Environmental Monitoring Programme

for the Comprehensive Stormwater Network Discharge Consent for Ōtautahi/Christchurch City and Te Pātaka o Rākaihautū/Banks Peninsula

June 2022

Environmental Monitoring Programme

for the Comprehensive Stormwater Network Discharge Consent

Version 9

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ENVIRONMENTAL MONITORING PROGRAMME

Contents

1 Introduction

1.1 Background and Purpose

In accordance with the consent conditions of the Comprehensive Stormwater Network Discharge Consent (CSNDC), the primary purpose of this Environmental Monitoring Programme (EMP) is to assess the extent of mitigation of effects of stormwater discharges from the Christchurch City Council stormwater network on the receiving environment. Some of the monitoring will also have the added benefit of informing the refinement and improvement of waterway health and stormwater management practices in general.

This EMP includes details (including site info and methodology) of the monitoring of:

- Infiltration facilities;
- Groundwater;
- Surface water levels;
- Surface water quality;
- Instream sediment quality;
- Aquatic ecology; and
- Mana whenua values.

This programme includes additional monitoring to that required under the consent conditions. This is to provide additional information useful to improve waterway health and mitigate the effects of stormwater discharges under this consent, such as prioritisation of areas for management. It is also useful information that can be used for the purposes of achieving CCC plans, strategies and policies. Some of this information will not specifically be linked to consent conditions, but will be included in the monitoring report, as detailed throughout the document.

1.2 Current Environmental Monitoring Programme

The Christchurch City Council (CCC) currently carries out monitoring of treatment facilities, surface water levels, surface water quality, instream sediment quality and aquatic ecology throughout Christchurch. This monitoring is to fulfil the requirements of:

(a) monitoring programmes for existing stormwater discharge consents from Environment Canterbury (ECan) (Table 1);
(b) CCC policies and strategies (e.g. District Plan and Surface Water Strategy); and
(c) to provide information for the operation and development of the stormwater and wastewater networks.

Table 1. Existing Christchurch City Council stormwater discharge consent monitoring programmes

Title	Consent	Reference
Interim Global Stormwater Consent Monitoring Plan	CRC090292	Dewson & Rodrigo, 2009
Monitoring Programme for South-West Christchurch Stormwater Management Plan	CRC120223	Golder Associates, 2011
Monitoring Programme for the Pūharakekenui/Styx River Stormwater Management Plan	CRC122598	Golder Associates, 2012

The results of this monitoring are currently summarised annually in reports submitted to ECan to fulfil the conditions of the three current stormwater consents. These reports are also used Council-wide for a number of other reasons (e.g. to assess community outcomes). The existing monitoring programme will be formalised into this one document, and updated for the purposes of both the CSNDC and other CCC requirements.

One of the purposes of the Interim Global Stormwater Consent (IGSC) monitoring plan was "to collect information relating to the impacts of stormwater from various land-uses within a range of SWMP catchments, and the performance of various stormwater devices used to treat stormwater" (Dewson & Rodrigo, 2009). This baseline data has been used to better understand the impacts of stormwater within the city and help in the development of stormwater management practices. Because of this wider objective, the monitoring programme for the IGSC was more comprehensive than is intended for the CSNDC. The CSNDC EMP will focus on measuring whether the Receiving Environment Objectives and Attribute Target Levels, as specified in the resource consent conditions, are being met.

2 Soil Quality Monitoring at Infiltration Facilities

2.1 Purpose for Monitoring under this Consent

The purpose of this monitoring is to ensure that the infiltration treatment facilities do not accumulate contaminants to a point where they may negatively impact ground or surface water quality, or pose a human health risk.

2.2 Soil Quality Monitoring

Under the IGSC, soil quality monitoring took place at five sites which were selected to represent infiltration or soakage systems and dry detention ponds servicing a range of land-uses across the city. It is proposed to continue to monitor those sites, but also add in one representative rain garden site. Soils within the five IGSC representative facilities were monitored in 2010 and 2015, and this will continue on a five-yearly basis. This information will help determine the rate of contaminant accumulation and at what point remediation measures need to take place. The sites and parameters to be analysed are shown in Table 2 and in Figure 1, with coordinates provided in Appendix A.

Table 2. Soil sampling monitoring of stormwater devices. Cu = total recoverable copper; Zn = total recoverable zinc; Pb = total recoverable lead; As = total recoverable arsenic; Cd = total recoverable cadmium; Cr = total recoverable chromium; Ni = total recoverable nickel; PAH = Polycyclic Aromatic Hydrocarbons; SVOC = Semi-Volatile Organic Compounds.

Location	Type of System	Land Use	Year System Constructed	Parameters to be Tested
Denton Park	Soakage Basin	Residential	1997	Cu, Zn, Pb, PAH
Beckenham Library	Detention Swale	Car Park	2005	Cu, Zn, Pb, PAH
Tumara Park	Infiltration and Detention	Large Residential	2003	Cu, Zn, Pb, PAH
Hornby Industrial Park	Infiltration Basin	Industrial	1995	As, Cd, Cr, Cu, Ni, Pb, Zn, PAH, SVOCs
Richmond Housing Complex	Swale and First- flush Basin	High Density Housing	2007	Cu, Zn, Pb, PAH
Grove Road	Rain Garden	Commercial	2015	Cu, Zn, Pb, PAH

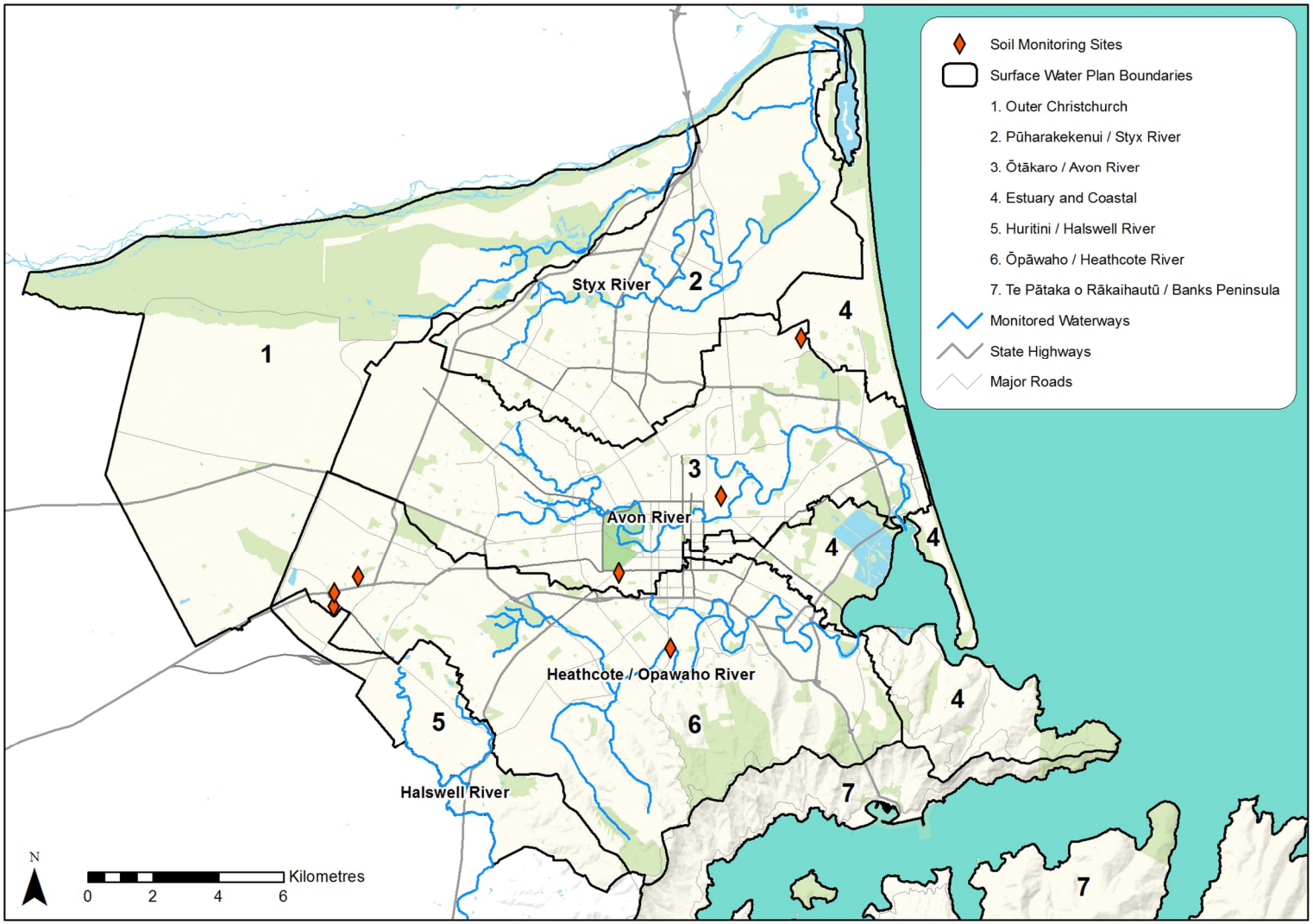

Figure 1 Location of soil monitoring sites

2.3 Soil Sampling Protocol

Representative samples of the soil shall be collected from the relevant soil adsorption basin. The sample shall be collected from a depth of between zero and 50 millimetres below the ground surface at the point of lowest elevation. All samples shall be collected using a stainless steel trowel pre-cleaned with phosphate free detergent and transferred immediately into jars or containers provided by the laboratory. Field personnel shall wear gloves at all times during sampling.

A completed chain of custody shall accompany all samples dispatched to an external testing laboratory. Samples shall be stored in a chilly bin on ice until delivery to the laboratory. At each sampling location a field sheet shall be completed describing the site characteristics and photographs taken of the basin surface.

2.4 Analysis

Analysis of soil adsorption basin samples shall be undertaken by an IANZ accredited laboratory. Detection limits for each parameter shall be suitable to enable comparison of the results with relevant guidelines and trigger levels for reporting purposes.

The soil sample results shall be compared against the most appropriate and relevant soil quality guideline values for recreational use and any other standard pertaining to protection of ground and surface water quality. The following documents will be assessed as to their suitability for comparison with the results:

- National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (Ministry for the Environment, 2012); In particular, the recreation standards in *Table B2: Soil contaminant standards for health ($SCS_{(health)}$) for inorganic substances*;
- Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Ministry for the Environment, 1999);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000); and
- Trigger values for soil quality contained in other Christchurch City Council stormwater discharge consent conditions.

The guidelines that are deemed most suitable for comparing the soil sample results will be accompanied by a justification for their use and suitability.

2.5 Reporting

The annual monitoring report for the consent shall include a report on the visual inspections and soil quality monitoring undertaken during the previous calendar year. This report shall include:

- A summary of the visual inspections undertaken;
- A summary of any soil quality monitoring;
- Identification of key issues and any trends noted;
- Summary of any notifications made to ECan and why;
- Responses undertaken to any issues identified; and
- Recommendations for changes to the maintenance and operation of the facilities.

3 Groundwater

Stormwater management has the potential to affect groundwater levels, flow in spring-fed streams and groundwater quality. Therefore, the objective of the groundwater and spring monitoring programme shall be to provide ongoing information on groundwater levels, spring flows and groundwater quality so that current trends can be determined and compared with historical patterns. In achieving this objective in the most efficient manner, use will be made of existing monitoring programs operated by both CCC and ECan.

3.1 Purpose for Monitoring under this Consent

The purpose of this monitoring is to (1) measure whether stormwater discharges are causing adverse effects on groundwater quality or quantity, (2) determine compliance with the conditions of consent and (3) inform stormwater mitigation.

3.2 Groundwater Quantity

3.2.1 City-Wide Shallow Groundwater Levels

CCC carry out monthly groundwater level monitoring at the network of wells shown in Figure 2. These wells are typically 6m or less deep and provide a general coverage of the water table elevation across the city. This network of groundwater level monitoring wells helps to identify patterns of water level change, some of which will be affected by stormwater management systems and land use changes that affect the area and location of pervious surfaces and infiltration patterns.

3.2.2 Springs

Springs contribute to the overall flow and quality of surface waterways, and in general arise from artesian sources. The discharge of stormwater is unlikely to impact on springs, and overall issues of water flow or water quality emanating from the springs is incorporated into the surface water monitoring programme. Particularly significant springs are documented on CCC and ECan records, and any noteworthy changes are likely to be noted and reported by residents and/or CCC/ECan staff. Any such reports would be investigated to check on the cause and determine if any mitigation measures are required.

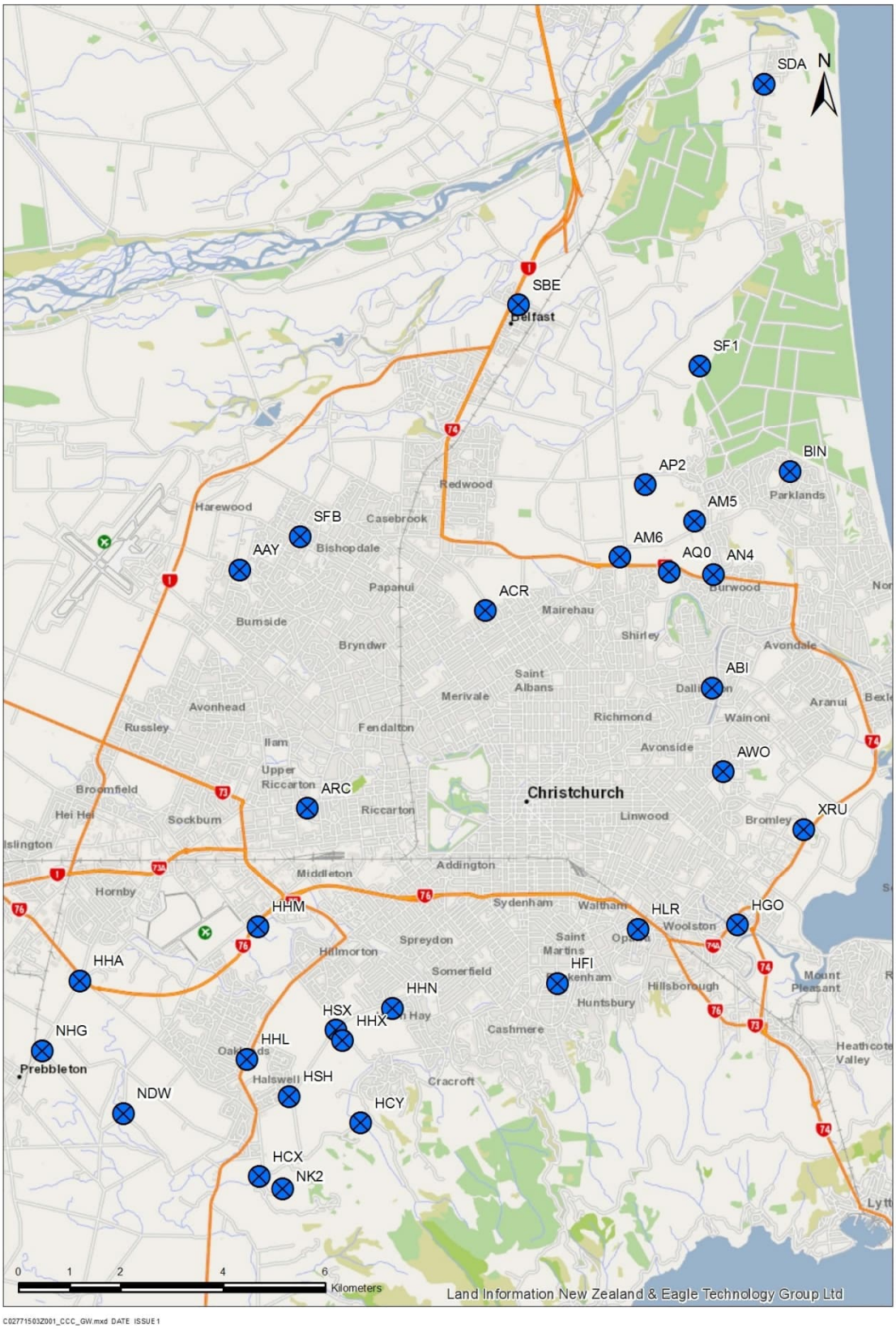

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Figure 2 CCC groundwater level monitoring network

3.2.3 Localised Groundwater Quantity Issues

Localised groundwater drainage issues can arise from stormwater basins or can be exacerbated by high groundwater conditions. Localised deterioration in groundwater quality can occur from localised contamination sources, including infiltration basins. As well as the regular monitoring, a detailed 12 month study is proposed in 2020 to specifically investigate the impacts of infiltration facilities.

Regular Monitoring

Regular monitoring will consist of CCC responding to observations or queries about potential groundwater drainage issues as these are received. These will be investigated and, if it is likely to be beneficial, some monitoring of the localised situation will be initiated to understand the groundwater related effects that may be occurring.

In the case of stormwater infiltration basins, their drainage rates will be observed by CCC maintenance staff. If delayed drainage is occurring, investigations will be initiated to investigate whether the cause is due to elevated groundwater levels or poor soil infiltration characteristics.

Detailed Study

In 2020, in addition to the more general city-wide monitoring described above, a more detailed study will be initiated for a period of at least 12 months. This will involve monitoring at three infiltration basin facilities to assess localised changes in groundwater levels, and the flow and quality of any nearby springs arising from the facilities.

The methodology is yet to be fully developed, but will likely involve:

- Identification of three representative basins;
- The installation of at least one groundwater level monitoring well at each site;
- 12 months monitoring of groundwater levels;
- Monitoring in at least one new basin within the monitoring period, designed to characterise the change from the pre-basin to post-basin environment (note this may affect the timing of the study depending on whether a suitable basin is located); and
- Analysis and reporting.

3.3 Groundwater Quality

Two issues arise from groundwater quality; these are the quality of well water and of spring flow. Of most importance is the potential impact on CCC public water supply wells from stormwater discharges. Public wells are very unlikely to be affected by the activity, as public water supply is drawn from deep artesian wells fed by deep groundwater originating from the Waimakariri River and the inland plains. However, some shallow private wells (potentially affected by unconfined groundwater quality) still exist in the north-west and south-west.

Environment Canterbury (ECan) carry out regular sampling of groundwater quality within the city urban area and also in some wells further to the west which provide an indication of the quality of groundwater moving into urban aquifers. These wells are sampled for general chemical indicators at either quarterly or annual intervals. The locations of the currently recommended monitoring wells are shown in Figure 3 (from Scott, 2013). These monitoring wells will be used to provide the data for analysis by the monitoring programme.

CCC carry out groundwater quality monitoring of the output from their public water supply pumping stations. Monitoring for *Escherichia coli* is carried out each day at a pumping station supplied by shallow wells in the north-west zone of the CCC water supply network. This sampling schedule cycles through the pumping stations so that repeat samples from each station are collected at a frequency of around 3 or 4 times per month. Pumping stations supplied by deep wells or located in areas other than the north-west are sampled for *E. coli* once a month.

In addition to the *E. coli* sampling, a representative selection of wells is sampled every year for a full chemical analysis by CCC. The wells are selected so as to take representative samples from each aquifer each year, and to have each aquifer at each pumping station tested every 5 years.

The CCC water supply network changes from time to time as new wells are drilled and poorly performing wells are decommissioned. The current location of the water supply wells are shown in Figure 4.

The data from this network of wells will be used to assess, on an annual basis, the effects of stormwater on:

- Groundwater quality patterns for copper, lead and zinc in ECan monitoring wells;
- *E. coli* detections in CCC water supply wells; and
- Groundwater quality patterns for copper, lead and zinc from CCC water supply wells.

