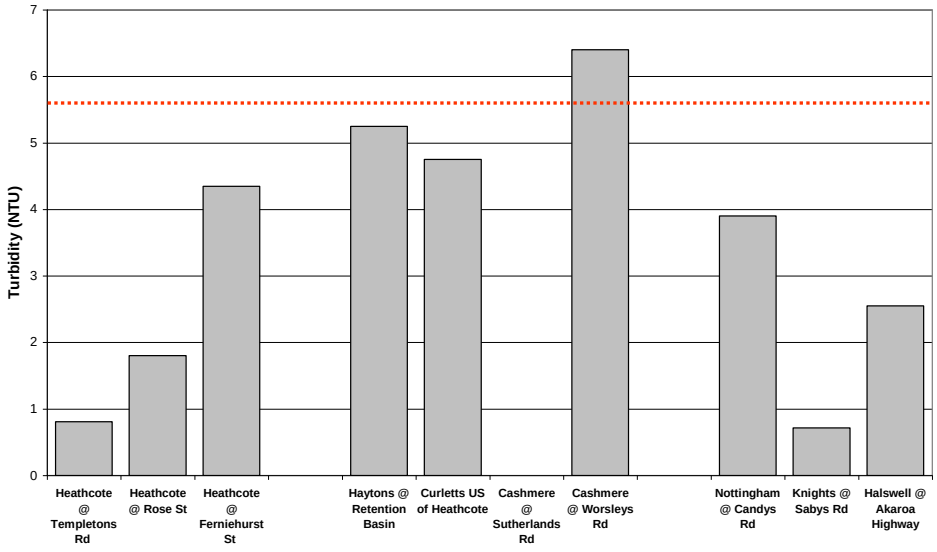
Trend analysis was completed for data collected over a six year period between January 2007 and December 2012, using the Time Trends software developed by NIWA (http://www.niwa.co.nz/our-science/freshwater/tools/analysis). The trend analysis was performed on raw data and flow adjusted data within the Time Trends software. Trend analysis was only performed on parameters that did not have a high proportion of data reported below laboratory detection limits, as these values can compromise the results of trend analysis. The Seasonal Kendall trend test within the Time Trends software was used to test the significance of trends in water quality over time. The non-parametric Seasonal Kendall Sen Slope Estimator was used as a measure of the magnitude and direction of the trend, and this was normalised by dividing by the site median to provide a measure of the slope as a percent change per year (NIWA 2011).

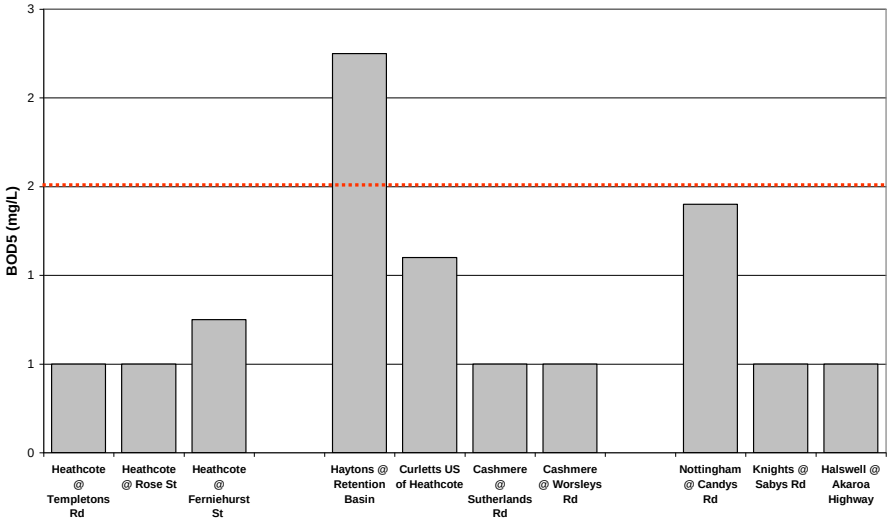
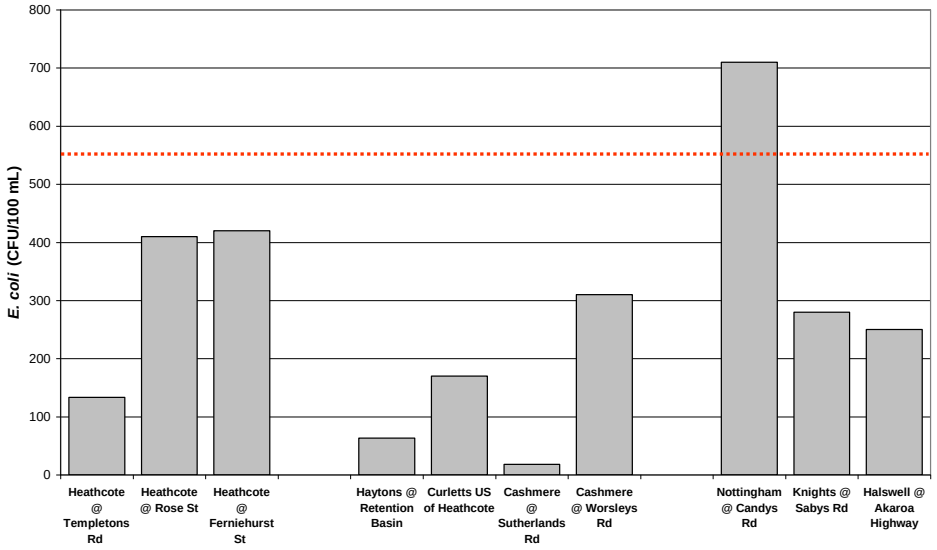
Where water quality results were reported by the laboratory as 'less than' the lower detection limit, the Time Trends software defaulted to a value of 10% below the detection limit, and this was used for the analysis of trends.