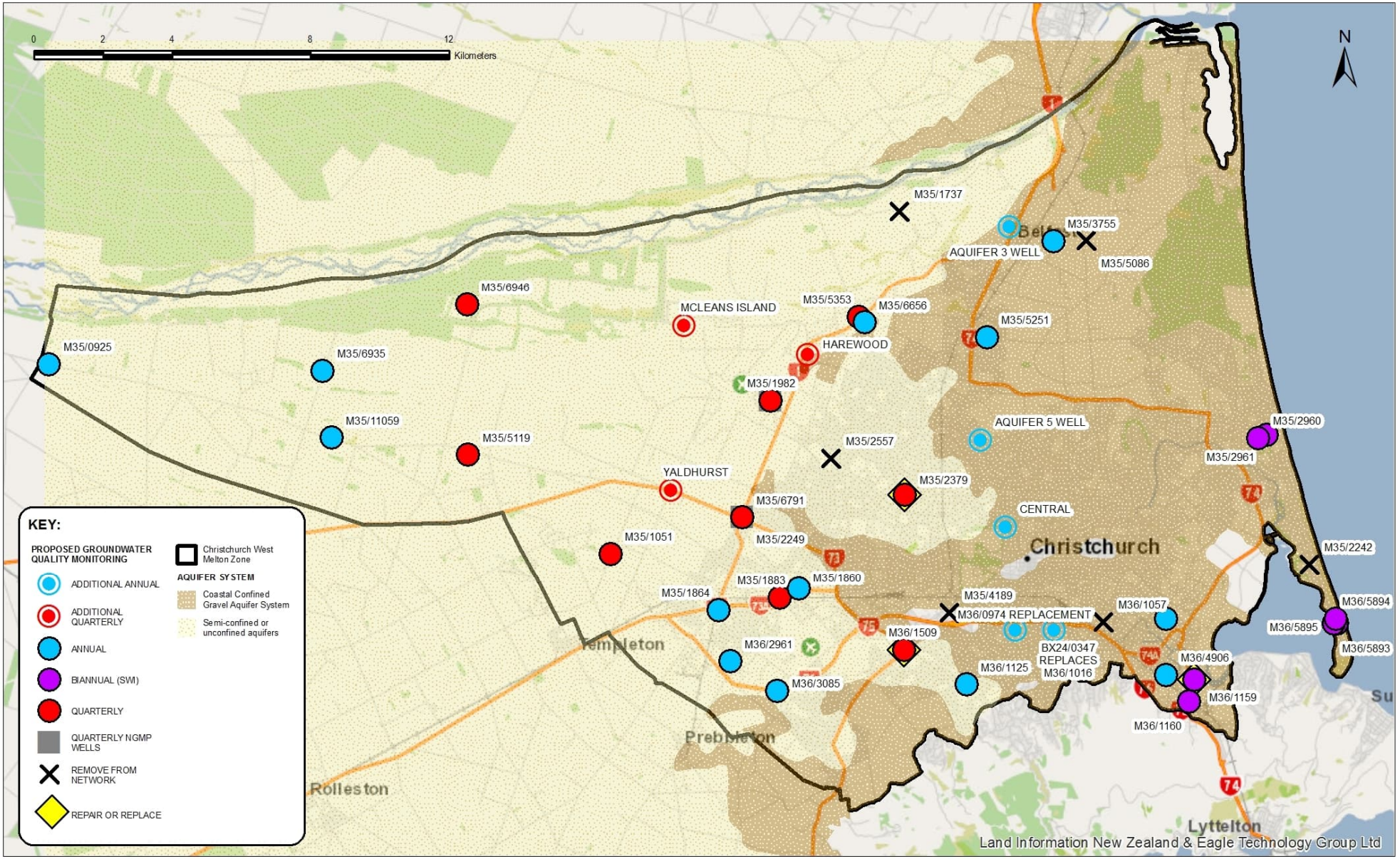

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Figure 3 ECan groundwater quality monitoring network

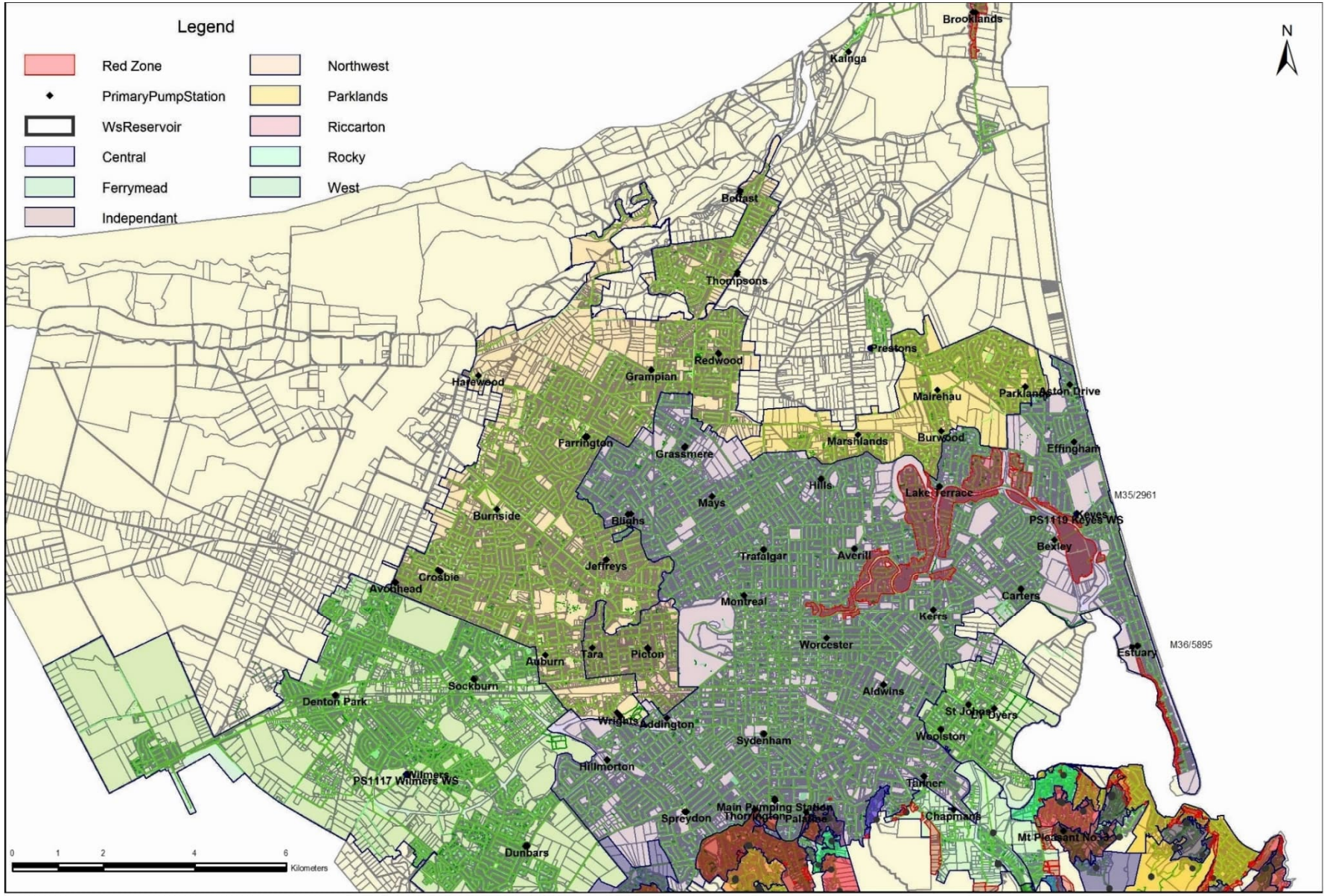

Figure 4 CCC water supply pumping station locations

3.3.1 Localised Groundwater Quality Issues

Localised deterioration in groundwater quality can occur from localised contamination sources, including infiltration basins. Regular monitoring will be undertaken, as well as an in-depth 12 month study proposed in 2020 to specifically investigate the impacts of infiltration facilities.

Regular Monitoring

Regular monitoring will consist of CCC responding to observations or queries about potential groundwater quality issues as these are received. These will be investigated and, if it is likely to be beneficial, some monitoring of the localised situation will be initiated to understand the groundwater related effects that may be occurring.

Detailed Study

In 2020, in addition to the more general city-wide monitoring described above, a more detailed study will be initiated for a period of at least 12 months. This will involve monitoring at three infiltration basin facilities to assess localised changes in groundwater quality.

The methodology is yet to be fully developed, but will likely involve:

- Identification of three representative basins;
- The installation of at least one groundwater level monitoring well at each site;
- 12 months monitoring of groundwater quality;
- Monitoring in at least one new basin with the monitoring period designed to characterise the change from the pre-basin to post-basin environment (note this may affect the timing of the study depending on whether a suitable basin is located); and
- Analysis and reporting.

3.4 Reporting

Groundwater monitoring should be reviewed on an annual basis, and a report prepared to identify any results or patterns that are likely to have resulted from stormwater management issues. The annual report should include the following topics:

- Groundwater level patterns in CCC water level monitoring wells;
- Groundwater quality patterns for copper, lead and zinc in ECan monitoring wells;
- *E. coli* detections in CCC water supply wells;
- Groundwater quality patterns for copper, lead and zinc from CCC water supply wells;
- Any information from spring monitoring that could be attributed to stormwater impacts on groundwater;

- Statistical analyses of change for *E. coli* (daily data from pumping stations) and electrical conductivity (quarterly data at ECan monitoring wells; used as an indicator of changes in metals levels) shall be undertaken using Time Trends or other robust analysis, using a statistical level of significance of 5% (i.e. $p \leq 0.05$);
    - A minimum of three years is required before trends analysis can be undertaken (NIWA, 2014);
    - Trends analysis shall be conducted on data since the beginning of the dataset;
- Any groundwater related issues that affect the performance of stormwater management systems; and
- An assessment as to whether the Receiving Environment Objectives and Attribute Target Levels specified in Schedule 9 (Groundwater and Springs) of the consent conditions are being met at each site for copper, lead and zinc.

4 Surface Water Levels and Flows, Sea Level and Rainfall Depth

4.1 Purpose for monitoring under this consent

Monitoring of surface water levels and flows, sea level and rainfall depth enables CCC to assess the accuracy of the water quantity models developed for the Pūharakekenui/ Styx, Ōtakaro/ Avon, Ōpāwaho/ Heathcote River and Huritini/ Halswell Rivers. This in turn allows CCC to confirm whether the conditions of consent are being met.

CCC intends to use monitoring data collected, along with surveyed flood extents during significant rainfall events, to validate and calibrate its stormwater quantity models for the Pūharakekenui/ Styx, Ōtākaro/ Avon, Ōpāwaho/ Heathcote and Huritini/ Halswell Rivers. Further, as new greenfields developments and their associated stormwater mitigation systems are completed and commissioned, the models will be updated as needed to ensure the expected progress is being made toward the Maximum Probable Development (MPD) flood mitigation targets set in Schedule 10 of the consent.

4.2 Sites

CCC has maintained and added to the hydrometric[1] network which was established by the Christchurch Drainage Board. This network consists of monitoring sites for surface water levels and flows, sea level, rainfall and groundwater levels (the latter discussed in the groundwater section of this document). The data collected from this network is used for the Council's management of the rivers and for the design of stormwater networks. Data is also used for emergency management purposes, particularly in time of flood. CCC engages a subcontractor to maintain the hydrometric network and collect the data. Quarterly and annual reports are produced that summarise the data, and make recommendations for maintenance and upgrades.

4.2.1 Surface Water Level and Flows

Continuous water level gauging data began in about 1980 and additional sites were added in 1989. CCC currently obtains data from 25 river level gauges (Figures 5 and 6). This includes 20 permanent and 5 project-based sites. The permanent river level gauges are telemetered and provide real time information at 15 minute (or less) intervals. Project-based gauges are typically connected to a data-logger which is downloaded monthly. River flow is calculated at eight rated sites (both permanent and project-based). Regular flow gaugings are undertaken to

[1] Hydrometry refers to the measurement of all elements in the hydrological cycle. In this context the hydrometric network refers to the measurement of rainfall, surface water levels and flows, and groundwater levels.

maintain accurate ratings. In addition to the automatically gauged sites, there are a number of locations with staff gauges. Levels at these sites can be recorded manually as needed.

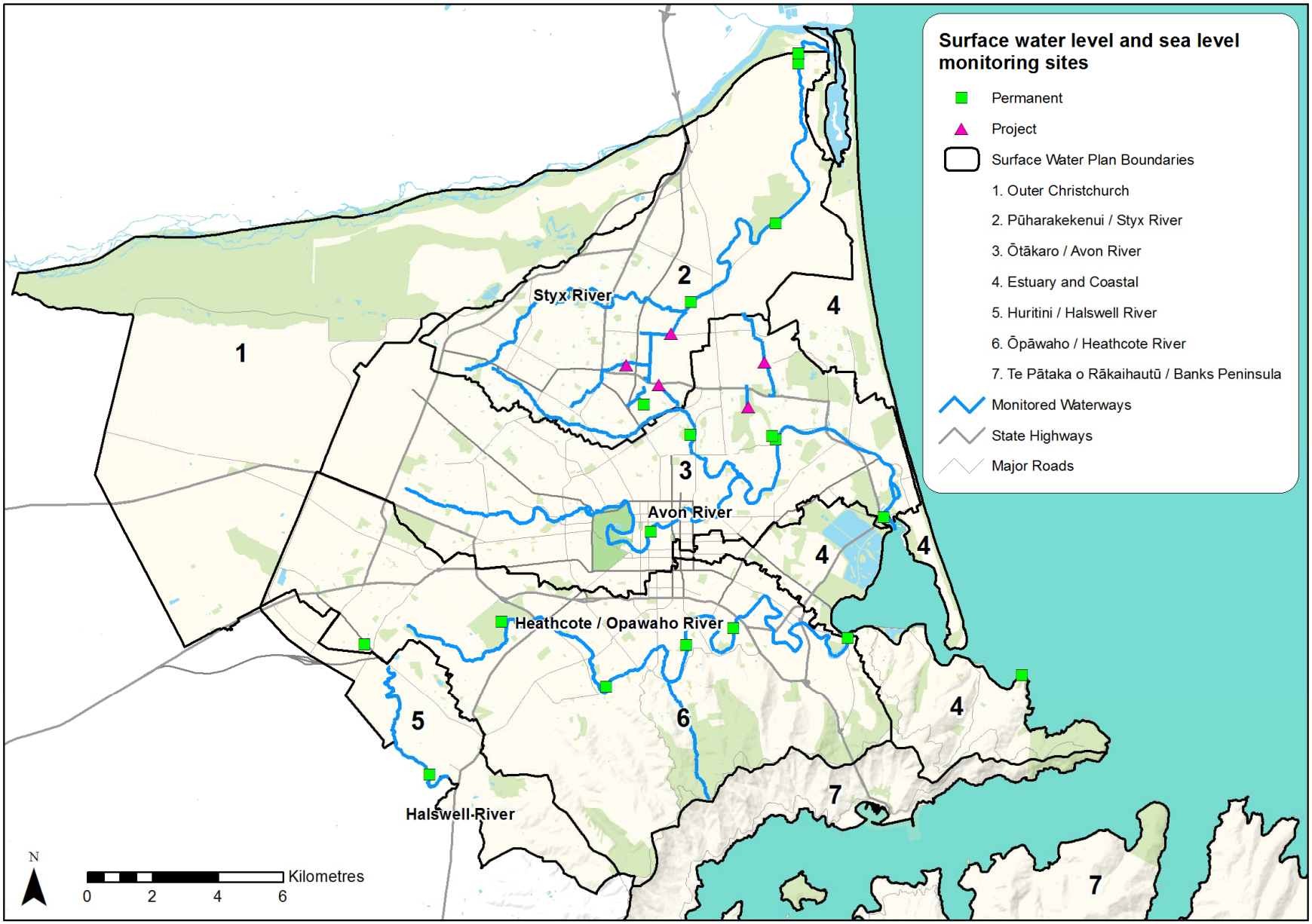

Figure 5 Location of water level sites (City)

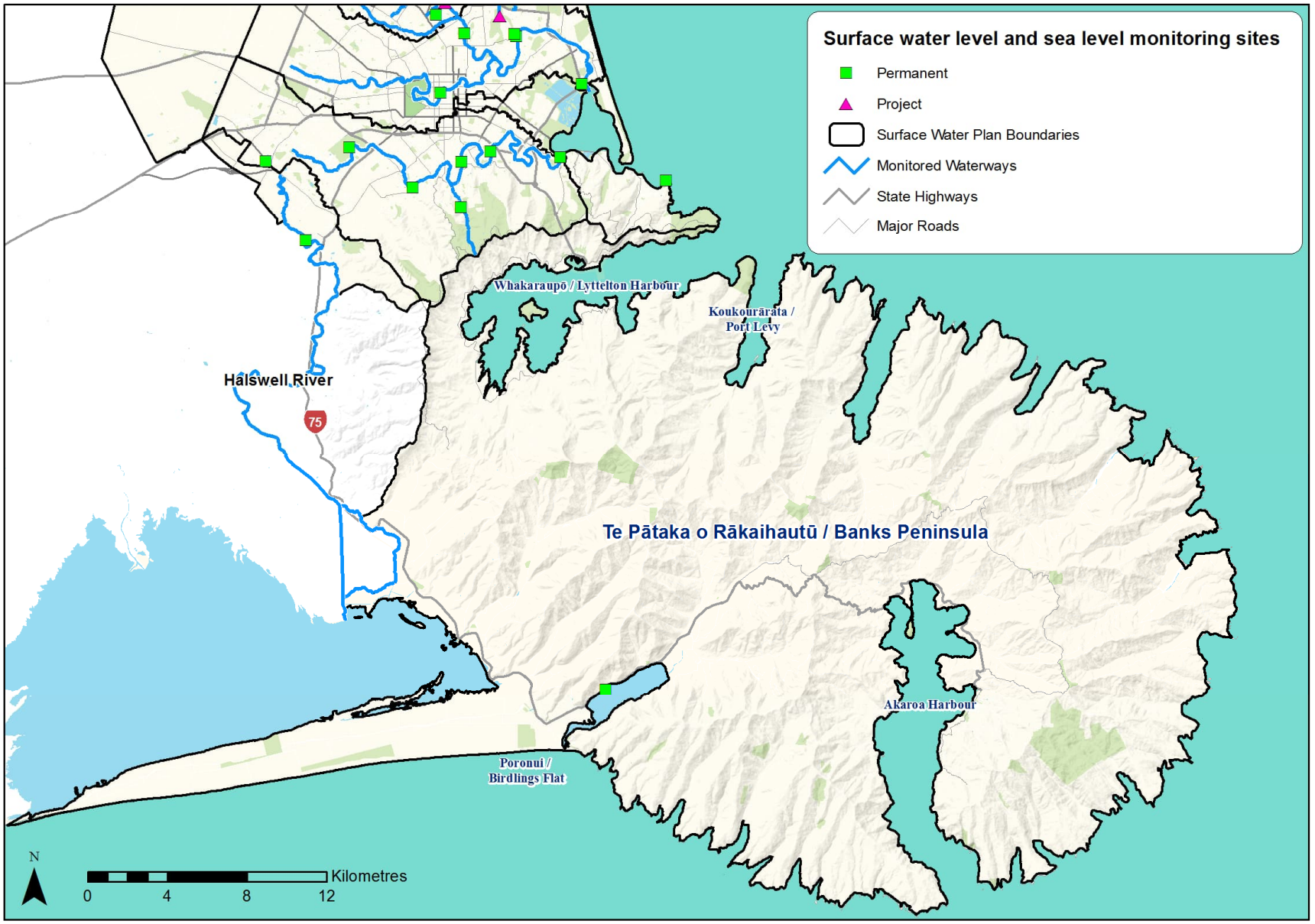

Figure 6 Location of water level sites (Banks Peninsula)

4.2.2 Sea Level

The National Institute of Water and Atmospheric Research (NIWA) maintains a CCC/ECan sea level monitoring site at Sumner Head in Scarborough (Figure 5). Tide levels have been analysed and statistics generated by NIWA based on recordings at the Pūharakekenui/ Styx River tide-gates, Sumner Head, Avon River at Bridge Street and Heathcote River at Ferrymead (Goring, 2008; Goring, 2011). This information is used to inform the downstream water levels which are critical to the functioning of the Ōtākaro/ Avon and Ōpāwaho/ Heathcote River models, and also inform long-term planning decisions.

4.2.3 Rainfall Depth

There is a network of 21 rain gauges which presently provide real time information at 15 minute (or less) intervals (Figures 7 and 8). The longest record is the almost continuous daily rainfall record for the Botanic Gardens dating back as far as 1873. However, it was not until 1962 that records of rainfall began at hourly intervals and this has progressively been reduced to sub-hourly recording. This provides Christchurch with a good basis for its rainfall statistics, which have been compiled by NIWA for use in stormwater design (Griffiths *et al*, 2009).

4.3 Reporting

CCC will report on the stormwater quantity models in the annual report on a 5-yearly basis, starting in the year 2021. Reporting will cover:

- Any significant changes made to the input parameters of the models;
- Any significant changes to development patterns (greenfield or brownfield);
- Any significant updates to model hydraulics (bridges, culverts, etc.);
- Any significant calibration or validation exercises undertaken;
- A discussion of progress toward meeting the flood mitigation targets set in Schedule 10 of the consent; and
- Any other relevant discussion involving changes to models or analysis of modelling results.

In addition, CCC maintains a database with all recorded data to be made available as needed for projects or updating of hydrological models. TIDEDA (a NIWA product for storing and analysing time dependent data) is used to allow detailed analysis of the data. Quarterly and annual reports are produced, with a summary of the data and a review of operational issues.