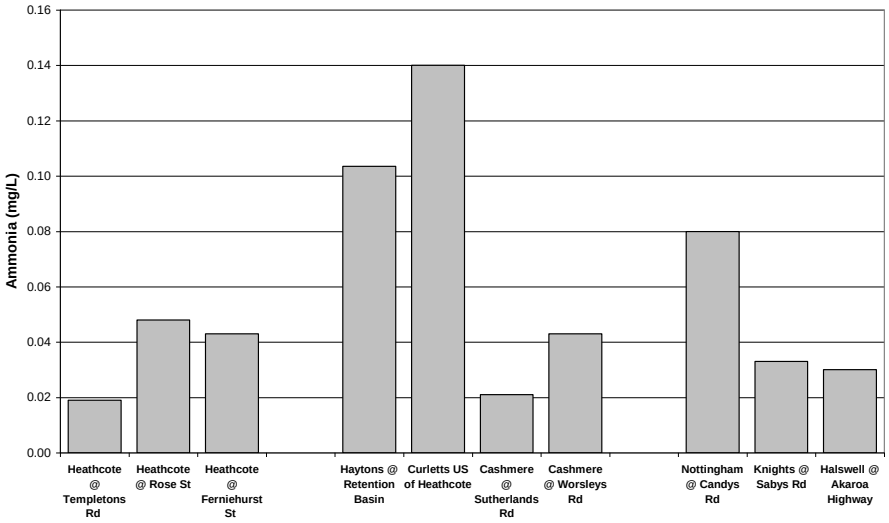
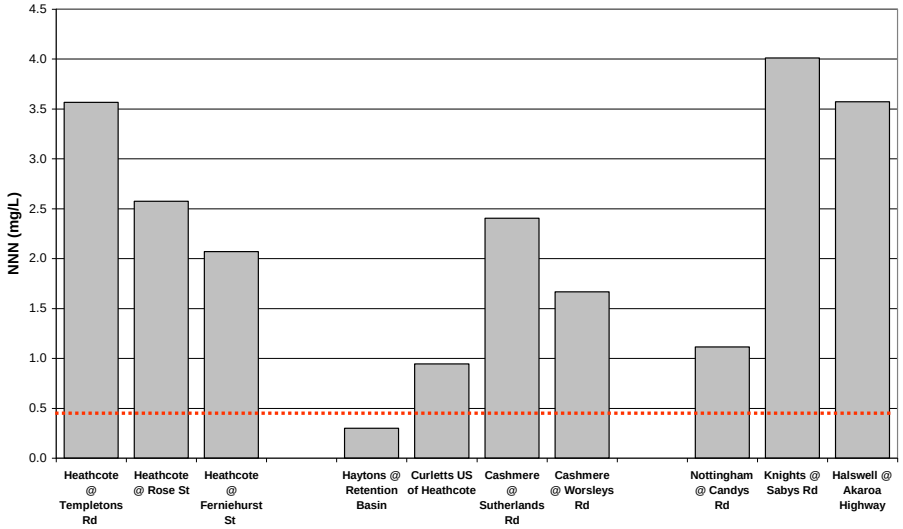
2 Annual results summary and comparison with guidelines

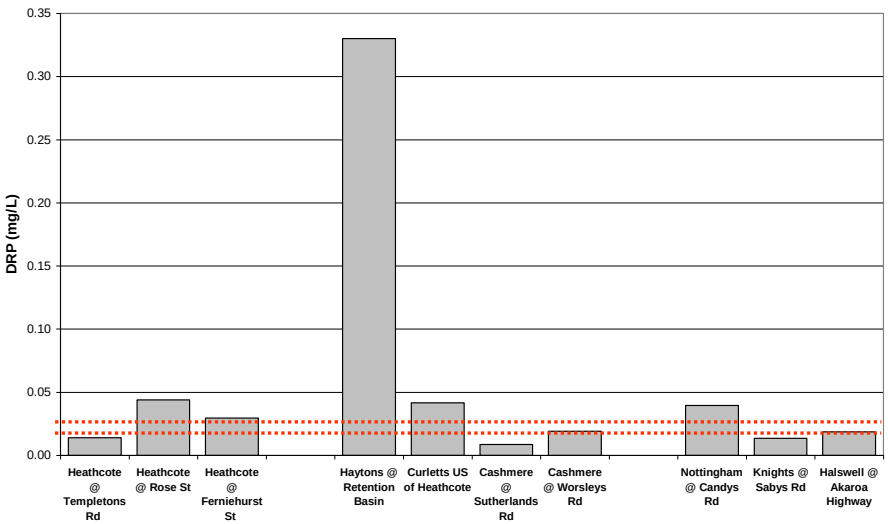
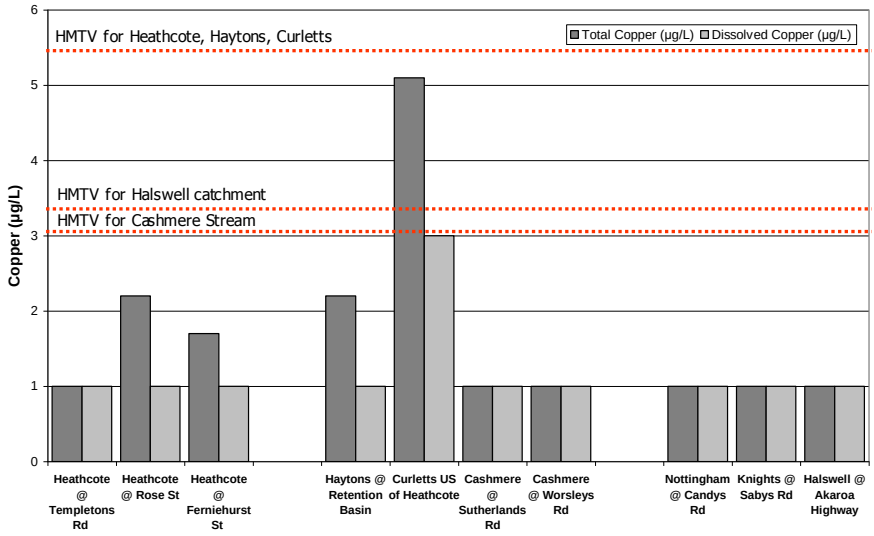
Water Quality Parameter	Median values by site
Conductivity — Conductivity is a measure of how well water conducts an electrical current. Pure water has very low conductivity, but dissolved ions in the water increase its conductivity, for example, contaminants such as metals and nutrients. A guideline of <175 µS/cm is recommended to avoid excessive periphyton growth in rivers (Biggs, 1988), but this may be less relevant in an urban setting, where nutrients may not be the main contaminant contributing to high conductivity. The measurement of conductivity does not differentiate between different contaminants, which is why other water quality measures are needed in combination with conductivity. With the exception of the Haytons Drain site downstream of the retention basin, median conductivity values exceeded the guideline of 175 µS/cm at all sites in the south-west area for the 2012 year.	
pH — pH is a measure of acidity or alkalinity, measured on a scale of between 0 and 14. A pH value of 7 is neutral, less than 7 is acidic and greater than 7 is alkaline. The water quality standards in the NRRP/pLWRP indicate that pH shall be between 6.5 and 8.5 for all waterways. ANZECC (2000) guidelines indicate that pH should be between 7.2 and 7.8 for lowland rivers. Median values of pH are within the NRRP standard for all sites in the south-west area for the 2012 year. Not all sites are within the guidelines recommended by ANZECC (2000).	

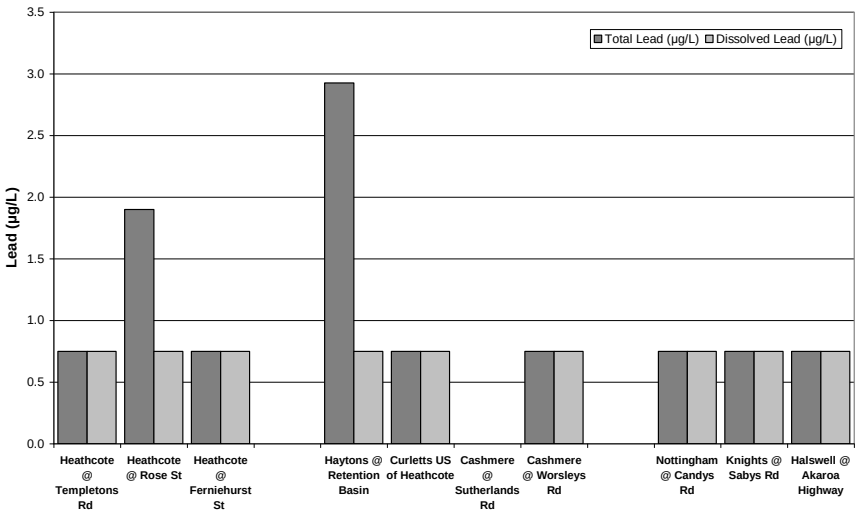
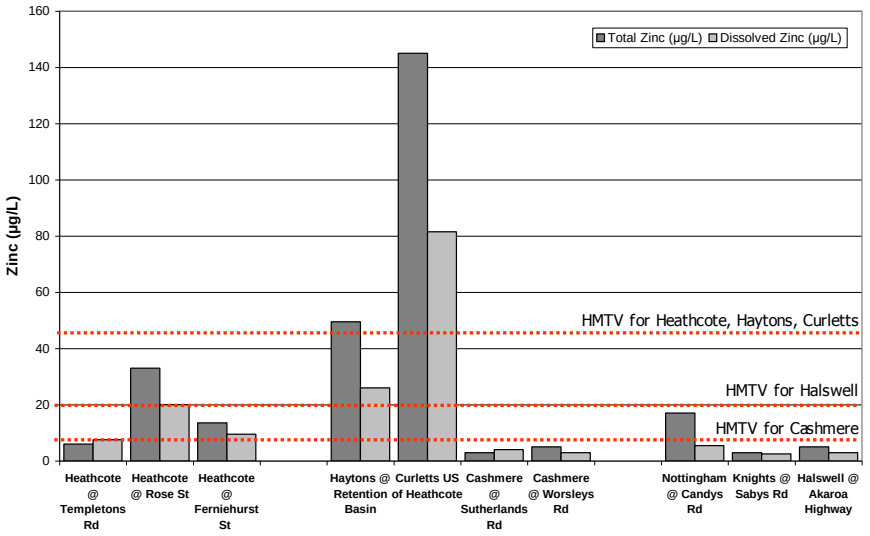
Water Quality Parameter	Median values by site
Dissolved Oxygen — Dissolved Oxygen (DO) is the concentration of oxygen that is dissolved or freely available in water and can be expressed as a percentage saturation (%). Adequate DO levels are essential for aquatic animals such as fish and invertebrates, but can be influenced by many factors, including temperature, velocity, decomposition of organic material and the photosynthesis and respiration of aquatic plants. The standards in the NRRP/pLWRP indicate that DO saturation should be greater than 70% for spring-fed-plains streams and greater than 90% for streams in the Banks Peninsula water quality class. Low DO at the upstream most sites on the Heathcote River and Cashmere Stream are potentially a result of low water velocities in these spring fed headwaters, but the very low DO in Curletts Stream is more likely to be a result of poor water quality in the catchment.	
Temperature — The NRRP/pLWRP water quality outcomes indicate that water temperature should be a maximum of 20°C for Canterbury rivers. Water temperatures were below 20°C at all south-west area monitoring sites during 2012, with most sites recording minimum water temperatures during July and maximum temperatures between December and February.	