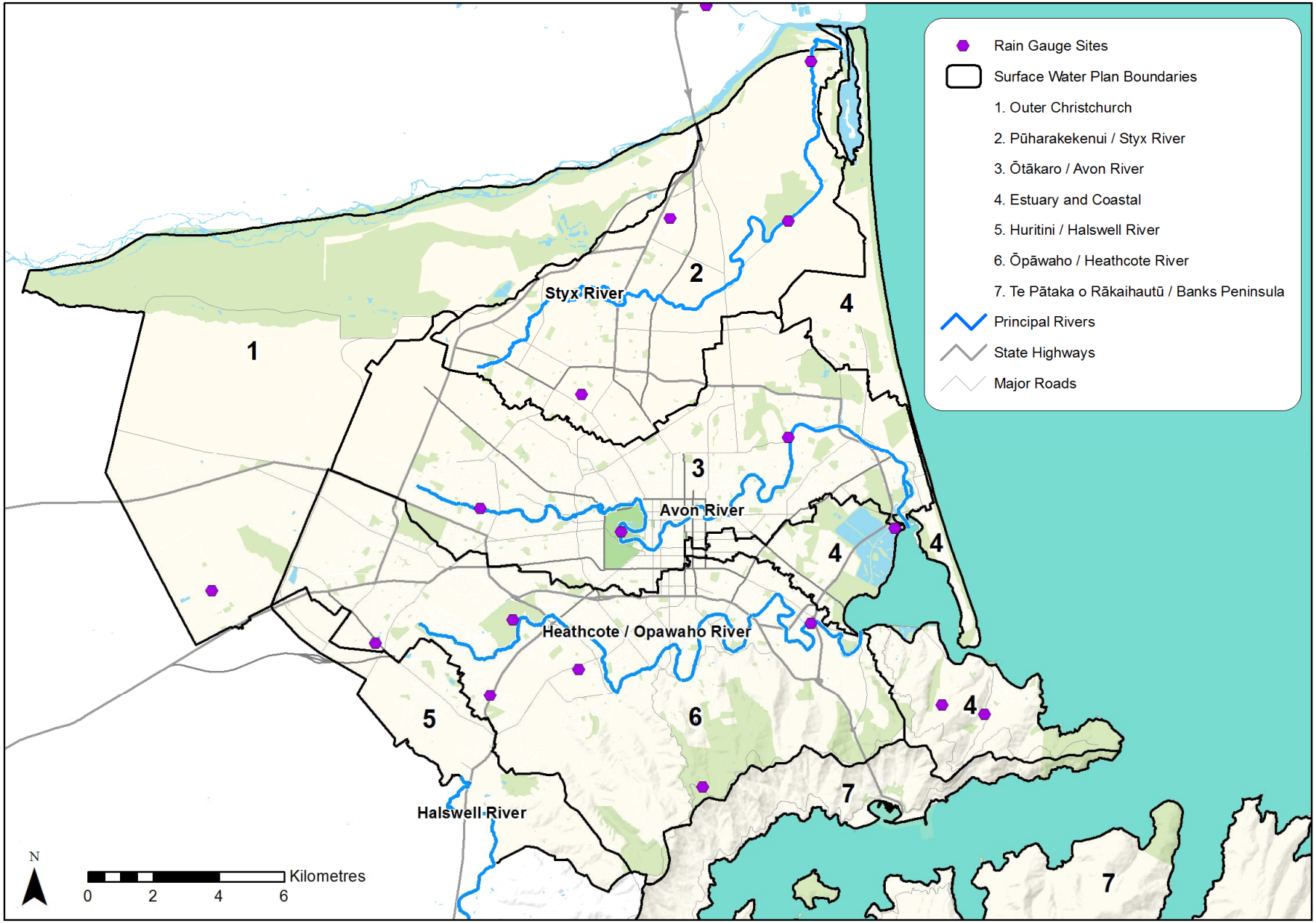

Figure 7 Location of rainfall depth sites (City)

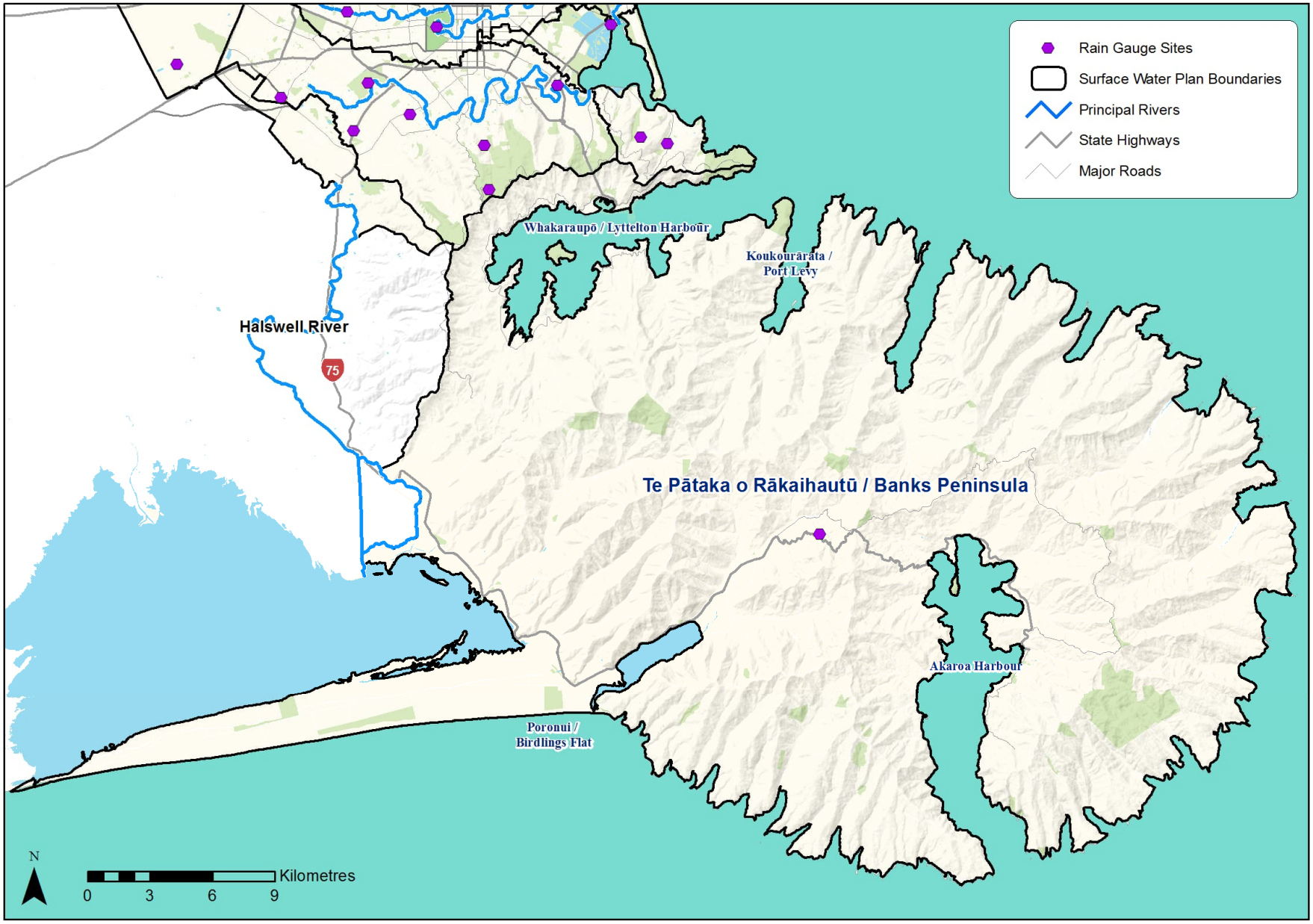

Figure 8 Location of rainfall depth sites (Banks Peninsula)

5 Surface Water Quality

5.1 Purpose for monitoring under this consent

The purpose of this monitoring is to (1) measure whether stormwater discharges are causing adverse effects on surface water quality, (2) determine compliance with the conditions of the consent, (3) inform stormwater mitigation and (4) inform management of waterway health. This monitoring is of a range of parameters present in stormwater (such as metals and sediment), but also additional parameters to give a better understanding of water quality overall. Monitoring includes baseline monitoring (to understand the typical quality of the water and because it is easier to undertake a widespread monitoring) and wet weather monitoring (to particularly focus on stormwater inputs).

5.2 Background

Water quality monitoring of waterways has been undertaken previously by the CCC for many decades, with regular monthly sampling being undertaken at numerous sites in Christchurch since 2007. This new monitoring programme builds on this past monitoring by including additional sites and receiving environments.

5.3 Sampling Sites and Frequency

5.3.1 Regular Monitoring

A total of 51 sites within the waterways and coastal areas of Christchurch and Banks Peninsula shall be monitored monthly (Figures 9 to 15; Appendix B). These sites predominantly include (a) waterways within the five main river catchments of Christchurch (Ōtākaro/ Avon River, Ōpāwaho/ Heathcote River, Puharakekanui/ Styx River, Huritini/ Halswell River and Ōtūkaikino River), (b) waterways within Banks Peninsula settlement areas and (c) coastal areas (estuaries and ports, within Christchurch and Bank Peninsula).

5.3.2 Wet Weather Monitoring

Wet weather monitoring of waterways has previously been undertaken as part of stormwater discharge consents requirements. This new monitoring programme builds on this monitoring, by including more sites. Wet weather monitoring is to be undertaken at 28 sites within the five main Christchurch river catchments and four sites from coastal areas (Figures 9 to 15; Appendix B). This monitoring shall be done on a five yearly rotation, in the same year as the sediment and ecological monitoring for each catchment (Appendix B). Two wet weather events shall be monitored each year in the relevant catchment.

Wet weather sampling shall be carried out using the following criteria:

- By using grab sampling, or other method that results in more robust sampling, such as Nalgene bottles or autosamplers, as approved by Environment Canterbury (Regional Leader – Monitoring and Compliance).
- Dry period prior to sampling = minimum of 3 days (on advice from Ash O'Sullivan from PDP that even 24 hours is sufficient time for contaminants to accumulate);
- Rainfall depth = minimum of 3mm total before sampling begins (based on modelling by Tom Parsons for Avon Stormwater Management Plan that this is sufficient to obtain the first flush (15-25 mm) of contaminants); and
- Sampling timeframe = within 1-2 hours of the desired rainfall being achieved, as determined using MetConnect or equivalent forecasted and real-time rainfall, to ensure first flush is captured. Tide cycles needed to be taken into consideration for tidal sites.

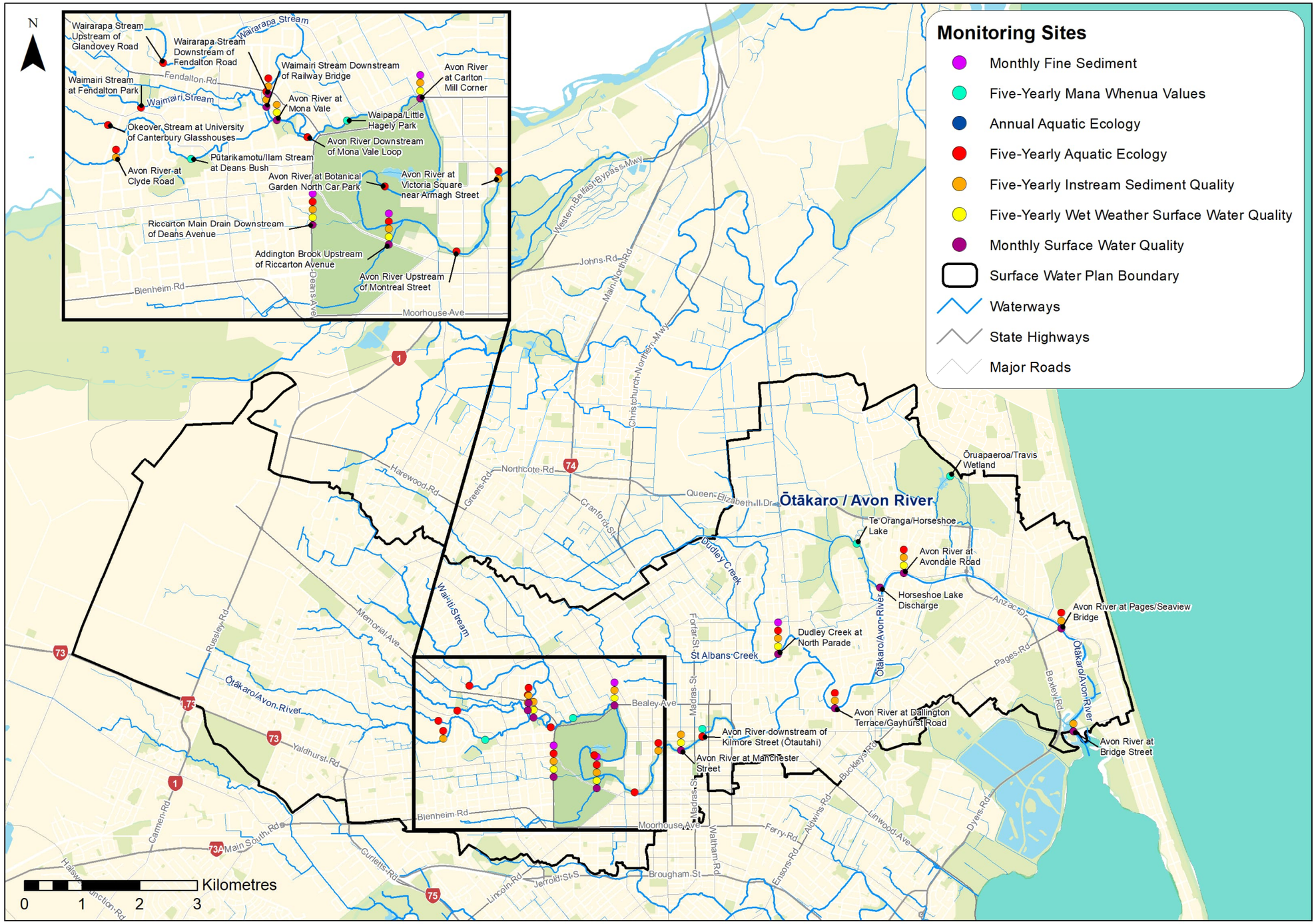

Figure 9 Location of surface water, instream sediment, aquatic ecology and mana whenua values monitoring sites in the Ōtākaro/ Avon River Stormwater Management area

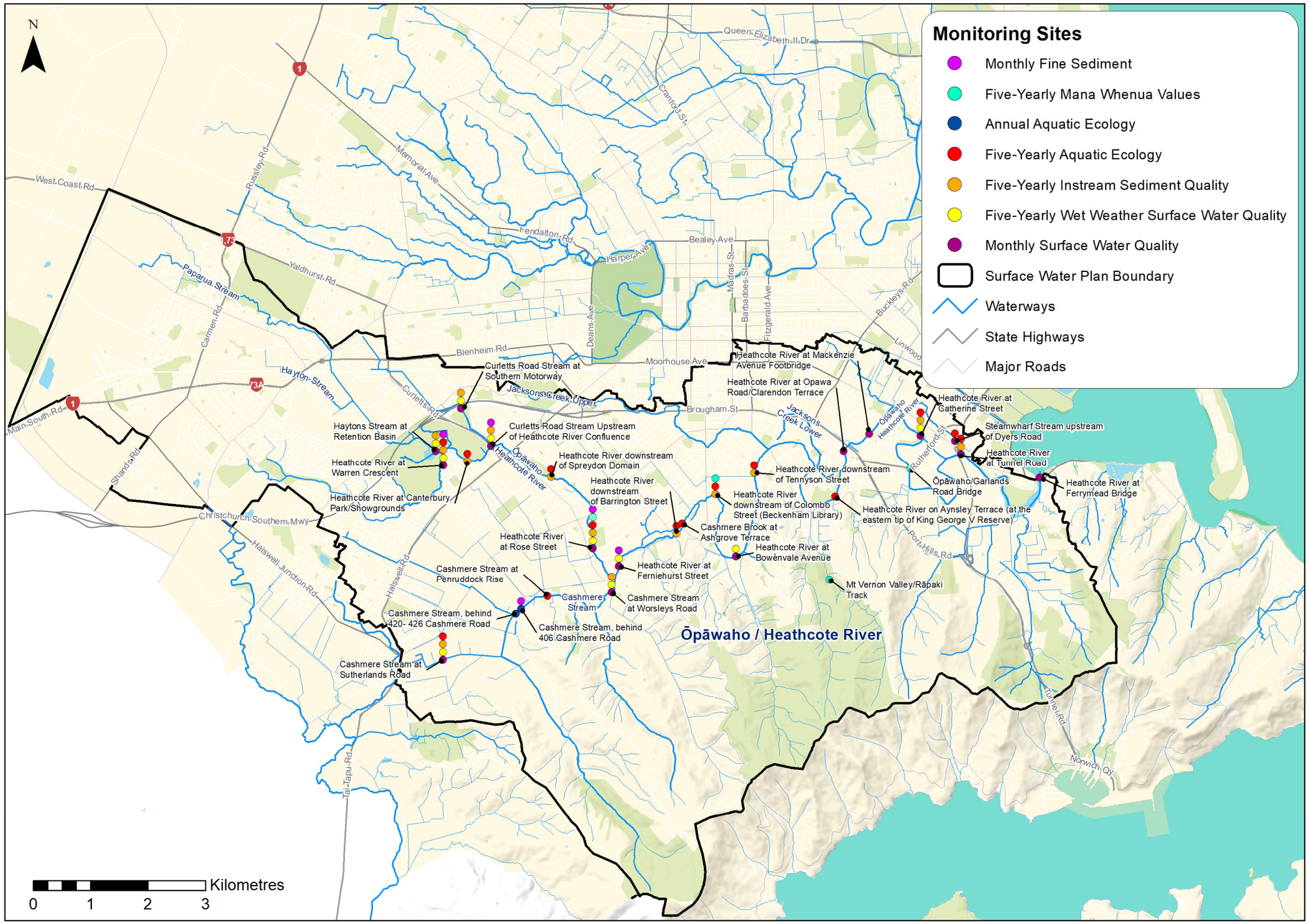

Figure 10 Location of surface water, instream sediment, aquatic ecology and mana whenua values monitoring sites in the Opāwaho/ Heathcote River Stormwater Management area

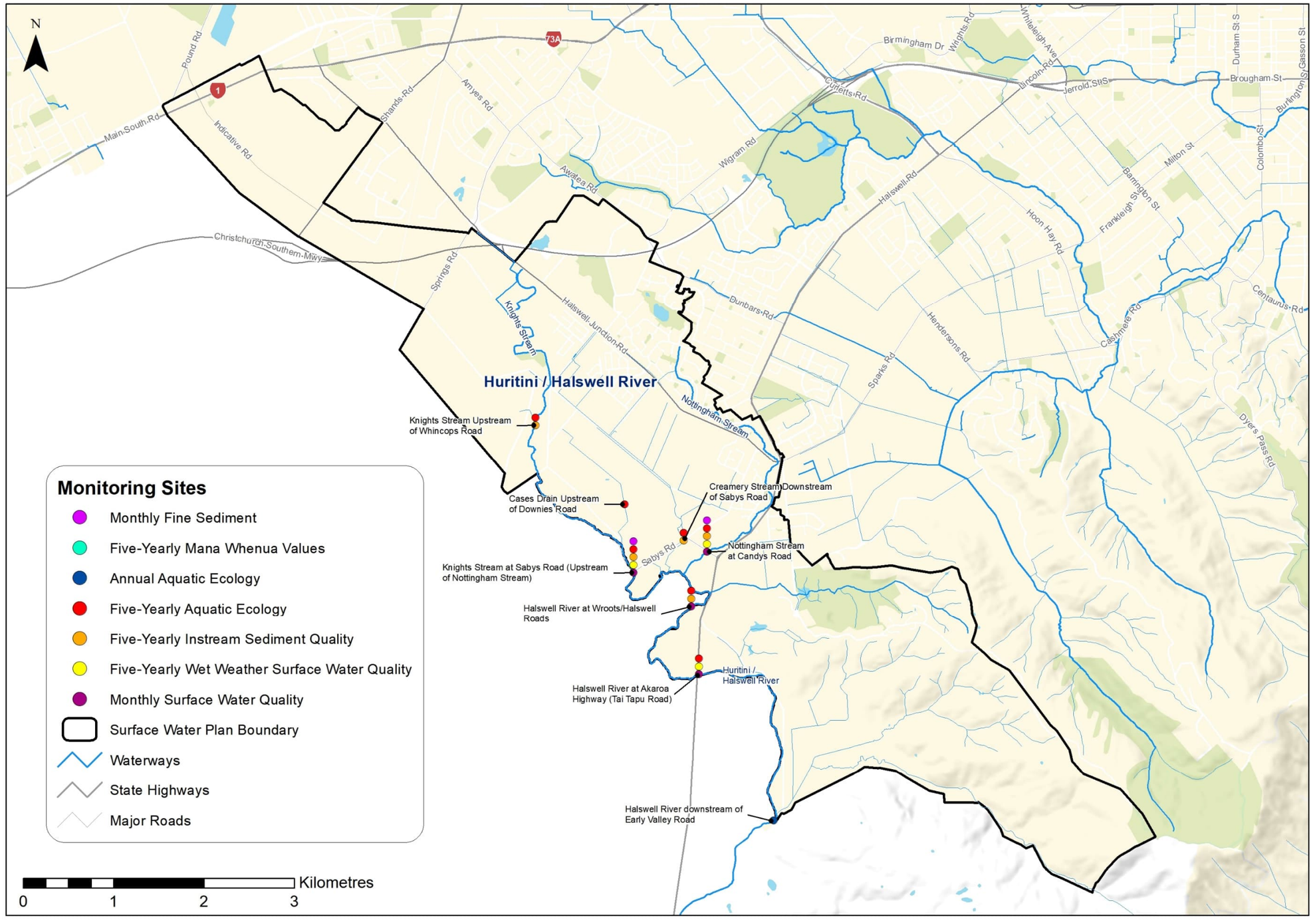

Figure 11 Location of surface water, instream sediment and aquatic ecology monitoring sites in the Huritini/ Halswell River Stormwater Management Plan area

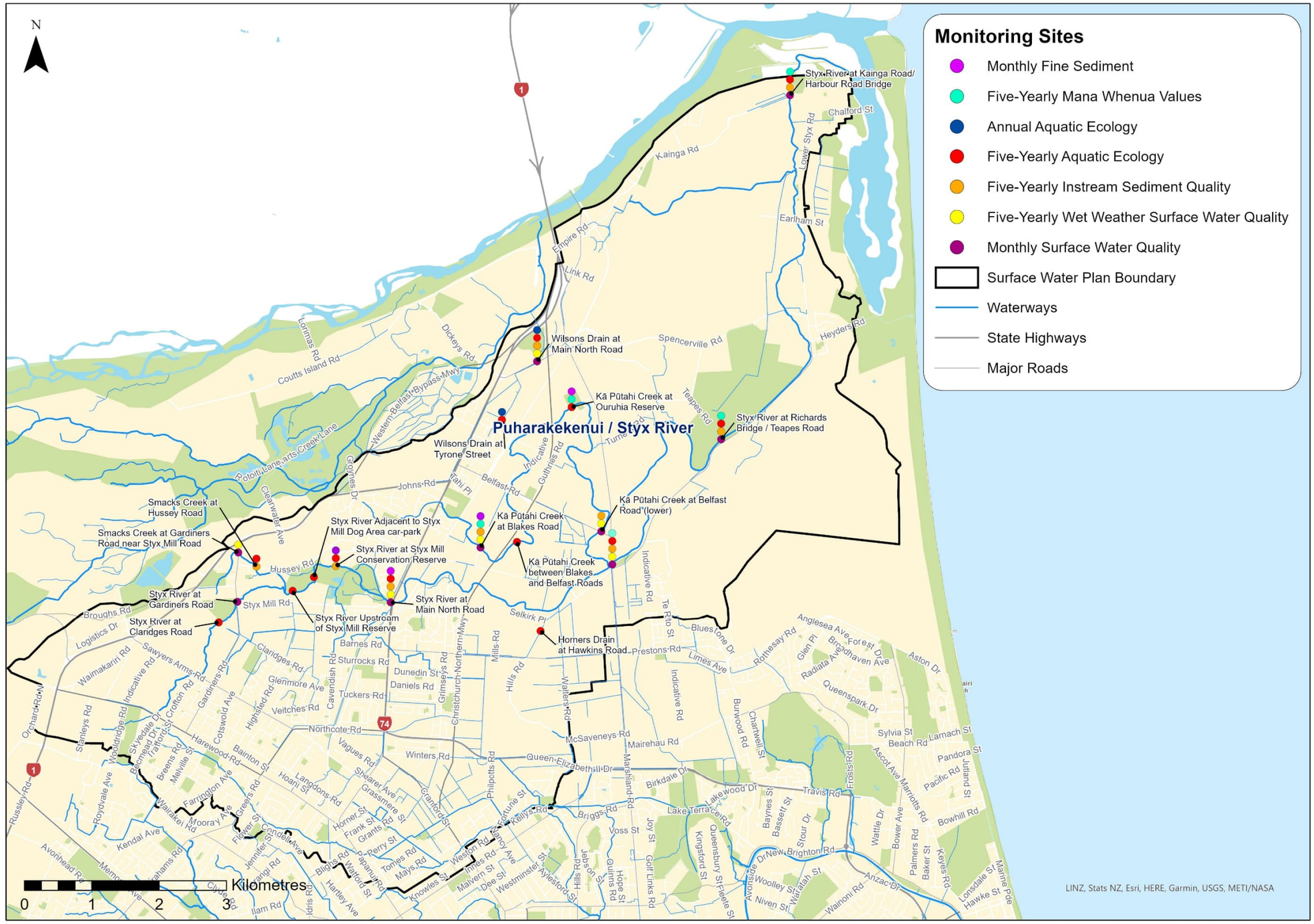

Figure 12 Location of surface water, instream sediment, aquatic ecology and mana whenua values monitoring sites in the Pūharakekenui/ Styx River Stormwater Management Plan area