Water Quality Parameter	Median values by site
Total Suspended Solids (TSS) — Elevated levels of suspended sediment in the water column decrease the clarity of the water and can influence the behaviour of invertebrates and fish, as well as the growth of aquatic plants. A guideline of 25 mg/L (Ryan 1991) provides for the protection of aesthetic values and the aquatic ecosystem. Median values of TSS were well below 25 mg/L for all monitoring sites in the south-west area during 2012. There were several sites where TSS exceeded this guideline on individual sampling occasions, including Cashmere Stream at Worsleys Road and the Heathcote River at Ferniehurst Street (downstream of the Cashmere Stream confluence). High sediment levels in Cashmere Stream have been investigated and reported on previously (e.g., James & McMurtrie 2010).	
Turbidity — 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 influence the behaviour of invertebrates and fish. ANZECC (2000) provides a guideline of 5.6 NTU for turbidity in lowland rivers. Median values of turbidity were below 5.6 NTU for all monitoring sites except for Cashmere Stream at Worsleys Road during 2012. As for TSS, several sites exceeded this guideline on individual sampling occasions.	

Water Quality Parameter	Median values by site
Biochemical Oxygen Demand — Biochemical Oxygen Demand (BOD5) is an indicator of the amount of biodegradable organic material in the water and a measure of the amount of oxygen required by bacteria to break down this organic material. High values of BOD5 indicate the potential for bacteria to deplete oxygen levels in the water. A guideline value for BOD5 is 2 mg/L (MfE, 1992). For monitoring sites in south-west Christchurch, many samples are measured with BOD5 values below the laboratory detection limit of 1 mg/L. Only the Haytons Drain site downstream of the retention basin had a median BOD5 value greater than the 2 mg/L guideline.	
***E. coli* —** Elevated levels of *E. coli* may make the water unsuitable for contact recreation. Guidelines recommend that *E. coli* concentrations of single samples should not exceed 550 *E. coli* /100 mL to be safe for contact recreation (MfE, 2003). The NRRP/pLWRP water quality standards also indicate that 95% of samples should be below 550 *E. coli* /100 mL. With the exception of Nottingham Stream at Candys Road, median *E. coli* concentrations at monitoring sites in the south-west area are less than 550 *E. coli* /100 mL, which would meet the NRRP/pLWRP standards. Individual samples at several sites do exceed the 550 *E. coli* /100 mL contact recreation guideline, which indicates that they may not always be suitable for contact recreation.	

Water Quality Parameter	Median values by site
Ammonia N — Ammonia N 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 and the NRRP/pLWRP water quality standards provide maximum total ammonia concentrations to protect aquatic species from chronic ammonia toxicity at different values of pH, ranging from 2.57 mg/L at pH 6 to 0.18 mg/L at pH 9. Average pH at monitoring sites in the south-west area for 2012 is 7.4 and therefore, the relevant ammonia standard is 1.75 mg/L. Ammonia concentrations were well below this standard for all sites and on all sampling occasions during 2012.	
Nitrate + Nitrite Nitrogen (NNN) — 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. Although most sites in the south-west area exceed this guideline, median values of NNN decrease downstream on the Heathcote mainstem, as well as for the two sites on the Cashmere Stream and Knights/Halswell River. Tributaries Haytons, Curletts & Nottingham streams have relatively low median NNN values compared to other sites in the south-west area.	

Water Quality Parameter	Median values by site
Dissolved Reactive Phosphorus — Dissolved Reactive Phosphorus (DRP) is a soluble form of phosphorus, which is readily available for use by plants. Phosphorus is an essential nutrient for plant growth and can limit primary production at low levels. The ANZECC (2000) water quality guidelines provide a DRP trigger value of 0.01 mg/L for lowland rivers to avoid excessive plant growth. The NRRP/pLWRP standard for spring-fed-plains and spring-fed-plains-urban surface waters is 0.016 mg/L. For waterways in the Banks Peninsula water quality class (includes Cashmere Stream), the NRRP/pLWRP standard is 0.025 mg/L. Median values of DRP exceeded these guidelines at most sites, but were typically below 0.05 mg/L, with the exception of very high concentrations recorded in Haytons Drain, downstream of the retention basin.	
Total and Dissolved Copper — The ANZECC (2000) water quality guidelines provide a method for modifying copper trigger values so that they are relevant for local environmental conditions. 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). As water hardness increases, the toxicity of some metals decreases, therefore trigger values to protect aquatic life can be higher. Hardness modified trigger values (HMTV) for copper are: 5.43 µg/L (Heathcote, Haytons, Curletts; 90% species protection) 3.02 µg/L (Cashmere Stream, 99% species protection) 3.36 µg/L (Halswell, 95% species protection) Median values of both total and dissolved copper were below the relevant HMTV for all sites in the south-west area for 2012.	

Water Quality Parameter	Median values by site
Total and Dissolved Lead — As for copper, the ANZECC (2000) water quality guidelines provide a method for modifying lead trigger values so that they are relevant for local environmental conditions. Hardness modified trigger values (HMTV) for lead are: 29.16 µg/L (Heathcote, Haytons, Curletts; 90% species protection) 5.21 µg/L (Cashmere Stream, 99% species protection) 12.57 µg/L (Halswell, 95% species protection) Median values of both total and dissolved lead were well below the relevant HMTV for all sites in the south-west area for 2012 and were regularly reported as below the laboratory detection limit of 1.5 µg/L.	
Total and Dissolved Zinc — As for copper and lead, the ANZECC (2000) water quality guidelines provide a method for modifying zinc trigger values so that they are relevant for local environmental conditions. Hardness modified trigger values (HMTV) for zinc are: 45.26 µg/L (Heathcote, Haytons, Curletts; 90% species protection) 7.24 µg/L (Cashmere Stream, 99% species protection) 19.19 µg/L (Halswell, 95% species protection) Median values of both total and dissolved zinc were below the relevant HMTV for sites in the Heathcote River, Cashmere Stream and Halswell catchment for 2012, but median values of total zinc for Haytons Stream and both total and dissolved zinc for Curletts Stream were above the relevant HMTV for the Heathcote catchment.	

3 Water Quality Trends

Results of monthly water quality monitoring over the six year period from January 2007 to December 2012 (less data available for some sites) have been used to assess trends in water quality parameters at monitoring sites in the south-west area. Significant trends for each monitoring site and water quality parameter are shown in Table 3 & Table 4.

Table 3. Direction of significant trends (p<0.05) for Ammonia Nitrogen, Nitrate-Nitrite Nitrogen (NNN), Dissolved Reactive Phosphorus (DRP) and turbidity at surface water quality monitoring sites in the south-west area of Christchurch City for the six years from January 2007 to December 2012 since monthly sampling was initiated.

Catchment	Site Description	Ammonia N	NNN	DRP	Turbidity
Heathcote	Heathcote River at Templetons Rd				↓ -20%*
	Heathcote River at Rose St				↓ -24%*
	Heathcote River at Ferniehurst St				
	Haytons Drain at Retention Basin outlet	↓ -35%			↓ -18%*
	Curletts Road Drain US Heathcote				↓ -14%*
	Cashmere Stream at Sutherlands Rd				No data
	Cashmere Stream at Worsleys Rd				↓ -18%*
Halswell	Nottingham Stream at Candys Rd		↓ -20%		↑ +23%
	Knights Stream at Sabys Road				
	Halswell River at Akaroa Highway				

* trends calculated using flow adjusted values, because flow explained a high proportion of the variation in the data

Table 4. Direction of significant trends (p<0.05) for Electrical Conductivity (EC), pH, *E. coli*, and total zinc at surface water quality monitoring sites in the south-west area of Christchurch City for the six years from January 2007 to December 2012 since monthly sampling was initiated.

Catchment	Site Description	EC	pH	*E. coli*	Total Zinc
Heathcote	Heathcote River at Templetons Rd	↑ +4%			↓ -81%*
	Heathcote River at Rose St		↑ +1%		↓ -18%*
	Heathcote River at Ferniehurst St				↓ -20%*
	Haytons Drain at Retention Basin outlet				
	Curletts Road Drain US Heathcote				
	Cashmere Stream at Sutherlands Rd				
	Cashmere Stream at Worsleys Rd				
Halswell	Nottingham Stream at Candys Rd	↓ -6%	↑ +1%		
	Knights Stream at Sabys Road				
	Halswell River at Akaroa Highway				

* trends calculated using flow adjusted values, because flow explained a high proportion of the variation in the data

The majority of sites and parameters showed no significant trend over the six years of monthly monitoring. The most consistent trend was a decline in turbidity at sites within the Heathcote catchment (Table 3, Figure 2). A large proportion of the variance in the turbidity data was explained by the discharge of the river on the day of sampling (represented by mean daily discharge, m^3/s). Therefore, turbidity data were flow adjusted so that long term trends were not obscured by variations in discharge between sampling occasions. Decreases of between 14 and 24% per year (median annual decline) were detected for sites in the Heathcote catchment (Table 3). Of the three sites in the Halswell catchment, the only site showing a significant trend for turbidity was Nottingham Stream at Candys Road, with a median annual increase in turbidity of 23%.