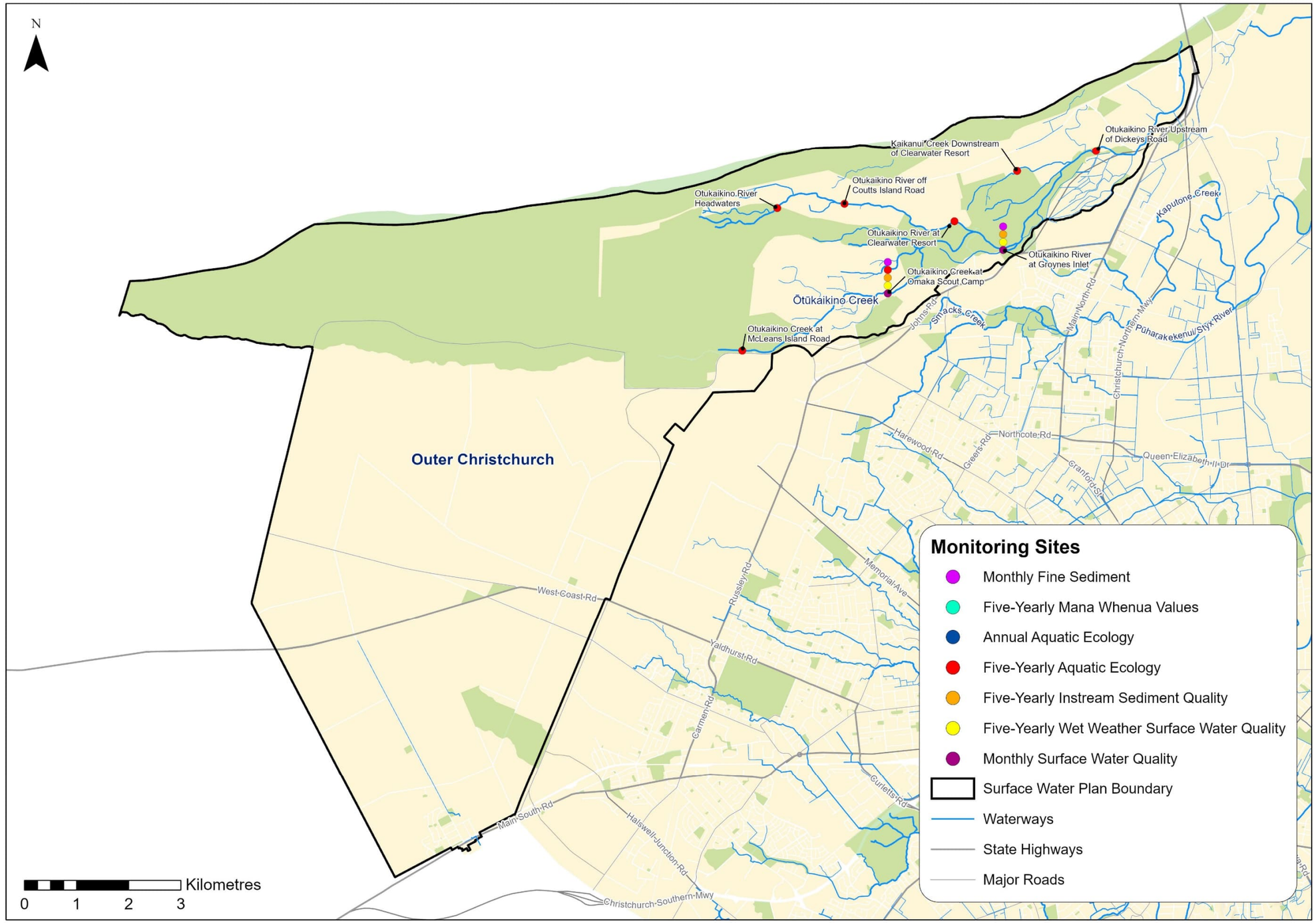

Figure 13 Location of surface water, instream sediment and aquatic ecology monitoring sites in the Outer Christchurch Stormwater Management Plan area

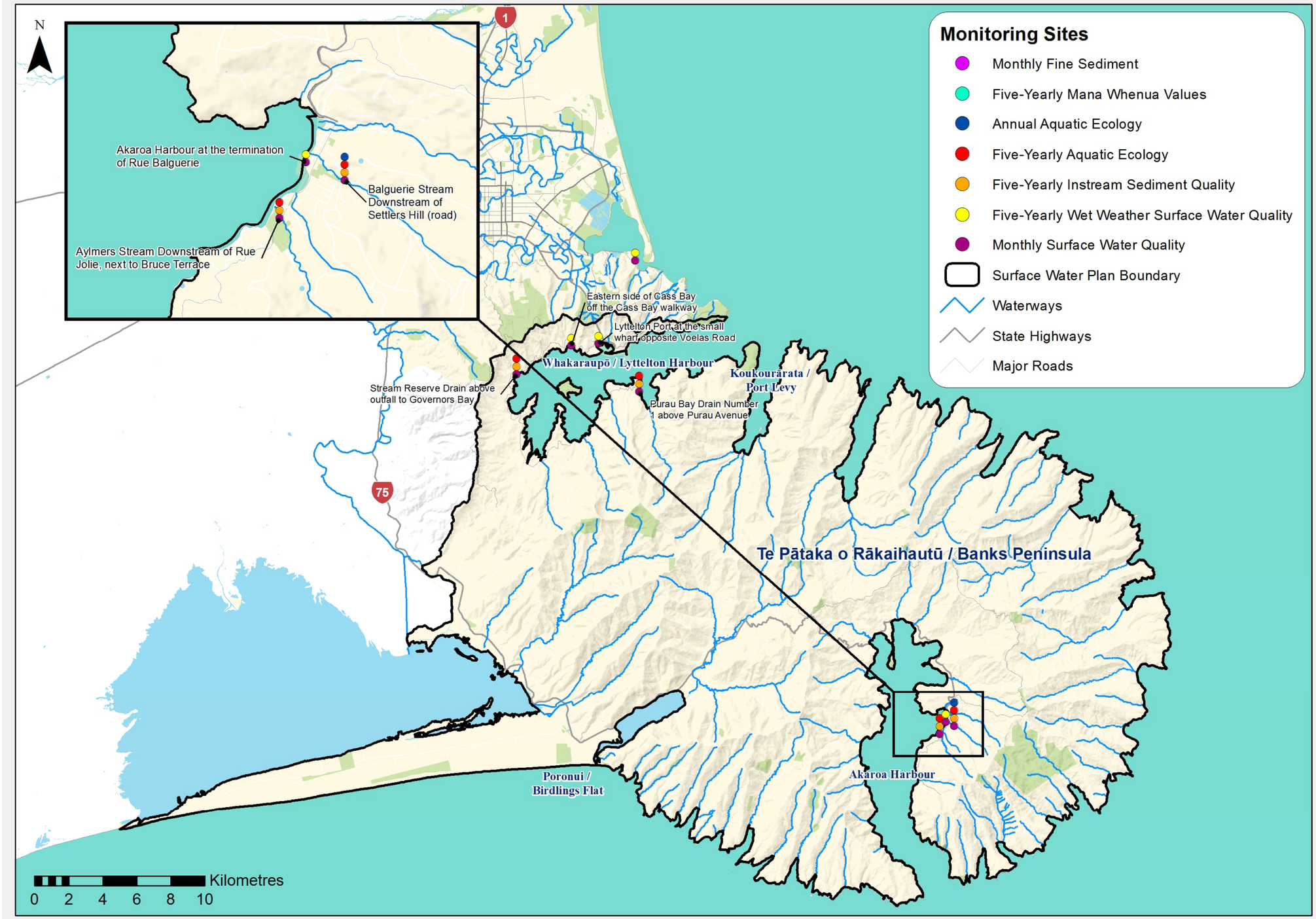

Figure 14 Location of surface water, instream sediment and aquatic ecology monitoring sites in the Banks Peninsula Stormwater Management Plan area

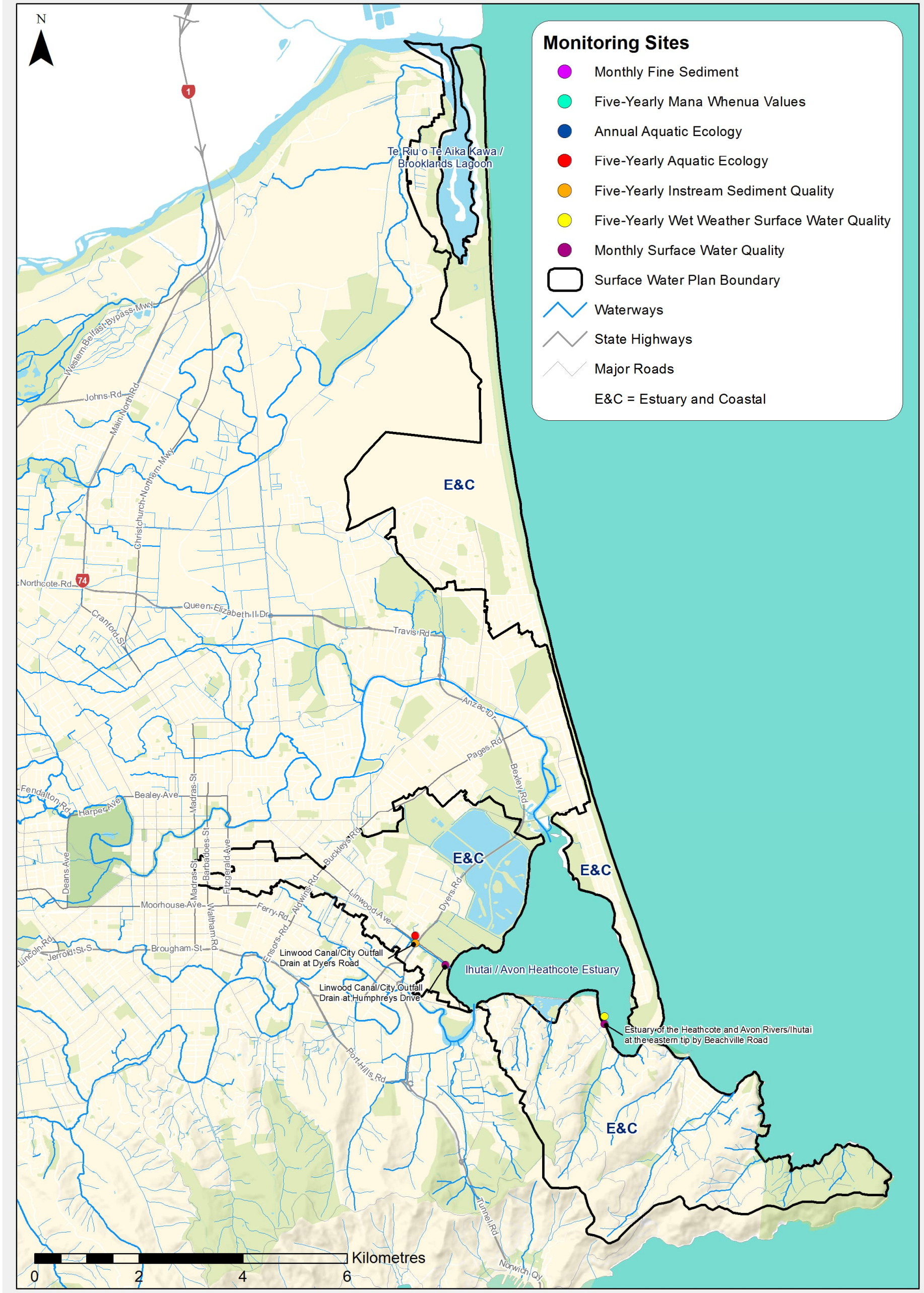

Figure 15 Location of surface water, instream sediment and aquatic ecology monitoring sites in the in the Estuary and Coastal Stormwater Management Plan area

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5.4 Methods

The sample collection and laboratory analysis methods detailed in this section are consistent with past sampling undertaken by the CCC (primarily for stormwater consenting requirements). Samples from tidal sites shall be taken during low tide, with sampling within catchments starting at the most downstream site. The exception to this is the Beachville Road Ihutai/ Avon-Heathcote Estuary site, which shall be sampled at high tide. Low tide times for Lyttelton and Akaroa sites shall be based on their respective harbour tide times, while tide times for the Ōtākaro/ Avon River, Opāwaho/ Heathcote River and the Ihutai/ Avon-Heathcote Estuary shall be considered to be one hour after the respective tide in Lyttelton Harbour. Monthly sampling will take place on a routine basis regardless of the weather, which will allow for some of those samples to be taken during rainfall events.

Samples of water from each site shall be collected and analysed as follows:

- Samples should be collected from an area most representative of the site and should be in approximately the same location each time sampling is undertaken;
- Samples may be collected in a bucket before transfer to an appropriate, correctly labelled bottle, provided the bucket is rinsed twice beforehand with water from the site;
- Bottles (and lids) that do not have preservative should be rinsed with a small amount of water from the site immediately prior to sample collection and the rinsate discarded away from the sampling site; any bottles with preservative in them must not be rinsed, nor filled to overflowing as the preservative will be lost;
- Never allow the inner surface of a sample container or lid to be contacted by any material other than the sample water;
- Samples shall be dispatched in bottles prepared by an International Accreditation New Zealand (IANZ) accredited laboratory[2] and as such will follow a Quality Assurance Plan; samples shall be immediately stored on ice and delivered to the laboratory within 24 hours, and a completed chain of custody form shall accompany all samples;
- At each site, *in situ* measurements of conductivity/salinity, temperature and dissolved oxygen shall be recorded at the same representative location as water samples were taken;
- The occurrence of rainfall at the time of sampling and within the 24-hours previous should be recorded, with rain defined as stormwater being seen flowing along gutters or out of stormwater pipes; and

[2] The Christchurch City Council Laboratory is an IANZ accredited laboratory and currently undertakes the analyses

- Samples shall be analysed for the parameters in Table 3 by an IANZ accredited laboratory; detection limits for each parameter shall be suitable to enable comparison of the results with relevant guidelines for reporting purposes.

Hardness will also be monitored across each waterway site every five years, to review the appropriateness of the hardness modified guideline values (i.e. lead and zinc) for each catchment. The first review will be undertaken in 2020. During this review, each site will be monitored three times throughout the monitoring year, to establish these hardness values. Values will be calculated in the same manner as that detailed in Appendix C, using the algorithms in the ANZECC (2000) guidelines. There is the potential that the guideline modifiers will change in the future and this assessment will be adapted to meet these new requirements.

The parameters to be tested were chosen specifically due to the following potential effects on instream biota, determined by whether the following guidelines are being met, as detailed in Table 3:

- 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 lead and zinc in freshwater, and therefore the risk of adverse biological effects, alters depending on several abiotic factors. These factors include, but are not limited to, organic carbon, hardness, pH, temperature, alkalinity and inorganic ligands (Warne *et al*., 2018). The LWRP refers to default ANZG (2022) guidelines for metals. However, current recommendations are to modify these default guideline levels by water hardness (ANZG, 2022; Warne *et al*., 2018). As such, CCC has recently updated the Hardness Modified Guideline Values (HMGV) for dissolved lead and zinc, in accordance with ANZG (2022) and Warne *et al*., (2018) (see Appendix C). In contrast to ANZECC (2000), it is no longer recommended to modify the default copper guideline by water hardness (ANZG, 2022; Warne *et al*., 2018). Values for Banks Peninsula sites will be calculated after the initial year of monitoring, based on the same ANZG (2022) methodology, or any other relevant methodology should these requirements change. For coastal sites, the ANZG (2022) guidelines detail values of 0.0013 mg/L for copper, 0.0044 mg/L for lead, and 0.008 mg/L for zinc.
- *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. 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). The guidelines in the Land and Water Regional Plan (LWRP; Environment Canterbury, 2015) for all waterways are a lower limit of 6.5 and an upper limit of 8.5. The ANZECC (2000) guidelines have a guideline value for estuaries of 7.0 - 8.5.

- *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 in waterways 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 2013). They instead consider that analysis of trends is more useful. There are no New Zealand guidelines for conductivity in coastal environments and it is more relevant to measure salinity in any case. There are no guidelines for salinity either.
- 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). The LWRP details in Rule 5.95 standards for TSS in stormwater prior to discharge, but does not detail specifically a guideline value within waterways (Environment Canterbury, 2018). The WRRP also does not detail a guideline level. A guideline level of 25 mg/L is considered an appropriate threshold to prevent detrimental effects on biota (Hayward et al., 2009; Stevenson et al., 2010) and is therefore used in this report. There are no New Zealand guidelines for coastal environments.
- *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 LWRP. ANZG (2022) provides a guideline of 1.3 Nephelometric Turbidity Units (NTU) for Cool Dry Low-elevation rivers and ANZECC (2000) provides a value of <10 NTU for coastal environments. Turbidity has historically been analysed at the laboratory using NTU, but since December 2020 has been analysed using Formazin Nephelometric Units (FNU), in accordance with the requirements of the National Environmental Monitoring Standards (NEMS, 2019). Turbidity NTU values prior to December 2020 have been converted to FNU at the catchment scale, using a conversion factor calculated from 12 months of concurrent testing of both methods (NEMS, 2019).

However, the NTU guideline values are still used for direct comparsion against this FNU data (i.e., guidelines of 5.6 FNU for lowland rivers and <10 FNU for coastal environments) (Michele Stevenson, ECan, personal communication, May 2021).

- *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 LWRP details a minimum DO level of 70% for 'spring-fed – plains' and 'spring-fed – plains – urban' waterways, and 90% for Banks Peninsula waterways. The RCEP (2012) guidelines are a minimum of 80 % DO for the selected coastal sample locations.
- 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 LWRP water quality standard for waterway temperatures is a maximum of 20°C; the RCEP (2012) details a maximum of 25°C for the coastal sites, with no more than a 3°C change as a result of discharge of contaminant or water.
- *Biochemical Oxygen Demand* (BOD5) 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 LWRP does not have a guideline level for this parameter. The Ministry for the Environment (1992) and RCEP (2012) guideline level is 2 mg/L, although this is for filtered samples and samples are currently tested for total levels, so comparisions to the guideline will be conservative.
- *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 LWRP 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, 2015). The water quality standard for this monitoring shall be adjusted based on the median pH levels for the relevant catchments. The exception to this is for Banks Peninsula waterways which have a set guideline value regardless of pH (0.32 mg/L; Environment Canterbury, 2015). Ammonical nitrogen is not required to be sampled at coastal sites.
- *Nitrate* can also be toxic to stream biota and specific guidelines for this parameter have recently been developed to protect freshwater species (Hickey, 2013). Guidelines are available for different species protection levels: 99% (pristine environment with high biodiversity and conservation values), 95% (environments which are subject to a range of disturbances from human activities, but with minor effects), 90% (environments which have naturally seasonally elevated concentrations for significant periods of the

year (1-3 months)), 80% (environments which are measurably degraded and which have seasonally elevated concentrations for significant periods of the year (1-3 months)), and acute (environments which are significantly degraded; probable chronic effects on multiple species). Based on these descriptions and the predominantly urban nature of the waterways monitored, most of the waterways would fall under the 80% to acute species description (i.e. Ōtākaro/ Avon, Opāwaho/ Heathcote and Huritini/ Halswell River catchments). However, the Pūharakekenui/ Styx and Ōtūkaikino River catchments (and Cashmere Stream) likely fall under the 90% species protection. To be conservative, the 90% species protection shall be used as the guideline level for all waterways. 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). Nitrate is not required to be sampled at coastal sites.

- *Dissolved Inorganic Nitrogen* (DIN), which is the sum of ammonia, nitrite and nitrate, provides a measure of the risk of eutrophication and toxicity (Environment Canterbury, 2015). The LWRP details a value of 1.5 mg/L for 'spring-fed – plains' and 'spring-fed – plains – urban' waterways, and 0.09 mg/L for Banks Peninsula waterways. DIN is not required to be sampled at coastal sites.
- *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 guideline levels in the LWRP for 'spring-fed - plains' and 'spring-fed – plains – urban' waterways are 0.016 mg/L, and 0.025 mg/L for Banks Peninsula waterways. DRP is not required to be sampled at coastal sites.
- *Escherichia coli* is a bacterium that is commonly used as an indicator of faecal contamination in freshwater and therefore health risk from contact recreation (Ministry for the Environment, 2003). The guideline level in the LWRP for 'spring-fed – plains', 'spring-fed – plains – urban' and Banks Peninsula waterways is 550 *E. coli* per 100ml (for 95% of samples). There are no New Zealand guidelines for coastal environments.
- *Enterococci* is a faecal streptococci bacterium that is used as an indicator of faecal contamination in saline environments and therefore health risk from contact recreation (Ministry for the Environment, 2003). This parameter is not relevant to non-tidal waterway sites, only tidal waterway and coastal sites. There are guideline levels for coastal sites in the RCEP, but these are considered difficult to measure, with the requirement for running medians not to exceed certain values, as well as maximum values for any given sample. These guidelines are also only in relation to some of the site classifications and only during the summer months. Instead, enterococci shall be compared against the Ministry for the Environment (2013) guidelines, with more

stringent levels adopted for those sites where contact recreation is more likely to occur (Cass Bay and Akaroa Harbour; 200 CFU/100 ml), compared to those were contact recreation is less likely to occur (500 CFU/100 ml).

- *Faecal coliforms* are also to be monitored in surface water at the Akaroa coastal site, to allow comparisions to the Ministry for the Environment (2003) guidelines for shellfish consumption.

5.5 Reporting

The annual monitoring report for the consent shall include a report on the water quality monitoring undertaken during the previous calendar year (monthly and five-yearly wet weather). This report shall include:

- An assessment of parameter concentrations at each site against the most relevant guideline levels (Table 3), where available, to determine likely effects on the receiving environment due to water quality. For the monthly data this shall include;
    - A three-year rolling dataset for all parameters
    - Additionally for TSS, copper, lead and zinc, data for the monitoring year alone, to allow an assessment of whether responses to monitoring will be triggered (i.e., the three-year rolling dataset will not be used for this compliance assessment)
- For the strongly salinity affected tidal waterway sites (Avon River at Bridge Street Bridge, Heathcote River at Tunnel Road, Heathcote River at Ferrymead Bridge and Linwood Canal), coastal guidelines shall be used instead of waterway guidelines for dissolved metals, conductivity, turbidity and TSS, and enterococci not *E. coli* shall be assessed;
- Spatial comparisons of concentrations within and across catchments;
- For the monthly data, statistical temporal trends analyses against historical data to determine whether water quality is remaining stable, improving or declining, using Time Trends or other robust method;
    - A minimum of three years is required before trends analysis can be undertaken in Time Trends (NIWA, 2014) and the statistical level of significance for this analysis shall be 5% (i.e. $p \leq 0.05$)
    - Trends analyses shall be conducted on data collected since the beginning of the dataset (typically 2007)
- For the monthly data, an assessment as to whether the Receiving Environment Objectives and Attribute Target Levels relating to surface water quality (TSS, copper, lead and zinc), as specified in Schedules 7 (Waterways) and 8 (Coastal Waters) of the consent conditions, are being met. In accordance with Schedule 8 of the CSNDC,

metals shall not be assessed against the Attribute Target Levels at the Lyttelton Port site;

- For the wet weather monitoring, an assessment of rainfall levels at the time of sampling and whether the events concincide with the First Flush of stormwater;
- A discussion of likely reasons for any poor or declining water quality (i.e. whether there is the potential this could be due to stormwater inputs);
- A discussion of contaminants of concern and sites/catchments with poor values that should be considered as priority areas for stormwater management; and
- Sites not meeting the required Attribute Target Levels, shall trigger the further investigations detailed in the consent conditions.

Table 3. Parameters to be analysed in surface water samples and the corresponding guideline levels. Guidelines should be compared to median levels from one calendar year of monitoring, unless otherwise indicated. ANZG = Australian and New Zealand Guidelines for Fresh and Marine Water Quality; HMGV = Hardness Modified Guideline Value; RCEP = Regional Coastal Environment Plan; LWRP = Land and Water Regional Plan; ANZECC = Australia and New Zealand Environment and Conservation Council.

Parameter	Waterway Guideline Level	Coastal Guideline Level
Dissolved copper	ANZG (2022) (95th percentile, not medians): • Ōtākaro / Avon and Opāwaho/ Heathcote River catchments (90% species protection: ≤0.0018 mg/L • Huritini/ Halswell, Pūharakekenui/ Styx and Ōtūkaikino River catchments (95% species protection): ≤0.0014 mg/L • Cashmere Stream and Banks Peninsula waterways (99% species protection): ≤0.001 mg/L	ANZG (2022) (95th percentile, not medians): • ≤0.0013 mg/L
Dissolved lead	ANZG (2022) HMGV (95th percentile, not medians): • Ōtākaro/ Avon River catchment (90% species protection): ≤0.01539 mg/L • Opāwaho/ Heathcote River catchment (90% species protection): ≤0.02388 mg/L • Cashmere Stream (99% species protection): ≤0.00427 mg/L • Huritini/ Halswell River catchment (95% species protection): ≤0.01089 mg/L • Pūharakekenui/ Styx River catchment (95% species protection): ≤0.00601 mg/L • Ōtūkaikino River catchment (95% species protection): ≤0.00414 mg/L • Stream Reserve Drain & Aylmers Stream (Banks Peninsula): ≤0.00293 mg/L • Balguerie Stream (Banks Peninsula): ≤0.00254mg/L	ANZG (2022) (95th percentile, not medians): • ≤0.0044 mg/L
Dissolved zinc	ANZG (2022) HMGV (95th percentile, not medians): • Ōtākaro/ Avon River catchment (90% species protection): ≤0.02951 mg/L • Opāwaho/ Heathcote River catchment (90% species protection): ≤0.0396 mg/L • Cashmere Stream (99% species protection: ≤0.00634 mg/L • Huritini/ Halswell River catchment (95% species protection): ≤0.01743 mg/L • Pūharakekenui/ Styx River catchment (95% species protection): ≤0.01172 mg/L • Ōtūkaikino River catchment (95% species protection): ≤0.00912 mg/L • Stream Reserve Drain & Aylmers Stream (Banks Peninsula): ≤0.00135 mg/L • Balguerie Stream (Banks Peninsula): ≤0.00109 mg/L	ANZG (2022) (95th percentile, not medians): • ≤0.008 mg/L
Total water hardness and Dissolved Organic Carbon (DOC)	No New Zealand guidelines currently exist; should they become available these will be used; this parameter is usually only relevant to determine the toxicity of other parameters such as metals	Not to be tested
pH	LWRP (Environment Canterbury, 2015): • All waterways: 6.5 - 8.5	ANZECC (2000)[3]: • 7.0 - 8.5
Conductivity	No New Zealand guidelines currently exist; should they become available these will be used	No New Zealand guidelines currently exist; should they become available these will be used
Salinity[4]	No New Zealand guidelines currently exist, should they become available these will be used	No New Zealand guidelines currently exist, should they become available these will be used
Total Suspended Solids (TSS)	Hayward et al., 2009; Stevenson et al., 2010: • All waterways: ≤25 mg/L	No New Zealand guidelines currently exist; should they become available these will be used
Turbidity	ANZECC (2000): • All waterways: ≤5.6 NTU	ANZECC (2000)[3]: • ≤10 NTU
Dissolved Oxygen (DO)	LWRP (Environment Canterbury, 2015): • 'Spring-fed – plains – urban' and 'spring-fed – plains waterways:' ≥70 % • Banks Peninsula waterways: ≥90	RCEP (Environment Canterbury, 2012): • ≥ 80 %
Water temperature	LWRP (Environment Canterbury, 2015): • All waterways: ≤20ºC	RCEP (Environment Canterbury, 2012): • ≤25°C

[3] These values are from the ANZECC (2000) guidelines for estuaries of South-East Australia; the guidelines recommend these values are used for New Zealand while no other guidelines are available, but they should be used with caution due to the differing ecosystems between countries and replaced with national guidelines should they become available

[4] Salinity and enterococci are to be tested at the salinity affected waterway sites (Avon River at Bridge Street Bridge, Heathcote River at Tunnel Road, Heathcote River at Ferrymead Bridge, Steamwharf Stream upstream of Dyers Road, Styx River at Harbour Bridge and Linwood Canal) and all coastal sites

Parameter	Waterway Guideline Level	Coastal Guideline Level
Biochemical Oxygen Demand (BOD_5)	Ministry for the Environment (1992): • All waterways: ≤2 mg/L	RCEP, excluding The Operational Area of the Port of Lyttelton (Environment Canterbury, 2012): • ≤2 mg/L
Total ammonia (ammoniacal nitrogen)	LWRP (Environment Canterbury, 2015): • Banks Peninsula waterways: ≤0.32 mg/L • All other waterways: determined by median catchment pH, as per the LWRP	Not required to be sampled
Nitrate nitrogen	LWRP (Environment Canterbury, 2015): • Banks Peninsula waterways: Median: ≤1.0 mg/L; 95th percentile: ≤1.5 mg/L NPS-FM (2020): • Median: ≤2.4 mg/L; 95th percentile: ≤3.5 mg/L[5]	Not required to be sampled
Dissolved Inorganic Nitrogen (DIN)	LWRP (Environment Canterbury, 2015): • 'Spring-fed – plains – urban' and 'spring-fed – plains' waterways: ≤1.5 mg/L • Banks Peninsula waterways: ≤0.09 mg/L	Not required to be sampled
Nitrite nitrogen	No New Zealand guidelines currently exist; should they become available these will be used	Not required to be sampled
Dissolved Reactive Phosphorus (DRP)	LWRP (Environment Canterbury, 2015): • 'Spring-fed – plains – urban' and 'spring-fed – plains' waterways: ≤0.016 mg/L • Banks Peninsula waterways: ≤0.025 mg/L	Not required to be sampled
Escherichia coli[6]	LWRP (Environment Canterbury, 2015): • All waterways: ≤550 CFU/100ml (95th percentile, not medians)	No New Zealand guidelines currently exist; only tested at Ihutai/ Avon-Heathcote Estuary, as enterococci more relevant at the other coastal sites
Enterococci[4]	Ministry for the Environment (2013): • At all measured sites: ≤500 CFU/100 ml (95th percentile, not medians)	Ministry for the Environment (2013)[7]: • Ihutai/ Avon-Heathcote Estuary, Cass Bay and Akaroa Harbour: ≤200 CFU/100 ml (95th percentile, not medians) • Lyttelton Harbour: ≤500 CFU/100 ml (95th percentile, not medians)
Faecal coliforms	Not relevant to waterway sites	Ministry for the Environment (2013): • Akaroa Harbour: 14/100 mL (median) and 43/100 mL (not exceeded in more than 10% of samples) This parameter is not required to be measured at the remaining coastal sites

[5] National bottom line – to be used for all waterway sites, except those in Banks Peninsula

[6] Not to be tested in Lyttelton Harbour, Cass Bay or Akaroa Harbour, as enterococci is more relevant to these saline environments

[7] These values are more stringent for coastal areas where swimming is likely to occur

6 Instream Sediment Quality

6.1 Purpose for monitoring under this consent

The purpose of this monitoring is to (1) measure whether stormwater discharges are causing adverse effects on instream sediment, (2) determine compliance with the conditions of the consent, (3) inform stormwater mitigation and (4) inform management of waterway health. This monitoring is of a range of parameters typically present in stormwater.

6.2 Background

The quality of sediment within Christchurch waterways has been analysed on one-off occasions a number of times since the inception of the CCC and the former Christchurch Drainage Board. This new monitoring programme again builds on this past monitoring, by monitoring additional sites on a more regular basis.

6.3 Sampling Sites and Frequency

Waterway sediments shall be sampled at 45 sites from Christchurch's main river catchments and four sites from Banks Peninsula (Figures 9 to 15; Appendix B). The year of sampling is to coincide with the five-yearly catchment rotation for wet weather water quality and aquatic ecology monitoring (Appendix D).

6.4 Methods

The methods detailed in this section are similar to those previously used in sediment surveys around Christchurch (e.g. Kingett Mitchell, 2005; Golder Associates, 2009; Golder Associates, 2012b; Gadd & Sykes 2014).

Samples are to be collected and analysed in the following manner:

- Samples should be collected following a period of at least three days of dry weather, to ensure that sediments are settled and fine surface sediments have not been removed by high flows;
- Sediment samples should be collected from the surface at a depth of no greater than 3 centimetres of sediment, which reflects the most recently accumulated sediment;
- Sampling methods should be employed with the aim of ensuring capture of sufficient fine material (< 2 millimetres) for laboratory analyses;

- Samples are to be collected by making multiple sweeps with a container across the stream bed to collect at least 5 subsamples, which are then composited into one sample;
- Three composite samples shall be collected at each site;
- Water shall be drained off directly from the sample container or using a mesh sieve of less than 2 µm in size;
- Following sample collection at each site, all equipment must be washed thoroughly with water to remove all visible sediment, then rinsed with acid (10% HCl) to remove any metals adsorbed to the sampler and then rinsed thoroughly to remove all acid (Burton & Pitt 2002);
- Samples shall be placed in a chilly bin containing pre-chilled ice-bricks;
- Samples shall be transported to an IANZ accredited laboratory within 24 hours; any samples stored overnight shall be chilled in a refrigerator;
- A completed chain of custody form shall accompany all samples;
- Samples shall be analysed for the parameters listed in Table 4, using the most relevant USEPA methods (< 2 millimetres fraction to be used for analysis); detection limits for each parameter shall be suitable to enable comparison of the results with relevant guidelines for reporting purposes; and
- Polycyclic Aromatic Hydrocarbons should be normalised by 1% Total Organic Carbon in accordance with the relevant guideline methodology.

Table 4. Parameters to be analysed in waterway sediment samples

Parameter	Units of Measurement
Particle size distribution	-
Total recoverable copper, lead and zinc	mg/kg dry weight
Total Organic Carbon (TOC)	mg/kg dry weight
Total Phosphorus	mg/kg dry weight
Total Polycyclic Aromatic Hydrocarbons (PAHs)	mg/kg dry weight

6.5 Reporting

The annual monitoring report for the consent shall include a report on the instream sediment quality monitoring undertaken during the previous calendar year. This report shall include:

- An assessment of parameter concentrations at each site against the most relevant available guideline levels, such as ANZECC (ANZECC, 2000; Simpson et al., 2013) to determine likely effects on the receiving environment due to sediment quality;
- Spatial comparisons of concentrations within and across catchments;
- Comparisons to historical data (using statistics where possible) to determine whether sediment quality is remaining stable, improving or declining;
- An assessment as to whether the Receiving Environment Objectives and Attribute Target Levels relating to sediment quality, as specified in Schedule 7 (Waterways) of of the consent conditions, are being met;
- A discussion of likely reasons for any poor or declining sediment quality (i.e. whether there is the potential this could be due to stormwater inputs); and
- A discussion of contaminants of concern and sites/catchments with poor values that should be considered as priority areas for stormwater management.

7 Aquatic Ecology

7.1 Purpose for monitoring under this consent

The purpose of this monitoring is to (1) measure aquatic ecology values, which in part can be affected by stormwater discharges, (2) determine compliance with the conditions of the consent, (3) inform stormwater mitigation and (4) inform management of waterway health. This monitoring covers general state of environment monitoring, so it is not possible to deduce specific effects of stormwater discharges.

7.2 Background

The aquatic ecology of Christchurch's five main river catchments (Ōtākaro/ Avon River, Opāwaho/ Heathcote River, Huritini/ Halswell River, Pūharakekenui/ Styx River and Ōtūkaikino River) have been assessed by the CCC/Christchurch Drainage Board on one-off occasions during a number of events historically, but also more recently on a regular five-yearly catchment rotation basis. Banks Peninsula has recently been monitored as a one-off event for the drafting of the District Plan Sites of Ecological Significance. This new monitoring programme includes many of these past sites, as well as additional sites and receiving environments. These sites are typically distributed throughout the catchment and are not focussed on sites of high or low ecological value specifically. Sites within Banks Peninsula are only located within the stormwater management areas being authorised by the comprehensive discharge consent (i.e. within settlement areas).

7.3 Sampling Sites and Frequency

7.3.1 Monthly Fine Sediment Monitoring

A total of 17 sites within the waterways and coastal areas of Christchurch shall be monitored monthly (Figures 9 to 15; Appendix B). These sites have been included because they are waterways within the five main river catchments of Christchurch (Ōtākaro/ Avon River, Opāwaho/ Heathcote River, Huritini/ Halswell River, Pūharakekenui/ Styx River and Ōtūkaikino River) that are considered to be sensitive and/or influenced by stormwater. The location of one site is yet to be determined (OTUKAI07). Non-wadeable sites have been excluded due to the difficulties in sampling this environment and because these sites can naturally be soft-bottomed; it is noted that this metric is excluded for non-wadeable sites in the LWRP.

7.3.2 Annual Aquatic Ecology Monitoring

Four sites (two in Cashmere Stream and two in Wilsons Drain) will be monitored annually for a number of aquatic ecology parameters (Figures 10 and 13; Appendix B). These annual monitoring sites are within waterways of high value compared to the other waterways being

monitored, and/or potentially influenced by stormwater inputs from adjacent subdivisions. These sites are intended to be reviewed and relocated throughout the duration of the consent where necessary, depending on changes in stormwater inputs throughout the catchments. Ideally the sites will be monitored prior to development, to allow pre- and post-development comparisons).

7.3.3 Five-Yearly Aquatic Ecology Monitoring

Aquatic ecology surveys at 61 waterway sites in Christchurch and four in Banks Peninsula shall be carried out on a five-yearly catchment rotation basis (Figures 9 to 15; Appendix B). These surveys will be undertaken during the same season and year as the wet weather water quality and sediment quality monitoring (Appendix D).

7.4 Methods

7.4.1 Monthly Fine Sediment Monitoring

Fine sediment cover (< 2 mm; i.e. silt/sand) of the streambed shall be estimated monthly at each site. The sampling method to be used is adapted from (a) methods used by ECan (Rachel Webster, ECan, personal communication, August 2015) and (b) Sediment Assessment Method 2 from Clapcott *et al* (2011). These methods have been adapted to allow a relatively semi-quantitative assessment of each reach, without having to undertake lengthy, and therefore costly, investigations.

Fine sediment cover shall be assessed using the following method:

- The reach to be assessed shall be 30 metres in length where available, with the reach starting at the downstream coordinate for the site and continuing upstream from that point;
- The upstream and downstream extents of each reach shall be marked to ensure consistency between monitoring events;
- The entire reach should be transversed and ten estimates taken of fine sediment (< 2 mm) percent cover, with these estimates taken at roughly equidistant points, where possible;
- A bathyscope shall be used to assess the percent cover of fine sediments;
- The ten estimates shall encompass all habitat types within the wetted margin of the reach (i.e. pools, runs, riffles, backwaters);
- Estimates shall consist of only visible cover, not assumed cover (e.g. not assumed sediment under macrophytes);

- Sediment that settles thickly on macrophytes and other substrates should be included in the estimate;
- Each estimate should be rounded to the nearest 5%, with 1% recorded if a small amount of sediment is present and 0% recorded if no sediment is present;
- The overall percent cover value for the site shall be the median of the ten assessments;
- Where possible, observations should be conducted by the same observer across each site and each month, to ensure consistency in the sometimes subjective percent cover assessments; and
- Should the visibility not be favourable at the time of the scheduled sampling, the site is not required to be revisited for that month.

7.4.2 Annual and Five-Yearly Aquatic Ecology Monitoring

As per previous surveys, monitoring will continue to be undertaken in March, to ensure no biases due to sampling during different seasons and this being the preferred time for ecological monitoring generally. Surveys will include assessments of habitat, periphyton, macrophytes, macroinvertebrates and fish, using similar methodology to that used in the past and the requirements of current stormwater consents. In the past, annual surveys have only involved the monitoring of invertebrates, but for this monitoring programme these surveys will include the full suite of parameters except fish (i.e. habitat, periphyton, macrophytes and macroinvertebrates).

7.4.3 Habitat, Periphyton and Macrophytes

At each site, an assessment of habitat, periphyton and macrophyte cover shall be carried out at either (a) each of three representative transects, or (b) as a site-wide assessment, as detailed in Table 5. The first transect shall be located at the downstream coordinates for the site and the following two transects located at 10m intervals upstream from this point (unless previous survey methodology deviates from this, in which case, transects shall be located in the same location as previous assessments). Representative photos shall also be taken at each site.

Table 5. Summary of habitat, macrophyte and periphyton data to be collected at aquatic ecology monitoring sites

Parameter	Characteristics	
Bank\riparian (for five metre width at each bank on each transect)	Bank material Bank height Surrounding land use Bank erosion Bank slope	Riparian vegetation Canopy cover Undercut banks Overhanging vegetation Ground cover vegetation
Instream (at five locations on each transect, including each bank and mid-channel)	Wetted width Water depth Fine sediment depth and % cover Embeddedness Substrate composition (modified from Harding *et al*, 2009) - Silt/sand (<2 mm) - Gravels (2-16 mm) - Pebbles (16-64 mm) - Small cobbles (64-128 mm) - Large cobbles (128-256 mm) - Boulders (256-4000 mm) - Bedrock/concrete/artificial hard surfaces (>4000 mm)	
Macrophytes (at five locations on each transect, including each bank and mid-channel)	Emergent macrophyte composition & % cover Total macrophyte composition & % cover Total macrophyte depth Species present and proportion of native versus exotic	
Periphyton (at five locations on each transect, including each bank and mid-channel)	Composition % cover (modified from Biggs & Kilroy, 2000) - Thin mat forming algae (<0.5 mm thick) - Medium mat forming algae (0.5 – 3 mm thick) - Thick mat forming algae (>3 mm thick) - Short filamentous algae (<20 mm long) - Long filamentous algae (>20 mm long)	
Organic matter (at five locations on each transect, including each bank and mid-channel)	% cover and type	
Water flow (at each transect)	Velocity (using a flow meter)	
Flow composition (site-wide assessment)	Still Backwater Pool Run	Riffle Rapid Cascade
Water permanence (site-wide assessment)	Ephemeral Intermittent	Perennial
Water chemistry (site-wide assessment)	Dissolved oxygen (%) Temperature (°C)	pH Conductivity (µS/cm)

7.4.4 Macroinvertebrates

The aquatic benthic invertebrate community shall be assessed using the following methodology:

- One kicknet sample shall be taken at each site (where sites are non-wadeable, the sample shall be taken from marginal sections only);
- Samples shall be collected using the semi-quantitative C1 (hard-bottomed streams) or C2 (soft-bottomed streams) protocols from Stark *et al* (2001);
- Samples shall be processed using Protocol P2 (200 Individual Fixed Count with scan for rare taxa) from Stark *et al* (2001);
- Taxa shall be identified to species level where possible; and
- The following invertebrate indices shall be calculated in accordance with Stark & Maxted (2007):
    - Total abundance
    - Taxa richness
    - Ephemeroptera-Plecoptera-Trichoptera (EPT) taxa richness and percent composition (% EPT)
    - Macroinvertebrate Community Index (MCI) and Quantitative MCI (QMCI)

7.4.5 Fish

Fish at each site shall be sampled using the following methodology (in general accordance with Joy *et al*, 2013):

- The fishing reach shall start at the downstream coordinate for the site and continue upstream until the desired fishing length/area is achieved;
- The fishing reach should be a minimum of 30 metres in length and 30m^2 in area;
- All habitat types within the reach should be sampled (i.e. pools, riffles, underhangs and backwaters);
- Wadeable sites shall be fished using a single pass with an electric fishing machine;
- Non-wadeable site shall be fished as follows:
    - A minimum of five Gee Minnow traps and two fyke nets shall be used
    - Gee Minnow traps shall be baited with marmite
    - Fyke nets are to be baited with chicken, liver or cat food
    - Fyke nets are to be set at a 15° – 30° angle to the bank, with the trailer upstream
- Fish shall be identified to species level where possible, counted, length measured and then released back into the waterway;
- Fish seen but not caught should be recorded as missed fish (e.g. 'missed bully' or 'missed fish' if identification cannot be certain), but not included in the total tally; and

- Fish abundance shall be standardised by Catch Per Unit Effort according to the methodology in Joy *et al* (2013). Electrofishing is considered an active fishing technique (CPUE = fish/m^2), and fyke nets and gee minnow traps are considered passive (i.e. use the soak time to calculate CPUE of fish/net/night).