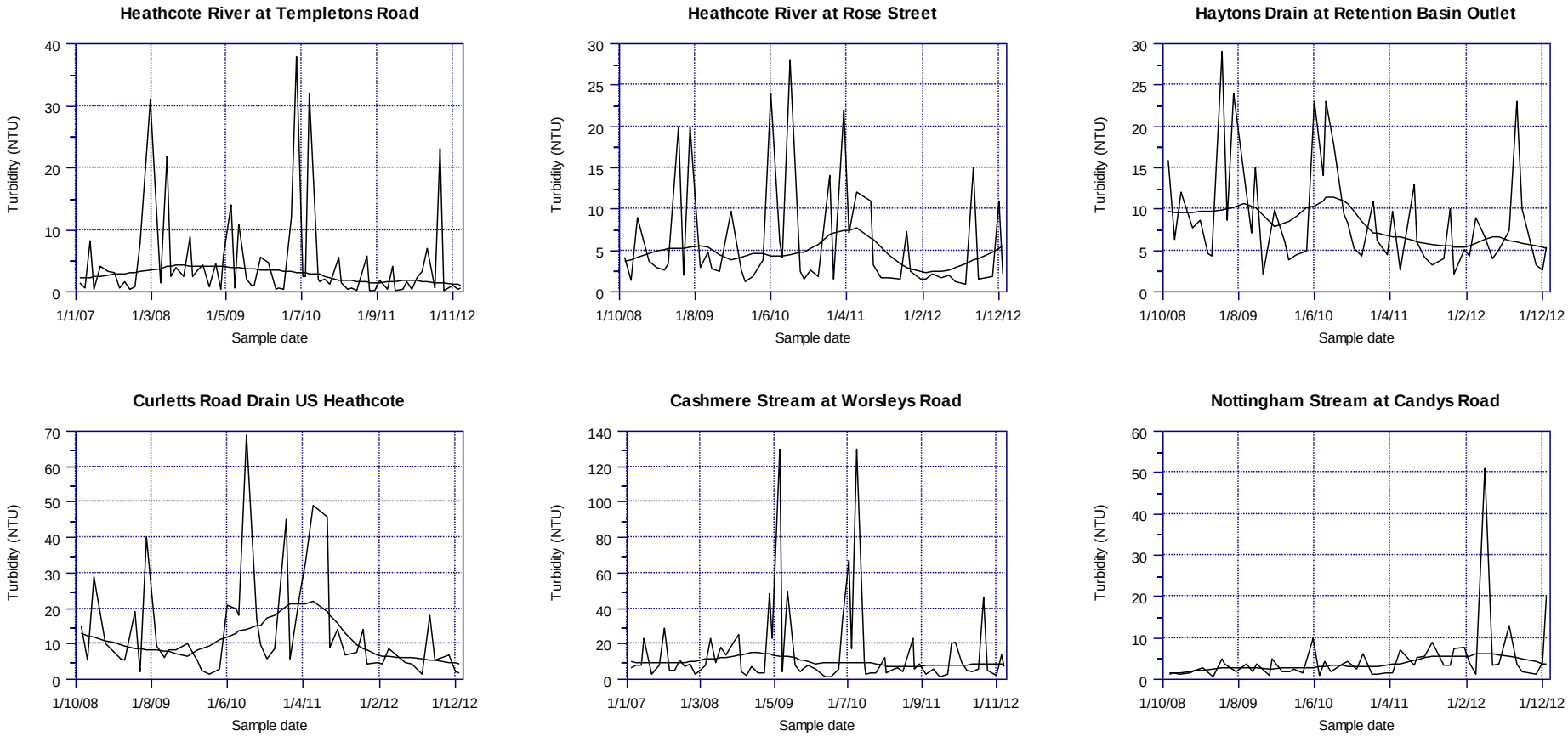


Figure 2. Graph of turbidity at sites within the South-West SMP area where statistically significant ($p<0.05$) trends over time have been detected. The trend lines shown in these graphs were fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

Of the significant trends detected for south-west monitoring sites, the largest was a decline of 81% per year for total zinc in the Heathcote River at Templetons Road (Table 4, Figure 3). There was also a substantial decline of 35% per year for ammonia nitrogen at the outlet of the Wigram retention basin (Table 3, Figure 4). Nitrate-Nitrite nitrogen declined by 20% per year for the Nottingham Stream sampling site at Candys Road (Table 3, Figure 5). Small but statistically significant trends were also observed for electrical conductivity and pH at sites in the upper Heathcote River and Nottingham Stream (Table 4).

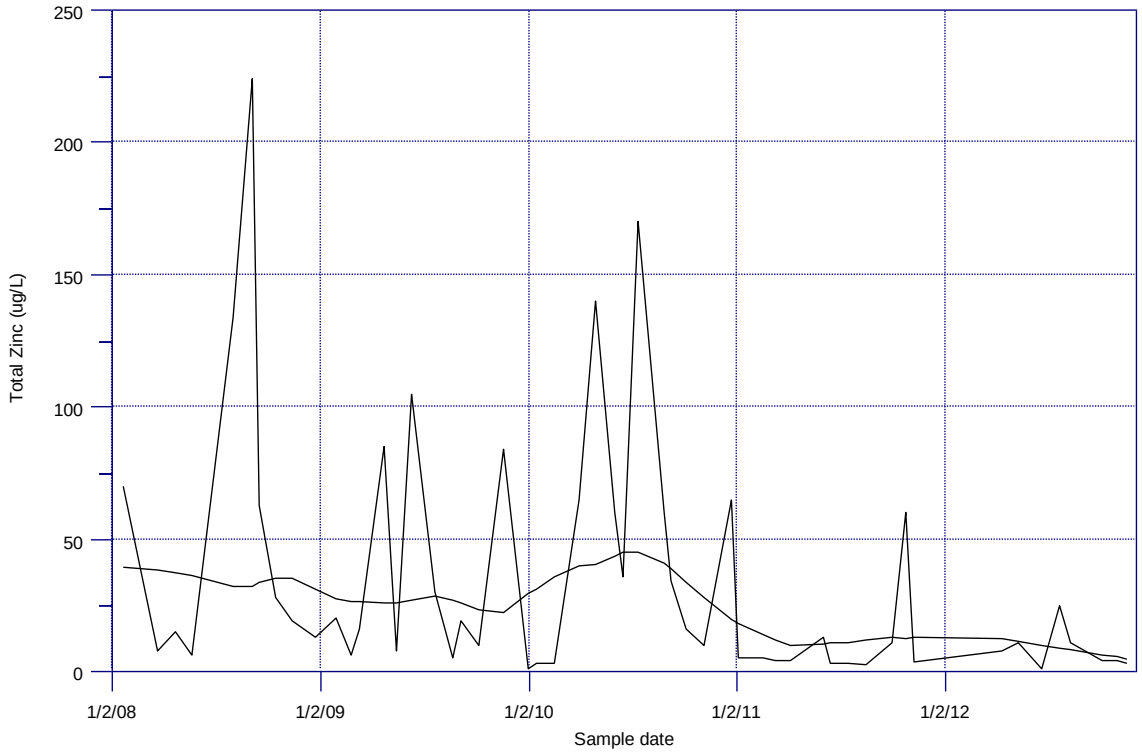


Figure 3. Graph of total zinc over time for the Heathcote River at Templetons Road. There was a statistically significant ($p<0.05$) decline in total zinc at this site over time. The trend line shown in this graph was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