7.5 Reporting

The annual monitoring report for the consent shall include a report on the aquatic ecology monitoring undertaken during the previous calendar year. This report shall include:

- An assessment at each site against the most relevant indices and guideline levels (i.e. macroinvertebrate indices), where available, to determine habitat quality and ecological values;
- Spatial comparisons of habitat quality and ecological values within and across catchments;
- Comparisons to historical data (using statistics where possible) to determine whether habitat quality and ecological values are remaining stable, improving or declining;
- An assessment as to whether the Receiving Environment Objectives and Attribute Target Levels relating to aquatic ecology (QMCI, fine sediment cover, and total macrophyte and filamentous algae cover), as specified in Schedule 7 (Waterways) of the consent conditions, are being met, using the following approach;
    - LWRP classifications ('spring-fed – plains – urban', 'spring-fed – plains' and 'Banks Peninsula') for each site, and therefore the relevant Attribute Target Level, shall be in accordance with that detailed in Appendix B
    - Fine sediment percent cover of the streambed shall be assessed using (a) monthly, (b) annual and (c) five-yearly data
    - QMCI, and total macrophyte and filamentous algae cover data shall be assessed using (a) annual and (b) five-yearly monitoring data
    - Monthly sediment cover data shall be assessed using Time Trends or other robust analyses:
        - Trends analyses shall be conducted on data collected since the beginning of the dataset
        - A minimum of three years is required before trends analysis can be undertaken in Time Trends (NIWA, 2014) and the statistical level of significance for this analysis shall be 5% (i.e. $p \leq 0.05$)
- A discussion of likely reasons for any poor or declining habitat quality and ecological values (i.e. whether there is the potential this could be due to stormwater inputs); and
- A discussion of contaminants of concern and sites/catchments with poor values that should be considered as priority areas for stormwater management.

8 Mana Whenua Values

8.1 Purpose for monitoring under this consent

The purpose of this monitoring is to (1) measure mana whenua values, which in part can be affected by stormwater discharges, (2) determine compliance with the conditions of the consent, (3) inform stormwater mitigation and (4) inform management of waterway health. This monitoring covers general state of environment monitoring, so it is not possible to deduce specific effects of stormwater discharges.

8.2 Background

Cultural monitoring under this consent is based on the methodology and sites of the State of the Takiwā. The State of the Takiwā monitoring system was developed by Te Rūnanga o Ngāi Tahu to facilitate tangata whenua to gather, store, analyse and report on information relevant to the cultural health of waterways within their takiwā (tribal areas). The major objective of State of the Takiwā is to enable tangata whenua to generate robust and defensible information on the health of the environment for a variety of purposes, including to inform recommendations for management (Pauling, 2004). The approach to data collection is a combination of field assessments measured against cultural criteria, and collection of supporting information on culturally relevant features of monitoring sites, including traditional use. The range of assessments attempts to capture key mana whenua values and indicators of environmental health, especially those important to mahinga kai (food gathering) and other cultural activities.

The following State of the Takiwā programmes have been undertaken within the Christchurch City Council jurisdiction:

- Ōtākaro and Ōpāwaho catchments in 2007 by Te Rūnanga o Ngāi Tahu, in-conjunction with members of Ngāi Tūāhuriri and Ngāti Wheke, for Environment Canterbury as part of the Healthy Estuary & Rivers of the City Monitoring Programme (Pauling *et al*, 2007);
- Ōtākaro and Ōpāwaho catchments in 2012 by Te Ngāi Tūāhuriri Rūnanga and Mahaanui Kurataiao Limited (MKT) (Lang *et al*, 2012); and
- Pūharakekenui in 2012 by Rūnanga roopu (monitoring team) in conjunction with MKT (Orchard & Lobb, 2013).

8.3 Sampling Sites and Frequency

Approximately 35 sites are to be sampled five-yearly in conjunction with the monitoring of surface water quality, instream sediment quality and aquatic ecology (Appendix D). The sites to be monitored are based on previous State of the Takiwā sites (Appendix B, Figures 9-10 and 12 and Table 6). Some of these sites overlap with other monitoring sites (e.g. instream sediment and aquatic ecology).

It is proposed to include an additional five sites each in waterways in the Huritini/ Halswell River, Ōtūkaikino River and Banks Peninsula, as well as a total of five coastal sites within Christchurch and Banks Peninsula. However, as State of the Takiwā assessments have predominantly not previously been undertaken in these catchments, these sites are yet to be confirmed. Two additional sites in the Heathcore will also be included, with the locations yet to be confirmed. The opportunity to overlap these additional sites with current ecological sites should be investigated, to ensure maximum collection of data, but it is acknowledged that none may overlap with areas of cultural importance and therefore new sites may be more appropriate. Site selection will be guided by MKT and Papatipu Rūnanga, and sites will be selected prior to the first scheduled monitoring of the relevant catchments.

Monitoring will be undertaken concurrently with the aquatic ecology surveys, during March, to ensure no biases due to sampling during different seasons and this being the preferred time for ecological monitoring generally.

Table 6. Summary of the sites to be monitored for mana whenua values and the reason for their importance. It is proposed to include two additional sites within the Opāwaho/ Heathcote River catchment, and five sites each in the Huritini/ Halswell River, Ōtūkaikino River and Banks Peninsula waterways, and five sites in total within coastal areas in Christchurch and Banks Peninsula. Site selection will be guided by Mahaanui Kurataiao Limited and Papatipu Rūnanga, and sites will be selected prior to the first scheduled monitoring of the relevant catchments. Sites are to be located in areas subjected to stormwater discharges from the reticulated network.

Site ID	Location Description	Cultural Importance
AVON14	Ōruapaeroa/Travis Wetland	Traditional settlement and food gathering site, significant urban/rural drainage sink and native/natural wetland remnant
AVON15	Te Oranga/Horseshoe Lake	Traditional settlement and food gathering site, significant urban drainage sink and native/natural wetland/spring remnant
AVON16	Ōtākaro/Avon River downstream of Kilmore Street	Traditional settlement and food gathering site
AVON20	Ōtākaro/Avon River at Waipapa/Little Hagley Park	Traditional settlement and food gathering site, upper most main channel site
AVON24	Pūtarikamotu/Ilam Stream at Deans Bush	Traditional settlement and food gathering site, remaining native forest remnant, protected reserve
HEATH18	Ōpāwaho/Heathcote River at Garlands Road Bridge	Traditional settlement and food gathering site
HEATH23	Ōpāwaho/Heathcote River downstream of Colombo Street	Mid-catchment reference
HEATH06	Ōpāwaho/Heathcote River at Rose Street	Significant recreational area – public pool, soccer and cricket, as well as site of Kura Kaupapa Māori
STYX08	Pūharakekenui/Styx River at Kainga Road/Harbour Road Bridge	To be clarified
STYX07	Pūharakekenui/Styx River at Richards Bridge/Teapes Road	To be clarified
STYX06	Pūharakekenui/Styx River at Marshland Road Bridge	To be clarified
STYX09	Kā Pūtahi Creek at Ouruhia Reserve	To be clarified
STYX04	Kā Pūtahi Creek at Blakes Road	To be clarified

8.4 Methods

A key part of this cultural monitoring is the involvement of tangata whenua in fieldwork and data collection. Monitoring will be carried out in conjunction with MKT and will involve Papatipu Rūnanga representatives in field work and data collection. Monitoring teams need to be mandated/selected by the appropriate Papatipu Rūnanga, and can be made up of representatives from multiple rūnanga, particularly where a shared boundary is involved. It may also involve the contracting of relevant expertise to assist in the monitoring. Monitoring team members will normally discuss the key features and issues of each monitoring site collectively, before filling out the relevant forms individually.

Monitoring will include three State of the Takiwā monitoring methods: (1) takiwā general site assessment (waterway and coastal sites), (2) Cultural Health Index (CHI) assessment (waterway sites only), and (3) Marine Cultural Health Index (MCHI) assessment (coastal sites only) (Tipa & Tierney, 2003; Pauling, 2004; Pauling *et al*, 2007; Lang *et al*, 2012; Schweikert *et al*, 2012; McCarthy *et al*, 2013). The details of these methods are outlined below. The fishing component of the waterway monitoring will be undertaken by the ecologists involved in the aquatic ecology surveys. Fishing will be undertaken at a time when the cultural assessments are being undertaken, so the cultural assessors can be involved in the process. Where sites do not overlap with ecological monitoring, fishing only will be undertaken and not the full suite of monitoring typically undertaken at the ecology sites. The results of the ecological monitoring for all sites within the catchment being surveyed will also be made available to the cultural assessors as soon as practicable after completion, as this information may also be useful and complimentary to their assessments. No fishing is proposed to be undertaken at the coastal sites, given the difficulties in obtaining a representative survey in these environments and that this does not appear to be a requirement for the MCHI.

Where previous monitoring has been undertaken (e.g., Ōtākaro, Ōpāwaho and Pūharakekenui) information on cultural association and historical state/species is not necessary to repeat. However, where this has not been done, monitoring will involve an initial step of working with rūnanga to complete this ahead of undertaking assessments.

Cultural monitoring will be undertaken on a five-yearly catchment rotation basis, as per the surface water, instream sediment and aquatic ecology monitoring. The timeframe for this is detailed in Appendix D.

8.3.1 Takiwā General Site Assessment

The Takiwā general site assessment consists of three forms. The Site Definition Form records the site name, locality, traditional significance and traditional condition of the site amongst other details. The Site Visit Form records information on aspects of the monitoring visit, including the date, time, weather conditions, heritage/archaeological details, land use and other relevant information. The General Site

Assessment Form includes questions addressing the health of the site in relation to the following categories:

- The amount of pressure from external factors;
- Levels of modification/change at the site;
- Suitability for harvesting of mahinga kai;
- Access issues;
- Willingness to return to the site;
- Overall state/health of the site; and
- Presence and abundance of culturally relevant species.

The information gathered from these forms is entered into the Takiwā 2.0 database and the index score for overall site health calculated. This index reflects the average score from nine individual assessments, all of which are a score on a one to five scale (Table 7).

8.3.2 Cultural Health Index Waterway Assessment

The Cultural Health Index (CHI) waterway assessment involves three aspects (Tipa & Tierney, 2003; Tipa & Tierney, 2006):

- Determination of whether site is of traditional or contemporary significance to Māori, assessed by the roopu based on feedback from whānau and kaumātua in particular;
- A mahinga kai assessment; and
- A cultural stream health assessment.

The mahinga kai and cultural stream health assessment consist of a series of questions to which scores of between 1 (poor quality/low values) and 5 (high quality/values) are assigned, and averaged to reflect the current condition of the site for these cultural aspects (Table 7).

8.3.3 Marine Cultural Health Index Assessment

The Marine Cultural Health Index was developed by Te Rūnanga o Ngāi Tahu in conjunction with the University of Otago (Schweikert *et al*, 2012) and provides an assessment tool that can be used in coastal sites to understand the ecological health of customary fishing areas and management. The MCHI toolkit is divided into four sections: (a) Key Cultural Indicators, (b) Habitat Threats & Quality Indicators, (c) Benchmark Questions and (d) Survey Results (Schweikert *et al*, 2012; McCarthy *et al*, 2013). The Key Cultural Indicators are scored on a 0 – 4 scale and include assessments of site contamination, the ability to get a feed, taste and condition of kai species, and replacement of kai (surveyors undertake this assessment on their most highly prized kai species). Assessments for Habitat Threats and Quality Indicators include water clarity, sedimentation, invasive species and presence of provision species. At the completion of the survey, data can be sent to Toitū Te Whenua for entry into

the Ngāi Tahu State of the Takiwā database, where overall site assessments are archived and analysed.

Table 7. Summary of assessment parameters under the two cultural monitoring methods

Method	Assessment	Criteria scored from 1- 5
Takiwā General Site Assessment		➢ Site human pressure ➢ Site modification ➢ Harvest access ➢ Willingness to harvest ➢ Willingness to return for cultural use ➢ Overall health of the site ➢ % cover of indigenous plants ➢ Current versus traditional number of species ➢ A score based on the Takiwā Abundance Index, which assesses all introduced and native species present (e.g. plants, birds and fish)
Cultural Health Waterway Assessment	Mahinga kai assessment	➢ Abundance of mahinga kai species present at the site in relation to traditional abundance ➢ Ease of access ➢ Whether or not Maori would return to use the site in the future
	Cultural stream health assessment	➢ Water clarity ➢ Flow ➢ Catchment land use ➢ Marginal vegetation ➢ Riverbed sediments ➢ Water quality ➢ Variety of habitats ➢ Impression of overall health

8.5 Reporting

The annual monitoring report for the consent shall include a report on the mana whenua values monitoring undertaken during the previous calendar year. This report shall include:

- A summary of the assessment scores and observations;
- Spatial comparisons within and across catchments;
- Temporal comparisons against previous studies, where available, to determine if values are remaining stable, improving or declining;
- An assessment of whether the Receiving Environment Objectives and Attribute Target Levels relating to mana whenua values (Waterway Cultural Health Index, Marine Cultural Health Index, and State of Takiwā scores), as specified in Schedules 7 (Waterways) and 8 (Coastal Waters) of the consent conditions, are being met, using the following approach;
    - Assessments shall be undertaken for each of the attributes at each monitored site
    - LWRP classifications ('spring-fed – plains – urban', 'spring-fed – plains' and ‘Banks Peninsula’) for each site, and therefore the relevant Attribute Target Level, shall be in accordance with that detailed in Appendix B

- A discussion of likely reasons for any poor or declining values (i.e. whether there is the potential this could be due to stormwater inputs); and
- A discussion of contaminants of concern and sites/catchments with poor values that should be considered as priority areas for stormwater management.

9 Reporting

In accordance with the conditions of the consent, a monitoring report is required to be submitted to the Canterbury Regional Council and stakeholders by the 30th of June each year. This report shall include the following:

- Detailed monitoring reports for each of the following aspects, which incorporate the reporting requirements detailed in the respective sections of this monitoring report:
    - Groundwater
    - Surface water levels and flows, sea level and rainfall depth
    - Surface water quality
    - Instream sediment quality
    - Aquatic ecology
    - Mana whenua values
- An holistic assessment of surface water quality, instream sediment quality, aquatic ecology and mana whenua values monitoring, to determine causes, relationships and trends, as far as is possible;
- A discussion of likely reasons for any poor results or declining trends (i.e. whether there is the potential this could be due to stormwater inputs);
- A discussion of contaminants of concern and sites/catchments with poor values that should be considered as priority areas for stormwater management;
- A summary of whether the Receiving Environment Objectives and Attribute Target Levels of the consent were met; and
- Responses to monitoring (in accordance with the conditions of the consent).

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11 Appendix A: Soil Quality Monitoring Sites

Table i. Soil sampling monitoring of stormwater devices. Cu = total recoverable copper; Zn = total recoverable zinc; Pb = total recoverable lead; As = total recoverable arsenic; Cd = total recoverable cadmium; Cr = total recoverable chromium; Ni = total recoverable nickel; PAH = Polycyclic Aromatic Hydrocarbons; SVOC = Semi-Volatile Organic Compounds.

Site	Type of System	Land Use	Year System Constructed	Metals	PAHs	SVOCs	Previous Sampling	Easting	Northing
Denton Park	Soakage basin	Residential	1997	✓ Cu, Zn, Pb	✓		2010 (IGSC)	2471174	5740565
Beckenham Library	Detention swale	Car park	2005	✓ Cu, Zn, Pb	✓		2010 (IGSC)	2480757	5738373
Tumara Park	Infiltration and detention	Large residential	2003	✓ Cu, Zn, Pb	✓		2010 (IGSC)	2484754	5747875
Hornby Industrial Park	Infiltration basin	Residential	1995	✓ Cu, Zn, Pb, As, Cd, Cr, Ni	✓	✓	2010 (IGSC)	2470426	5739650
Richmond Housing Complex	Swale and first flush basin	High density housing	2007	✓ Cu, Zn, Pb	✓		2010 (IGSC)	2482302	5743028
Grove Road	Rain garden	Commercial	TBA	✓ Cu, Zn, Pb	✓		None	2479132	5740733

12 Appendix B: Surface Water, Instream Sediment, Aquatic Ecology and Mana Whenua Values Monitoring Sites

Table i. Water quality (monthly and five-yearly wet weather), sediment quality and aquatic ecology sampling, at sites within waterways and coastal areas of Christchurch and Banks Peninsula, within the area of Christchurch City Council's jurisdiction. LWRP = Environment Canterbury Land and Water Regional Plan; RCEP = Environment Canterbury Regional Coastal Environment Plan; WRRP = Environment Canterbury Waimakariri River Regional Plan; IGSC = Christchurch City Council Interim Global Stormwater Consent; SWSMP = Christchurch City Council South-West Stormwater Management Plan; SSMP = Christchurch City Council Styx Stormwater Management Plan; CCC = Christchurch City Council; BPSES = Banks Peninsula Sites of Ecological Significance study for District Plan Review, unpublished raw data; and TBC = To Be Confirmed. Monthly CCC surface water monitoring refers to unpublished raw data, but this information is collated in annual monitoring reports that are not referenced in this document.

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON02	Avon River at Bridge Street	✓ (IGSC)		✓					Monthly surface water: • CCC since 2007 Instream Sediment[8]: • Robb (1988) [Site 204] • Gadd & Sykes (2014) [Site 35] Aquatic Ecology[9]: • Robb (1992) [Site 204] • James & McMurtrie (2012) [Reach: Mouth]	Spring-fed – plains – urban (LWRP)	2487694	5742425
Waterway	Avon River	AVON01	Avon River at Pages/Seaview Bridge	✓ (IGSC)		✓	✓				Monthly surface water: • CCC since 2007 Instream Sediment[10]: • Robb (1988) [Site 193] • Gadd & Sykes (2014) [Site 34] Aquatic Ecology: • Robb (1980) [Site 191] • Robb (1992) [Site 191] • James & McMurtrie (2012) [Reach: Avondale- Pages][9]	Spring-fed – plains – urban (LWRP)	2487487	5744202
Waterway	Avon River	AVON14	Ōruapaeroa/Travis Wetland							✓	Cultural Monitoring: • Pauling *et al* (2007) [Site 12] • Lang *et al* (2012) [Site 12]	Spring-fed – plains – urban[11]	TBC	TBC

[8] Sediment sampling and ecological monitoring site was 30 m upstream of Bridge Street (coordinates: 2487673, 5742466)

[9] Monitoring was undertaken using long reaches of the river, not smaller-scale sites; the coordinates for this site in this monitoring plan coincide with the downstream end of the James & McMurtrie (2012) reach and the surface water sampling site (i.e. sites are used, rather than reaches)

[10] Sediment sample site was 424 m downstream, opposite New Brighton Power Boat Club House (coordinates: 2487823, 5743976)

[11] This site is unclassified under the LWRP, however this is considered the most appropriate classification

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON13	Avon River at Avondale Road	✓ (IGSC)	✓ (IGSC)	✓	✓				Monthly surface water[12]: • CCC since 2008 Five-yearly wet weather surface water[12]: • CCC 2012 & 2014 Instream Sediment[13]: • Robb (1988) [Site 181] • Gadd & Sykes (2014) [Site 32] Aquatic Ecology: • Robb (1980) [Site 181] • Eldon and Kelly (1992) [Site 181] • Robb (1992) [Site 181] • James & McMurtrie (2012) [Reach: Gayhurst- Avondale][9]	Spring-fed – plains – urban (LWRP)	2484754	5745170
Waterway	Avon River	AVON11	Horseshoe Lake Discharge	✓ (IGSC)							Monthly surface water: • CCC since 2008	Spring-fed – plains – urban (LWRP)	2484344	5744907
Waterway	Avon River	AVON15	Te Oranga/Horseshoe Lake							✓	Cultural Monitoring: • Pauling *et al* (2007) [Site 11] • Lang *et al* (2012) [Site 11]	Spring-fed – plains – urban (LWRP)	TBC	TBC
Waterway	Avon River	AVON03	Avon River at Dallington Terrace/Gayhurst Road	✓ (IGSC)		✓	✓				Monthly surface water: • CCC since 2007 Instream Sediment: • Robb (1988) [Site 168] • Gadd & Sykes (2014) [Site 31][14] Aquatic Ecology: • Robb (1980) [Site 168] • Robb (1992) [Site 168] • James & McMurtrie (2012) [Reach: Fitzgerald- Gayhurst][9]	Spring-fed – plains – urban (LWRP)	2483562	5742822

[12] Surface water sampling is near to a stormwater outfall

[13] Sediment sampling site was 198 m upstream of the Avondale Bridge, nearer to Lake terrace Road (coordinates: 2484543, 5745167)