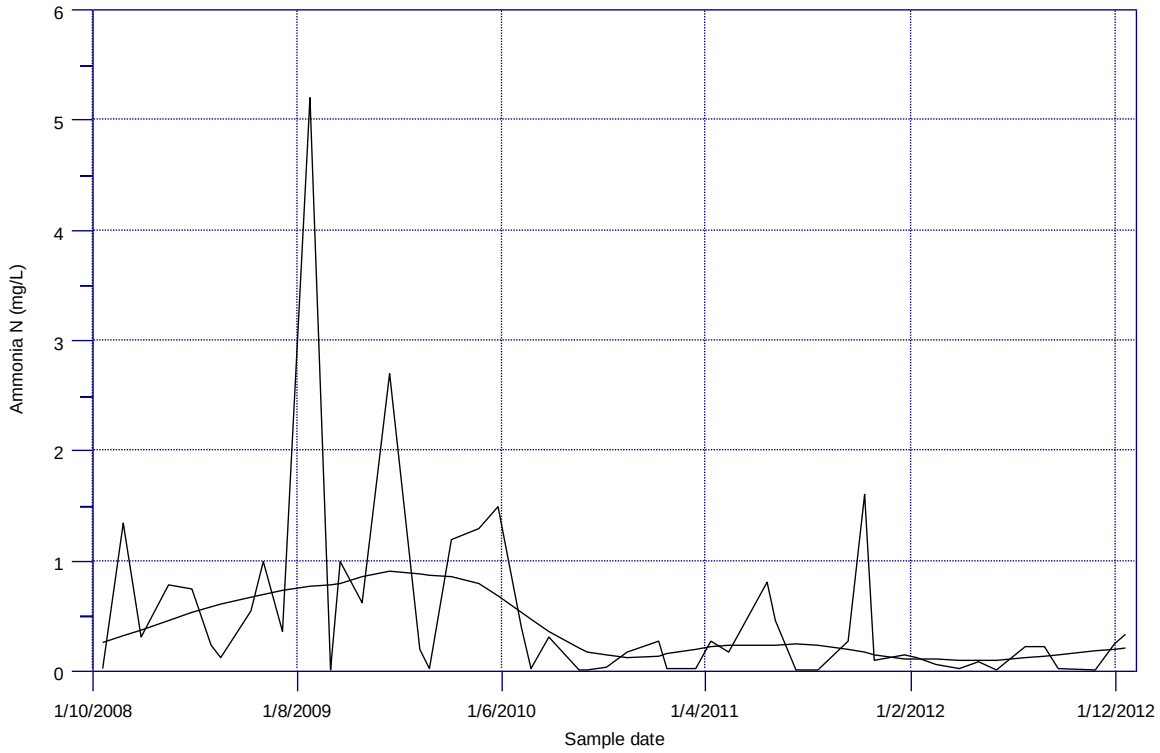


Figure 4. Graph of ammonia nitrogen over time for Haytons Drain at the outlet of Wigram retention basin. There was a statistically significant ($p<0.05$) decline in ammonia nitrogen at this site over time. The trend line shown in this graph was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