[14] Due to earthquake dredging no sediment was present, site was moved 500 m upstream to Morris Street (coordinates: 2483452, 5743210)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON10	Dudley Creek at North Parade	✓ (IGSC)	✓ (IGSC)	✓	✓		✓		Monthly surface water: • CCC since 2008 Five-yearly wet weather surface water: • CCC 2012 & 2014 Instream Sediment: • Robb (1988) [Site 108] • Gadd & Sykes (2014) [Site 18] Aquatic Ecology: • Robb (1980) [Site 108] • Robb (1992) [Site 108] • Blakely (2014) [Site 18]	Spring-fed – plains – urban (LWRP)	2482575	5743763
Waterway	Avon River	AVON16	Avon River Downstream of Kilmore Street (Ōtautahi)				✓			✓	Aquatic Ecology: • Robb (1980) [Site 152][15] • Robb (1992) [Site 152][15] • McMurtrie (2009) [Site 19] • Blakely (2014) [Site 29] Cultural Monitoring: • Pauling *et al* (2007) [Site 9] • Lang *et al* (2012) [Site 9]	Spring-fed – plains – urban (LWRP)	2481261	5742329
Waterway	Avon River	AVON04	Avon River at Manchester Street	✓ (IGSC)	✓ (IGSC)	✓					Monthly surface water: • CCC since 2008 Five-yearly wet weather surface water: • CCC 2012 & 2014 Instream Sediment: • Robb (1988) [Site 151] • Gadd & Sykes (2014) [Site 29]	Spring-fed – plains – urban (LWRP)	2480890	5742093
Waterway	Avon River	AVON17	Avon River at Victoria Square Near Armagh Street			✓	✓				Instream Sediment: • Robb (1988) [Site 149] • Gadd & Sykes (2014) [Site 28] Aquatic Ecology: • Robb (1980) [Site 149] • Robb (1992) [Site 149] • McMurtrie (2009) [Site 20][16] • Blakely (2014) [Site 28][16]	Spring-fed – plains – urban (LWRP)	2480498	5742085

[15] Ecological monitoring site was upstream at Madras Street (coordinates: 2481126, 5742226)

[16] Ecological monitoring site was 82 m downstream of Armagh Street (coordinates: 2480498, 5742085)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON18	Avon River Upstream of Montreal Street				✓				Aquatic Ecology: • Robb (1980) [Site 147] • Eldon and Kelly (1992) [Site 146] • Robb (1992) [Site 147] • McMurtrie (2009) [Site 21] • Blakely (2014) [Site 27]	Spring-fed – plains – urban (LWRP)	2480089	5741371
Waterway	Avon River	AVON09	Addington Brook Upstream of Riccarton Avenue	✓ (IGSC)	✓ (IGSC)	✓	✓		✓		Monthly surface water: • CCC since 2008 Five-yearly wet weather surface water: • CCC 2012 & 2014 Instream Sediment: • Robb (1988) [Site 129-131] • Gadd & Sykes (2014) [Site 22] Aquatic Ecology[17]: • Robb (1980) [Site 131] • Robb (1992) [Site 131] • Blakely (2014) [Site 12]	Spring-fed – plains – urban (LWRP)	2479427	5741438
Waterway	Avon River	AVON08	Riccarton Main Drain Downstream of Deans Avenue	✓ (IGSC)	✓	✓	✓		✓		Monthly surface water: • CCC since 2008 Five-yearly wet weather surface water: • CCC 2014 Instream Sediment[18]: • Robb (1988) [Site 118] • Gadd & Sykes (2014) [Site 21] Aquatic Ecology: • Robb (1980) [Site 117] • Eldon and Kelly (1992) [Site 118][18] • Robb (1992) [Site 117] • Blakely (2014) [Site 13]	Spring-fed – plains – urban (LWRP)	2478683	5741631
Waterway	Avon River	AVON19	Avon River at Botanical Garden North Car Park				✓				Aquatic Ecology: • McMurtrie (2009) [Site 22] • Blakely (2014) [Site 26]	Spring-fed – plains – urban (LWRP)	2479390	5742010

[17] Ecological monitoring site was 201 m downstream (coordinates: 2479512, 5741605)

[18] Sediment sample and ecological monitoring site was 360 m downstream, above Riccarton Avenue (coordinates: 2478997, 5741642)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON12	Avon River at Carlton Mill Corner	✓ (IGSC)	✓ (IGSC)	✓			✓		Monthly surface water[12]: • CCC since 2008 Five-yearly wet weather surface water[12]: • CCC 2012 & 2014 Instream Sediment: • Robb (1988) [Site 138] • Golder Associates (2012b) [Site 12] • Gadd & Sykes (2014) [Site 26] Aquatic Ecology: • Robb (1980) [Site 138] • Robb (1992) [Site 138] • Blakely (2014) [Site 25]	Spring-fed – plains – urban (LWRP)	2479737	5742871
Waterway	Avon River	AVON20	Avon River at Waipapa/Little Hagley Park							✓	Cultural Monitoring: • Pauling *et al* (2007) [Site 8] • Lang *et al* (2012) [Site 8]	Spring-fed – plains – urban (LWRP)	TBC	TBC
Waterway	Avon River	AVON21	Avon River Downstream of Mona Vale Loop				✓				Aquatic Ecology: • Robb (1992) [Site 133a] • McMurtrie (2009) [Site 23] • Blakely (2014) [Site 24]	Spring-fed – plains – urban (LWRP)	2478634	5742492
Waterway	Avon River	AVON07	Avon River at Mona Vale	✓ (IGSC)	✓ (IGSC)	✓					Monthly surface water: • CCC since 2007 Five-yearly wet weather surface water: • CCC 2012 & 2014 Instream Sediment: • Robb (1988) [Site 31] • Golder Associates (2012b) [Site 13] • Gadd & Sykes (2014) [Site 7] Aquatic Ecology: • Robb (1980) [Site 31] • Robb (1992) [Site 31]	Spring-fed – plains – urban (LWRP)	2478334	5742658

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON06	Waimairi Stream Downstream of Railway Bridge	✓ (IGSC)		✓	✓				Monthly surface water: • CCC since 2007 Instream Sediment[19]: • Robb (1988) [Site 13] • Gadd & Sykes (2014) [Site 2] Aquatic Ecology: • Robb (1980) [Site 13] • Robb (1992) [Site 13] • Blakely (2014) [Site 22]	Spring-fed – plains – urban (LWRP)	2478232	5742784
Waterway	Avon River	AVON22	Waimairi Stream at Fendalton Park				✓				Aquatic Ecology: • Robb (1980) [Site 9] • Robb (1992) [Site 9] • McMurtrie (2009) [Site 25] • Blakely (2014) [Site 19]	Spring-fed – plains – urban (LWRP)	2477010	5742780
Waterway	Avon River	AVON05	Wairarapa Stream Downstream of Fendalton Road	✓ (IGSC)		✓	✓				Monthly surface water: • CCC since 2007 Instream Sediment[20]: • Robb (1988) [Site 78] • Gadd & Sykes (2014) [Site 12] Aquatic Ecology: • Robb (1980) [Site 77][21] • Robb (1992) [Site 77][21] • Blakely (2014) [Site 23]	Spring-fed – plains – urban (LWRP)	2478250	5742915
Waterway	Avon River	AVON23	Wairarapa Stream Upstream of Glandovey Road				✓				Aquatic Ecology: • Robb (1980) [Site 66] • Eldon and Kelly (1992) [Site 66] • Robb (1992) [Site 66] • McMurtrie (2009) [Site 24] • Blakely (2014) [Site 20]	Spring-fed – plains – urban (LWRP)	2477224	5743220
Waterway	Avon River	AVON24	Pūtarikamotu/Ilam Stream at Deans Bush							✓	Cultural Monitoring: • Pauling *et al* (2007) [Site 7] • Lang *et al* (2012) [Site 7]	Spring-fed – plains – urban (LWRP)	TBC	TBC

[19] Sediment sample site was 70 m upstream of the rail bridge (coordinates: 2478123, 5742853)

[20] Sediment sample site was 116 m downstream of Fendalton Road (coordinates: 2478246, 5742805)

[21] Ecological monitoring site was 50 m downstream of Fendalton Road (coordinates: 2478255, 5742874)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Avon River	AVON25	Okeover Stream at University of Canterbury Glasshouses				✓				Instream Sediment[22]: • Robb (1988) [Site C15] • Gadd & Sykes (2014) [Site 6] Aquatic Ecology: • McMurtrie (2009) [Site 26] • Blakely (2014) [Site 6]	Spring-fed – plains – urban (LWRP)	2476686	5742608
Waterway	Avon River	AVON26	Avon River at Clyde Road			✓	✓				Instream Sediment: • Robb (1988) [Site 24] • Gadd & Sykes (2014) [Site 5] Aquatic Ecology: • Robb (1980) [Site 24] • Robb (1992) [Site 24] • McMurtrie (2009) [Site 27][23] • Blakely (2014) [Site 7][23]	Spring-fed – plains – urban (LWRP)	2476765	5742294
Waterway	Heathcote River	HEATH01	Heathcote River at Ferrymead Bridge	✓ (IGSC)							Monthly surface water: • CCC since 2007 Instream Sediment: • Robb (1988) [Site 190] • Kingett Mitchell (2005) [Site HE34][24] Aquatic Ecology: • Robb (1980) [Site 190] • Robb (1994) [Site 190/H190] • van den Ende & Partridge (2008) [Site 190/H190]	Spring-fed – plains – urban (LWRP)	2486494	5738760
Waterway	Heathcote River	HEATH17	Steamwharf Stream upstream of Dyers Road	✓			✓				Instream Sediment: • Gadd (2015) [Site 15] Aquatic Ecology: • Taylor & Blair (2011) • Blakely (2015a) [Site 15]	Spring-fed – plains – urban (LWRP)	2485052	5739405

[22] Sediment sample site was 30 m downstream of Clyde Road (coordinates: 2476804, 5742564)

[23] Ecological monitoring site was 131 m downstream of Clyde Road Bridge (coordinates: 2476657, 5742234)

[24] Sediment sample site was 200 m upstream of Ferrymead Bridge (coordinates: 2486481, 5738404)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH02	Heathcote River at Tunnel Road	✓ (IGSC)		✓	✓				Monthly surface water: • CCC since 2007 Instream Sediment[25]: • Robb (1988) [Site 179] • Golder (2012) [Site 16] • Gadd (2015) [Site 14] Aquatic Ecology: • Robb (1980) [Site 179] • Robb (1994) [Site 179/H179] • van den Ende & Partridge (2008) [Site 179/H179] • Blakely (2015a) [Site 14]	Spring-fed – plains – urban (LWRP)	2485076	5739154
Waterway	Heathcote River	HEATH18	Ōpāwaho/Heathcote River at Garlands Road Bridge							✓	Cultural Monitoring: • Pauling *et al* (2007) [Site 21] • Lang *et al* (2012) [Site 21]	Spring-fed – plains – urban (LWRP)	TBC	TBC
Waterway	Heathcote River	HEATH11	Heathcote River at Catherine Street	✓ (IGSC)	✓ (IGSC)	✓	✓				Monthly surface water[12]: • CCC since 2008 Five-yearly wet weather surface water[12]: • CCC 2010 & 2011 Instream Sediment: • Robb (1988) [Site 164] • Gadd (2015) [Site 13] Aquatic Ecology: • Robb (1980) [Site 164] • Robb (1994) [Site 164/H164] • van den Ende & Partridge (2008) [Site 164/H164] • Blakely (2015a) [Site 13]	Spring-fed – plains – urban (LWRP)	2484415	5739494
Waterway	Heathcote River	HEATH12	Heathcote River at Mackenzie Avenue Footbridge	✓ (IGSC)							Monthly surface water[12]: CCC since 2008	Spring-fed – plains – urban (LWRP)	2483521	5739528
Waterway	Heathcote River	HEATH03	Heathcote River at Opawa Road/Clarendon Terrace	✓ (IGSC)							Monthly surface water: • CCC since 2007 Aquatic Ecology: • Robb (1980) [Site 154]	Spring-fed – plains – urban (LWRP)	2483072	5739226

[25] Sediment sample site was 100 m upstream, below the Woolston Cut (coordinates: 2484931, 5739133)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH19	Heathcote River on Aynsley Terrace (at the eastern tip of King George V Reserve)				✓				Instream Sediment: • Robb (1988) [near to Site 147] • Gadd (2015) [Site 12] Aquatic Ecology: • Robb (1980) [Site 148] • Taylor (2005) [Site E & F] • Blakely (2015a) [Site 12]	Spring-fed – plains – urban (LWRP)	2482928	5738430
Waterway	Heathcote River	HEATH22	Heathcote River Downstream of Tennyson Street			✓	✓				Instream Sediment: • Robb (1988) [near to Site 138] • Gadd (2015) [Site 10] Aquatic Ecology: • Robb (1980) [Site 139] • Eldon *et al* (1989) [Site 139] • James (2010) [Site 29] • Taylor & Blair (2012) [Site 1] • Blakely (2015a) [Site 10]	Spring-fed – plains – urban (LWRP)	2481520	5738845
Waterway	Heathcote River	HEATH04	Heathcote River at Bowenvale Avenue	✓ (IGSC)	✓ (IGSC)						Monthly surface water: • CCC since 2007 Five-yearly wet weather surface water: • CCC 2010 & 2011 Aquatic Ecology:[26] • Robb (1980) [Site 134]	Spring-fed – plains – urban (LWRP)	2481198	5737390
Waterway	Heathcote River	HEATH23	Heathcote River Downstream of Colombo Street (Beckenham Library)			✓	✓			✓	Instream Sediment: • Robb (1988) [near to Site 127] • Gadd (2015) [Site 9] Aquatic Ecology: • Robb (1980) [Site 128] • James (2010) [Site 30] • Taylor & Blair (2012) [Site 8] • Blakely (2015a) [Site 9] Cultural Monitoring: • Pauling *et al* (2007) [Site 20] • Lang *et al* (2012) [Site 20]	Spring-fed – plains – urban (LWRP)	2480841	5738474

[26] Ecological monitoring site was 20 m upstream of Bowenvale Avenue (coordinates: 2481163, 5737382)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH25	Cashmere Brook at Ashgrove Terrace				✓				Instream Sediment: • Gadd (2015) [Site 8] Aquatic Ecology: • James (2010) [Site 38] • Blakely (2015a) [Site 8]	Spring-fed – plains – urban (LWRP)	2480258	5737964
Waterway	Heathcote River	HEATH24	Heathcote River downstream of Barrington Street			✓	✓				Instream Sediment: • Robb (1988) [near to Site 124] • Gadd (2015) [Site 7] Aquatic Ecology: • Robb (1980) [Site 123][27] • James (2010) [Site 31] • Blakely (2015a) [Site 7]	Spring-fed – plains – urban (LWRP)	2480159	5737791
Waterway	Heathcote River	HEATH07	Heathcote River at Ferniehurst Street	✓ (SWSMP)	✓ (SWSMP)				✓		Monthly surface water: • CCC since 2008 Five-yearly wet weather surface water: • CCC 2010 & 2011 Aquatic Ecology: • Robb (1980) [Site 119]	Spring-fed – plains – urban (LWRP)	2479157	5737222
Waterway	Heathcote River	HEATH05	Cashmere Stream at Worsleys Road	✓ (SWSMP)	✓ (SWSMP)	✓					Monthly surface water: • CCC since 2007 Five-yearly surface water: • CCC 2010 & 2011 Instream Sediment: • Robb (1988) [Site 49][28] • Kingett Mitchell Ltd, (2005) [Site HE10][28] • Golder Associates (2012b) [Site 20] [29] Aquatic Ecology: • Robb (1980) [Site 49][28] • Eldon *et al* (1989) [Site 49][28] • Taylor & Blair (2012) [Site 4]	Banks Peninsula (LWRP)	2479030	5736765

[27] Ecological monitoring site was 2 m upstream of Barrington Street (coordinates:2480102, 5737746)

[28] Sediment sample and ecological monitoring site was 20 m downstream of bridge and 5 m upstream of confluence with Cashmere Valley Drain (coordinates: 2479043, 5736773)

[29] Sediment sample site was 140 m downstream, at the termination of Hurunui Street (coordinates: 2479029 5736862)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH26	Cashmere Stream at Penruddock Rise				✓ (SWSMP)				Instream Sediment: • Robb (1988) [Site 42] • Gadd (2015) [Site 2] Aquatic Ecology: • Robb (1980) [Site 42] • James (2010) [Site 33] • Blakely (2015a) [Site 2]	Banks Peninsula[30]	2477914	5736700
Waterway	Heathcote River	HEATH27	Cashmere Stream, Behind 406 Cashmere Road (downstream of stormwater discharge)					✓	✓		Instream Sediment: • James & McMurtrie (2010) [Site 25]	Banks Peninsula[30]	2477452	5736476
Waterway	Heathcote River	HEATH28	Cashmere Stream, Behind 420- 426 Cashmere Road (upstream of stormwater discharge)					✓			Instream Sediment: • James & McMurtrie (2010) [Site 22] Aquatic Ecology: • EOS Ecology (2013) [Site 3] • Drinan (2014) [Site 3] • James (2015) [Site 3]	Banks Peninsula[30]	2477361	5736392
Waterway	Heathcote River	HEATH16	Cashmere Stream at Sutherlands Road	✓ (SWSMP)	✓ (IGSC)	✓	✓ (SWSMP)				Monthly surface water: • CCC since 2010 Five-yearly wet weather surface water: • CCC 2010 & 2011 Instream Sediment[31]: • Robb (1988) [near to Site 26] • Gadd (2015) [Site 1] Aquatic Ecology:[31] • James (2010) [Site 37] • Blakely (2015a) [Site 1]	Banks Peninsula[30]	2476084	5735598

[30] Not classified under the LWRP, but considered in this report a Banks Peninsula waterway, as per the lower reaches

[31] Sediment and ecological monitoring samples were taken upstream of Sutherlands Road

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH06	Heathcote River at Rose Street[32]	✓ (SWSMP)	✓ (SWSMP)	✓	✓ (SWSMP)		✓	✓	Monthly surface water: • CCC since 2008 Five-yearly wet weather surface water: • CCC 2010 & 2011 Instream Sediment: • Robb (1988) [near to Site 115] • Kingett Mitchell Ltd, (2005) [near to Site HE27] • Gadd (2015) [Site 6] Aquatic Ecology: • Robb (1980) [Site 114][33] • Eldon *et al* (1989) [Site 114][33] • James (2010) [Site 35] • Taylor & Blair (2012) [Site 2] • Blakely (2015a) [Site 6] Cultural Monitoring: • Pauling *et al* (2007) [Site 18] • Lang *et al* (2012) [Site 18]	Spring-fed – plains – urban (LWRP)	2478700	5737528
Waterway	Heathcote River	HEATH09	Haytons Stream at Retention Basi[34]	✓	✓	✓						Spring-fed – plains – urban (LWRP)	2476087	5739262
Waterway	Heathcote River	HEATH29	Heathcote River Downstream of Spreydon Domain			✓	✓ (SWSMP)				Instream Sediment: • Robb (1988) [near to Site 102] • Gadd (2015) [Site 5] Aquatic Ecology: • James (2010) [Site 34] • Blakely (2015a) [Site 5]	Spring-fed – plains – urban (LWRP)	2477972	5738774

[32] The previous State of the Takiwā monitoring site, Waimokihi/Pioneer Stadium, was actually located approximately 300 m upstream of this site, but the intent of the cultural site is still considered to be achieved (located in proximity to the school, the recreational facilities provided by Pioneer Stadium and the adjacent Centennial Park)

[33] Ecological monitoring site was 30 m upstream of Rose Street (coordinates: 2478713, 5737553)

[34] The location of this site was moved from the old outlet to the new outlet in May 2020

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH10	Curletts Road Stream Upstream of Heathcote River Confluence	✓ (SWSMP)	✓	✓			✓		Monthly surface water: • CCC since 2008 Aquatic Ecology: • Robb (1980) [Site 67] • Yungnickle & Barnett (2018) [Site 1]	Spring-fed – plains – urban (LWRP)	2476927	5739322
Waterway	Heathcote River	HEATH14	Curletts Road Stream at Southern Motorway	✓ (SWSMP)	✓	✓					Monthly surface water: • CCC since 2008 Instream Sediment: • Robb (1988) [Site 65[35]] • Kingett Mitchell Ltd, (2005) [Site HE14] Aquatic Ecology: • Robb (1980) [Site 65] • McMurtrie (2008) • Yungnickle & Barnett (2018) [Site 2[36]]	Spring-fed – plains – urban (LWRP)	2476404	5739969
Waterway	Heathcote River	HEATH30	Heathcote River at Canterbury Park/Showgrounds			✓	✓ (SWSMP)				Instream Sediment: • Robb (1988) [near to Site 90] • Kingett Mitchell Ltd, (2005) [near to Site HE22] • Gadd (2015) [Site 4] Aquatic Ecology: • Robb (1980) [Site 90][37] • James (2010) [Site 36] • Blakely (2015a) [Site 4]	Spring-fed – plains – urban (LWRP)	2476514	5739050
											•			

[35] Robb (1980) and Robb (1988) site description is not exact, but it is believed that this is the same site as Kingett Mitchell (2005)

[36] Ecological monitoring was undertaken 150 m downstream of the Southern Motorway