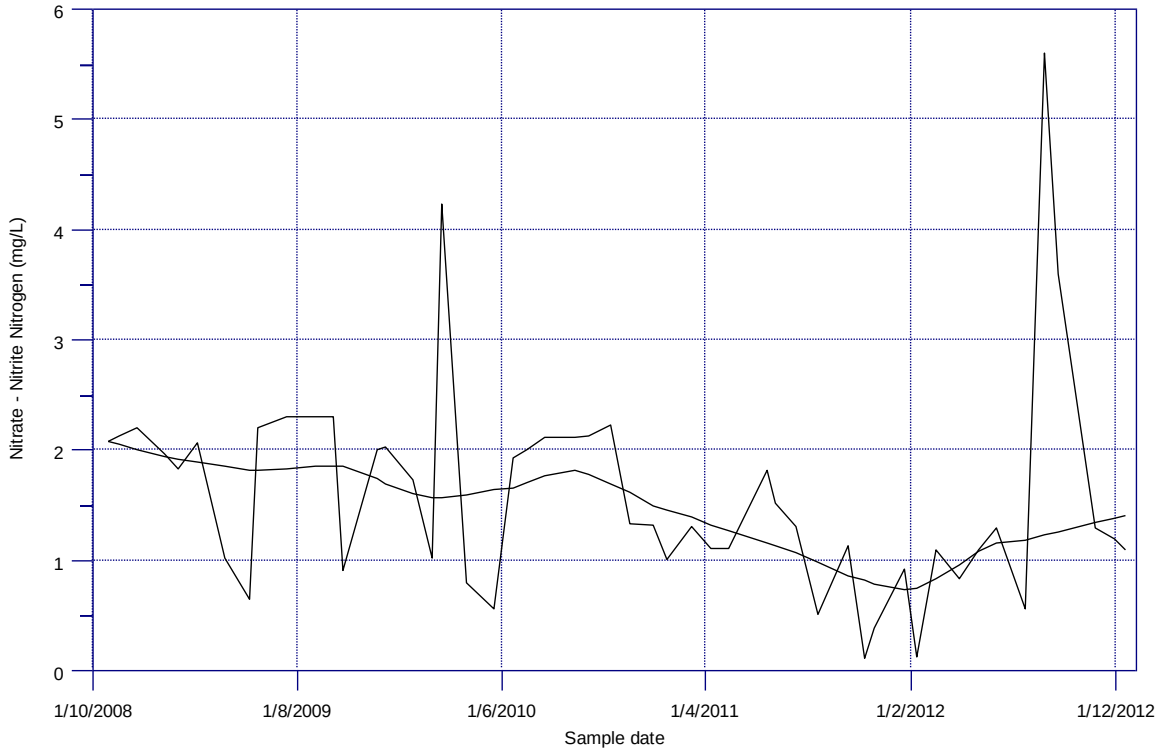


Figure 5. Graph of Nitrate-Nitrite Nitrogen (NNN) over time for Nottingham Stream at Candys Road. There was a statistically significant ($p<0.05$) decline in NNN at this site over time. The trend line shown in this graph was fitted using the Locally Weighted Scatterplot Smoothing (LOWESS) method in the Time Trends software.

Total metals have been included as a measure of water quality at most monitoring sites since monthly sampling was initiated in 2007. As part of the South-West SMP Monitoring Programme, both total and dissolved copper, lead and zinc are now measured at each of the south-west surface water quality monitoring sites. Laboratory detection limits for heavy metals have decreased over the time since monthly sampling began and because a high proportion of the heavy metal results, particularly for copper and lead are reported as being below these detection limits, then the results of trend analysis may falsely report a decline in metal concentrations that is not actually present. An even higher proportion of heavy metals results are being reported as below laboratory detection limits now that dissolved metals are being routinely analysed. For these reasons, trends have not been assessed for copper or lead. Zinc concentrations are typically greater than laboratory detection limits and therefore trends have been analysed for total zinc (Table 4). Trends have not been assessed for dissolved zinc because the length of the data record for dissolved zinc is less than 2 years.

4 Discussion

The resource consent for the South-West Christchurch Stormwater Management Plan was granted on 17 April 2012 and included conditions relating to a monitoring programme for surface and ground water quality and quantity. This report summarises the results of the surface water quality monitoring undertaken as part of this monitoring programme, for the year between January and December 2012. The surface water quality monitoring involves collection and analysis of monthly water quality samples from ten sites in the south-west area of Christchurch. As described in Section 2 of this report, many of the measured surface water quality parameters were within the NRRP/pLWRP and/or ANZECC (2000) guidelines at sites in the south-west SMP area for 2012.

Median values have been used to summarise the annual water quality results and for comparison with guidelines, as these provide an indication about whether each site is usually meeting or exceeding the guideline values or standards. This provides an indication of potential water quality issues within the SMP area. There are sampling occasions for all sites where some of the guidelines or standards are not being met, but these one-off values do not represent the typical situation, or indicate that further investigations are necessary. The purpose of this report is to identify current issues or emerging trends for water quality in the area, so that appropriate actions can be identified to address these issues.

The majority of the trends identified for these monitoring sites were declining or improving trends, most notably for turbidity and total zinc concentrations at several sites. There was an increasing trend for turbidity at Nottingham Stream, but this stream has been badly affected by earthquake liquefaction and is the subject of ongoing repair and sediment removal work. It is anticipated that once this fine sediment has been removed, turbidity levels should return to pre-earthquake levels.

A number of water quality issues and trends for sites in the south-west area have been identified following this analysis of water quality data collected during the 2012 year. These are discussed further below:

1. Turbidity regularly exceeds ANZECC (2000) guideline values for Cashmere Stream at Worsleys Road. High suspended sediment loads in Cashmere Stream are the subject of ongoing investigations by Environment Canterbury (e.g. James & McMurtrie 2010, McMurtrie & James in prep 2013), and these reports include recommendations for reducing the impacts on the waterway. Trend analysis (Section 3 of this report) has shown that turbidity is declining at several sites in the south-west area, including Cashmere Stream at Worsleys Road.
2. The Haytons Drain catchment is known to have poor water quality and the results for 2012 indicate that several water quality parameters regularly exceed guideline values, including biochemical oxygen demand, dissolved reactive phosphorus and zinc. In 2009-2010, NIWA undertook a detailed investigation of water quality in Haytons Drain on behalf of

Environment Canterbury, to identify sources of contaminants to the waterway. This 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.

3. *E. coli* values were often elevated for the monitoring site on Nottingham Stream at Candys Road. There is no significant trend over time for *E. coli* at this site, but there have been noticeably more high *E. coli* values recorded at this site since September 2010, when significant earthquake damage occurred to the wastewater system in the area. Repairs to the wastewater system in this area are ongoing as part of the Stronger Christchurch Infrastructure Rebuild, and it is anticipated that *E. coli* concentrations in the waterway will return to pre-earthquake levels once repairs are completed.
4. Nitrate-Nitrite nitrogen concentrations are high for the majority of monitoring sites in the south-west area. This is a concern, as high nutrient concentrations can encourage the proliferation of aquatic plants and algae. However, in these spring fed streams, NNN concentrations are highly influenced by NNN concentrations in the groundwater, and we have observed that concentrations decrease downstream for the majority of surface waterways in Christchurch, suggesting that dilution may be having an influence on concentrations.
5. Total and dissolved zinc are highly elevated in Curletts Drain and exceed the hardness modified zinc trigger values for the Heathcote catchment. At these concentrations, zinc would be expected to be causing adverse effects on instream biota. This catchment should be a high priority in terms of the industrial site audit programme and there may be a need for additional investigations to identify the likely sources of zinc within this catchment.

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6 Appendices

Appendix 1: Water quality summary statistics for monitoring sites within the South-West Christchurch SMP