[37] Robb (1980) site description is not exact, but it is believed that this is the same site as James (2010) and Blakely (2015a)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Heathcote River	HEATH31	Heathcote River at Warren Crescent	✓	✓	✓	✓		✓			Spring-fed – plains – urban (LWRP)	2476033	5738970
Waterway	Halswell River	HALS06	Halswell River downstream of Early Valley Road				✓				Aquatic Ecology: • James (2011) [Site 43] • Blakely (2016) [Site 4]	Spring-fed – plains (LWRP)	2475268	5731707
Waterway	Halswell River	HALS04	Halswell River at Akaroa Highway (Tai Tapu Road)	✓ (SWSMP)	✓ (SWSMP)		✓				Monthly surface water: • CCC since 2008	Spring-fed – plains (LWRP)	2474444	5733330
Waterway	Halswell River	HALS07	Halswell River at Wroots/Halswell Roads	✓		✓ (SWSMP)	✓				Instream Sediment[38]: • Kingett Mitchell (2005) [Site HA25] • Golder Associates (2012b) [Site 21] • Blakely (2016) [Site 5] Aquatic Ecology: • James (2011) [Site 46] • Blakely (2016) [Site 5]	Spring-fed - plains (LWRP)	2474357	5734086
Waterway	Halswell River	HALS03	Nottingham Stream at Candys Road	✓ (SWSMP)	✓	✓	✓		✓		Monthly surface water: • CCC since 2008 Instream Sediment[39]: • Kingett Mitchell (2005) [Site HA23] • Golder Associates (2012b) [Site 22]	Spring-fed - plains (LWRP)	2474530	5734689
Waterway	Halswell River	HALS08	Creamery Stream Downstream of Sabys Road			✓ (SWSMP)	✓				Instream Sediment: • Blakely (2016) [Site 2] Aquatic Ecology: • James (2011) [Site 40] • Blakely (2016) [Site 2]	Spring-fed - plains (LWRP)	2474273	5734813
Waterway	Halswell River	HALS05	Knights Stream at Sabys Road (upstream of Nottingham Stream)	✓ (SWSMP)	✓	✓	✓		✓		Monthly surface water: • CCC since 2012	Spring-fed - plains (LWRP)	2473720	5734461
Waterway	Halswell River	HALS09	Cases Drain Upstream of Downies Road				✓				Aquatic Ecology: • James (2011) [Site 47]	Spring-fed - plains (LWRP)	2473619	5735215
Waterway	Halswell River	HALS10	Knights Stream Upstream of Whincops Road			✓ (SWSMP)	✓				Instream Sediment: • Blakely (2016) [Site 3] Aquatic Ecology: • James (2011) [Site 42] • Blakely (2016) [Site 3]	Spring-fed - plains (LWRP)	2472634	5736096

[38] Sediment sample was taken downstream of the bridge

[39] Sediment sample was taken upstream of the bridge

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Styx River	STYX08	Styx River at Kainga Road/ Harbour Road Bridge	✓ (SSMP)		✓ (SSMP)	✓ (SSMP)			✓	Monthly surface water: • CCC since 2008 Instream Sediment: • Robb (1988) [Site 42] • Golder Associates (2009) [Site 5] • Whyte (2014) Aquatic Ecology[40] • Robb (1980) [Site 41] • James (2013) [Site 48] • Burrell (2018) [Site 48] Cultural Monitoring: • Orchard & Lobb (2013) [Site inanga spawning site]	spring-fed - plains[41]	2485000	5756366
Waterway	Styx River	STYX07	Styx River at Richards Bridge/ Teapes Road	✓ (SSMP)		✓ (SSMP)	✓ (SSMP)			✓	Monthly surface water: • CCC since 2008 Instream Sediment: • Robb (1988) [Site 29] • Golder Associates (2009) [Site 14] • Whyte (2014) Aquatic Ecology: • Robb (1980) [Site 27] • James (2013) [Site 49] • Burrell (2018) [Site 49] Cultural Monitoring: • Orchard & Lobb (2013) [Site Pūharakekenui mid catchment]	spring-fed - plains[42]	2483977	5751255

[40] Ecological monitoring site was upstream of Kainga Road

[41] Under the Natural Resources Regional Plan (NRRP) these waterways were classified 'spring-fed - plains' and it is likely the LWRP will be amended to be in line with the NRRP (Michele Stevenson, Environment Canterbury, personal communication, 2014); therefore, these locations are considered 'spring-fed - plains' for the purposes of this monitoring

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Styx River	STYX06	Styx River at Marshland Road Bridge	✓ (SSMP)	✓ (SSMP)	✓ (SSMP)	✓			✓	Monthly surface water: • CCC since 2007 Instream Sediment: • Robb (1988) [Site 18] • Golder Associates (2009) [Site 3] • Whyte (2014) Aquatic Ecology:[42] • Robb (1980) [Site K 18] • James (2013) [Site 50] • Burrell (2018) [Site 50] Cultural Monitoring: • Orchard & Lobb (2013) [Site Pūharakekenui/Kaputone Confluence]	spring-fed - plains[42]	2482359	5749393
Waterway	Styx River	STYX05	Kā Pūtahi Creek at Belfast Road (lower)	✓ (SSMP)	✓ (SSMP)	✓ (SSMP)					Monthly surface water: • CCC since 2007 Instream Sediment: • Robb (1988) [Site K19] • Golder Associates (2009) [Site 8] • Whyte (2014) Aquatic Ecology:[43] • Robb (1980) [Site K 29]	spring-fed - plains[42]	2482195	5749882
Waterway	Styx River	STYX09	Kā Pūtahi Creek at Ouruhia Reserve				✓ (SSMP)		✓	✓	Aquatic Ecology: • Eldon & Taylor (1990) [Site K 23] • Robb (1980) [Site K 23] • McMurtrie & Greenwood (2008) [Site 10] • James (2013) [Site 10] • Burrell (2018) [Site 10] Cultural Monitoring: • Orchard & Lobb (2013) [Site Ouruhia Domain]	spring-fed - plains[42]	2481755	5751732
Waterway	Styx River	STYX10	Kā Pūtahi Creek Between Blakes and Belfast Roads				✓ (SSMP)				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 11] • James (2013) [Site 11] • Burrell (2018) [Site 11]	spring-fed - plains[42]	2480943	5749727

[42] Ecological monitoring site was downstream of Marshland Road

[43] Ecological monitoring site was 10 m downstream of Belfast Road (coordinates: 2482163, 5749872)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Styx River	STYX04	Kā Pūtahi Creek at Blakes Road	✓ (SSMP)	✓	✓[44] (SSMP)			✓[45]	✓	Monthly surface water: • CCC since 2007 Instream Sediment[45]: • Robb (1988) [Site K15] • Golder Associates (2009) [Site 7] • Whyte (2014) Aquatic Ecology: • Eldon & Taylor (1990) [Site K 15][46] Cultural Monitoring: • Orchard & Lobb (2013) [Site Kaputone mid catchment]	spring-fed - plains[42]	2480401	5749645
Waterway	Styx River	STYX11	Horners Drain at Hawkins Road				✓ (SSMP)				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 12] • James (2013) [Site 12] • Burrell (2018) [Site 12]	spring-fed - plains[47]	2481293	5748401
Waterway	Styx River	STYX03	Styx River at Main North Road	✓ (SSMP)	✓ (SSMP)	✓ (SSMP)	✓ (SSMP)		✓		Monthly surface water: • CCC since 2007 Instream Sediment: • Robb (1988) [Site 12] • Golder Associates (2009) [Site 2] • Whyte (2014) Aquatic Ecology:[48] • Robb (1980) [Site 12] • McMurtrie & Greenwood (2008) [Site 13] • James (2013) [Site 13] • Burrell (2018) [Site 13]	spring-fed - plains[42]	2479066	5748834

[44] Samples should be taken upstream of the road, contrary to the water samples which are taken downstream

[45] Instream sediment monitoring site was upstream of Blakes Road.

[46] The 1990 report listed this site as being above Blakes Road, however distance upstream was not detailed

[47] Under the Natural Resources Regional Plan (NRRP) this waterway is unclassified; consistent with other waterways in this catchment (i.e. the downstream Styx River), this waterway is considered in this monitoring report as 'spring-fed – plains', as agreed with Environment Canterbury (Michele Stevenson, Environment Canterbury, personal communication, 02 April 2015)

[48] Ecological monitoring site was upstream of Main North Road

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Styx River	STYX12	Styx River at Styx Mill Conservation Reserve			✓ (SSMP)	✓ (SSMP)		✓		Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 14] • James (2013) [Site 14] • James (2014) [Site 14] • Blakely (2015b) • James (2016) [Site 14] • Demchick (2017) [Site 14] • Burrell (2018) [Site 14]	spring-fed - plains[42]	2478252	5749370
Waterway	Styx River	STYX13	Styx River Adjacent to Styx Mill Dog Area Carpark				✓				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 15] • James (2013) [Site 15] • Burrell (2018) [Site 15]	spring-fed - plains[42]	2477927	5749206
Waterway	Styx River	STYX14	Styx River Upstream of Styx Mill Reserve				✓ (SSMP)				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 10] • James (2013) [Site 16] • Burrell (2018) [Site 16]	spring-fed - plains[42]	2477610	5749003
Waterway	Styx River	STYX15	Smacks Creek at Hussey Road			✓ (SSMP)	✓ (SSMP)				Instream Sediment: • Golder Associates (2009) [Site 6] Aquatic Ecology: • Robb (1980) [Site Sm 3] • McMurtrie & Greenwood (2008) [Site 17][49] • James (2013) [Site 17][51] • Burrell (2018) [Site 17]	spring-fed - plains[42]	2477072	5749363
Waterway	Styx River	STYX01	Smacks Creek at Gardiners Road Near Styx Mill Road	✓ (SSMP)	✓ (SSMP)						Monthly surface water: • CCC since 2007 Aquatic Ecology: • Robb (1980) [Site Sm 2]	spring-fed - plains[42]	2476803	5749571

[49] Ecological Monitoring site was 60 m upstream of Hussey Road (coordinates: 2477033, 5749402)

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Styx River	STYX02	Styx River at Gardiners Road	✓ (SSMP)							Monthly surface water: • CCC since 2007 Instream Sediment: • Golder Associates (2009) [Site 1] Aquatic Ecology:[50] • Robb (1980) [Site 5] • Eldon & Taylor (1990) [Site 5]	spring-fed - plains[42]	2476789	5748841
Waterway	Styx River	STYX16	Styx River at Claridges Road				✓ (SSMP)				Aquatic Ecology: • Robb (1980) [Site 4] • McMurtrie & Greenwood (2008) [Site 18] • James (2013) [Site 18] • Burrell (2018) [Site 18]	spring-fed - plains[42]	2476512	5748528
Waterway	Ōtūkaikino River	OTUKAI02	Wilsons Drain at Main North Road	✓ (SSMP)	✓	✓ (SSMP)	✓	✓			Monthly surface water: • CCC since 2013 Instream Sediment[51]: • Golder Associates (2009) [Site 11] • Whyte (2014)	spring-fed - plains[52]	2481242	5752409
Waterway	Ōtūkaikino River	OTUKAI04	Ōtūkaikino River Upstream of Dickeys Road				✓				Aquatic Ecology: • James (2012) [Site 1] • Noakes & Blakely (2017) [Site 1]	spring-fed – plains[54]	2479660	5752383
Waterway	Ōtūkaikino River	OTUKAI05	Kaikanui Creek Downstream of Clearwater Resort				✓				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 3] • James (2012) [Site 3] • Noakes & Blakely (2017) [Site 3]	spring-fed - plains[54]	2478147	5751998
Waterway	Ōtūkaikino River	OTUKAI06	Wilsons Drain at Tyrone Street				✓	✓			•	spring-fed - plains[53]	2480720	5751544
Waterway	Ōtūkaikino River	OTUKAI01	Ōtūkaikino River at Groynes Inlet	✓ (IGSC)	✓	✓			✓		Monthly surface water: • CCC since 2008	spring-fed - plains[55]	2477878	5750484

[50] Ecological Monitoring site was 5 m upstream of Gardiners Road (coordinates: 2476769, 5748827)

[51] Sediment sampling site was 97 m downstream in Ōtūkaikino Memorial Reserve (coordinates: 2481259, 5752508)

[52]Under the WRRP, this site is classified as "WAIM-TRIB", however for the purposes of the consent conditions, these will be considered as 'spring-fed – plains'

[53] Under the WRRP, this site is classified as "Class OTU/GROYNES"; however, for the purposes of the consent conditions, these will be considered as 'spring-fed – plains'

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Ōtūkaikino River	OTUKAI03	Ōtūkaikino Creek at Omaka Scout Camp	✓	✓	✓	✓		✓		Monthly surface water: • CCC since 2014 Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 6] • James (2012) [Site 6] • Noakes & Blakely (2017) [Site 6]	spring-fed - plains[55]	2475663	5749653
Waterway	Ōtūkaikino River	OTUKAI08	Ōtūkaikino Creek at McLeans Island Road				✓				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 9] • James (2012) [Site 9] • Noakes & Blakely (2017) [Site 9]	spring-fed - plains[55]	2472871	5748547
Waterway	Ōtūkaikino River	OTUKAI09	Ōtūkaikino River at Clearwater Resort				✓				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 4] • James (2012) [Site 4] • Noakes & Blakely (2017) [Site 4]	spring-fed - plains[55]	2476944	5751034
Waterway	Ōtūkaikino River	OTUKAI10	Ōtūkaikino River off Coutts Island Road				✓				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 7] • James (2012) [Site 7] • Noakes & Blakely (2017) [Site 7]	spring-fed - plains[55]	2474833	5751369
Waterway	Ōtūkaikino River	OTUKAI11	Ōtūkaikino River Headwaters				✓				Aquatic Ecology: • McMurtrie & Greenwood (2008) [Site 8] • James (2012) [Site 8] • Noakes & Blakely (2017) [Site 8]	spring-fed - plains[55]	2473541	5751286
Waterway	Linwood Canal/City Outfall Drain	OUT02	Linwood Canal/City Outfall Drain at Dyers Road			✓	✓				Instream Sediment: • Robb (1988) [Site OD8] • Gadd (2015) [Site 18] Aquatic Ecology: • Robb *et al* (1994) [Site Od9] • Blakely (2015a) [Site 18]	Spring-fed – plains – urban[11]	2485373	5740054
Waterway	Linwood Canal/City Outfall Drain	OUT01	Linwood Canal/City Outfall Drain at Humphreys Drive	✓ (IGSC)							Monthly surface water: • CCC since 2007	Spring-fed – plains – urban[11]	2485954	5739637

Environment	Catchment	Site ID	Location Description	Monthly Surface Water Quality Monitoring	Five-Yearly Wet Weather Surface Water Quality Monitoring	Five-Yearly Instream Sediment Quality Monitoring	Five-Yearly Aquatic Ecology Monitoring	Annual Aquatic Ecology Monitoring	Monthly Fine Sediment Monitoring	Five-Yearly Mana Whenua Values Monitoring	Previous Surveys	LWRP or RCEP Classification	Easting	Northing
Waterway	Stream Reserve Drain/Zephyr Stream (Governors Bay)	BP01	Stream Reserve Drain Above Outfall to Governors Bay	✓		✓	✓				Aquatic Ecology: • CCC (2005) [Site SQ00659]	Banks Peninsula (LWRP)	2482036	5731805
Waterway	Balguerie Stream (Akaroa)	BP03	Balguerie Stream Downstream of Settlers Hill (road)	✓		✓	✓	✓ (desktop assessment of Environment Canterbury data)			Aquatic Ecology: • Environment Canterbury annual monitoring site [Site SQ00170][54]	Banks Peninsula (LWRP)	2507759	5711175
Waterway	Aylmers Stream (Akaroa)	BP04	Aylmers Stream Downstream of Rue Jolie, Next to Bruce Terrace	✓		✓	✓				Aquatic Ecology: • CCC BPSES (2014)	Banks Peninsula (LWRP)	2506930	5710693
Coastal	Ihutai/ Avon-Heathcote Estuary	CW01	Estuary of the Heathcote and Avon Rivers/Ihutai at the Eastern Tip by Beachville Road[12,55]	✓	✓							Coastal Contact Recreation Water (RCEP)	2489005	5738492
Coastal	The Operational Area of the Port of Lyttelton	CW02	Lyttelton Port at the Small Wharf Opposite Voelas Road[57,56]	✓	✓							Coastal Aquatic Ecology Water (RCEP)	2486837	5733612
Coastal	Cass Bay	CW03	Eastern Side of Cass Bay off the Cass Bay Walkway[12,57]	✓	✓							Coastal Contact Recreation Water (RCEP)[58]	2485238	5733505
Coastal	Akaroa Harbour	CW04	Akaroa Harbour at the Termination of Rue Balguerie[12,59]	✓	✓							Coastal Shellfish Gathering Water (RCEP)	2507268	5711403

[54] This survey includes an assessment of habitat, periphyton, macrophytes and macroinvertebrates, but the survey methods are not exactly the same as that detailed in this monitoring programme; however, comparisons over time and to other catchments can still be carried out to a suitable level

[55] Sample is to be taken in the receiving environment as far as can be reached from the top of the stormwater outfall

[56] Site in location of stormwater outfall from an urban and industrial (i.e. port) catchment

[57] Sample is to be taken in the receiving environment at the low tide mark, approximately 25 m from the stormwater outfall

[58] This site in within the Lyttelton Harbour/Whakaraupo (West) area

13 Appendix C: Metal Hardness Modified Guideline Values

Hardness Modified Guideline Values for Metals in Christchurch City and Bank Peninsula Waterways

Introduction

The Australian and New Zealand guidelines for fresh and marine water quality provide a set of default guideline values for dissolved metals (ANZG, 2022). If measured concentrations of toxicants are below the default guideline values, then there is a low risk of adverse environmental effects.

The guidelines also provide a process of modifying the default guideline values for local environmental conditions, namely hardness, which can affect the toxicity of metals (excluding copper) and therefore increase the risk of adverse biological effects (Warne et al., 2018). The default guideline values for metals assume that water is soft (hardness 0–59 mg/L as $CaCO_3$). However, as water hardness increases, the toxicity of some metals decreases and therefore the guideline value may increase, without increasing the risk of adverse biological effects.

Hardness Modified Guideline Values (HMGV), formerly known as Hardness Modified Trigger Values, have been previously calculated by Christchurch City Council (Dewson, 2012; Margetts & Marshall, 2015). It is considered that hardness values are unlikely to change over the years, so these values can be reassessed approximately every five years.

A 2020 memorandum by Marshall & Margetts (2020) included the first five-yearly update of these values for Christchurch City waterways under the Comprehensive Stormwater Network Discharge Consent (CRC190445) and reflected the recommendation that copper is no longer modified by hardness (Warne *et al*., 2018). This current memorandum is an update to the 2020 memorandum to include Banks Peninsula waterway values. To have the assessments all in one place, this memorandum includes the 2020 City waterways values, as well as the Banks Peninsula values. The next review will be undertaken in 2025 – this will include Banks Peninsula values, even though this will be less than five years, to bring them into the same scheduling.

Methods

For waterway sites within Christchurch City, water samples were collected monthly in 2019 from 36 non-tidal sites across the five main river catchments within the City (Avon, Heathcote, Styx, Ōtūkaikino and Halswell Rivers), as well as a tidal site within Linwood Canal, giving a total of 12 samples for each of the 37 sites (Appendix A, Tables i and ii). Tidal sites within the wider monitoring programme[59] were excluded from the analyses, as tidal sites typically have high hardness levels, which would skew the results for each catchment, resulting in inappropriately higher guideline levels. As there was only one site for Linwood Canal, it did not matter that this site was tidal. However, it has since been established that coastal guideline values are more appropriate for Linwood Canal and therefore hardness modification is not required.

For Banks Peninsula waterway sites, water samples were collected in 2021 from three sites (Zephyr Stream, Balguerie Stream, and Aylmers Stream). Five samples were collected at Stream Reserve Drain and Balguerie Stream, and four samples were collected at Aylmers Stream.

[59] Avon River at Pages/Seaview Bridge, Avon River at Bridge Street, Heathcote River at Catherine Street, Heathcote River at Tunnel Road and Heathcote River at Ferrymead Bridge.

Boxplots of the water hardness data were created in RStudio (version 1.2.5033), to show the median and interquartile range. The dark line in the boxplots represents the median, and the bottom and top lines of the box represent the 25th and 75th percentiles (the interquartile range), respectively. The T-bars that extend from the box approximate the location of the 5th and 95th percentiles (using HAZEN methodology).

To calculate the HMGV, the following species protection levels were chosen, as per ECan (2018).

- Avon River, Heathcote River, and Linwood Canal catchments: 90% (Spring-fed – plains – urban)
- Styx, Ōtūkaikino, and Halswell River catchments: 95% (Spring-fed – plains)
- Cashmere Stream and Banks Peninsula catchments: 99% (Banks Peninsula)

These default guideline values were then modified by the median catchment hardness, as per the below formula (Warne *et al*., 2018).

$$\boldsymbol{Lead\ HMGV = Default\ Guideline\ Value\ x \left(\frac{hardness}{30}\right)^{1.27}}$$

$$\boldsymbol{Zinc\ HMGV = Default\ Guideline\ Value\ x \left(\frac{hardness}{30}\right)^{0.85}}$$

Results and Conclusions

Median water hardness in the five main river catchments in Christchurch City (Avon, Heathcote, Styx, Ōtūkaikino and Halswell Rivers) ranged from 'soft' to 'moderate'; however, Linwood Canal fell between the 'very hard' and 'extremely hard' categories (Table 1; Figures 1–2). Median water hardness at the three Bank Peninsula sites (Zephyr Stream, Balguerie Stream, and Aylmers Stream) was soft (Table 1; Figure 3). The HMGV are all greater than the default guideline values in each of the waterways, as the default values assume water is 'soft' to conservatively protect aquatic ecosystems (Table 1).

Table 1. Default and Hardness Modified Guideline Values (HMGV; ANZG, 2022) for dissolved zinc and lead in Christchurch City and Banks Peninsula waterways.

Catchment	Median hardness (mg/L)	Species protection level (ECan, 2018)	Zinc guideline		Lead guideline	
			Default (mg/L)	HMGV (mg/L)	Default (mg/L)	HMGV (mg/L)
Heathcote River – Cashmere Stream	94.0	99%	0.0024	0.00634	0.0010	0.00427
Halswell River	75.0	95%	0.0080	0.01743	0.0034	0.01089
Styx River	47.0	95%	0.0080	0.01172	0.0034	0.00601
Ōtūkaikino River	35.0	95%	0.0080	0.00912	0.0034	0.00414
Avon River	66.5	90%	0.0150	0.02951	0.0056	0.01539
Heathcote River – remainder	94.0	90%	0.0150	0.03960	0.0056	0.02388
Linwood Canal	370.0	90%	0.0150	0.12691	0.0056	0.13610
Stream Reserve Drain	38.0	99%	0.0024	0.00293	0.0010	0.00135
Balguerie Stream	32.0	99%	0.0024	0.00254	0.0010	0.00109
Aylmers Stream	38.0	99%	0.0024	0.00293	0.0010	0.00135

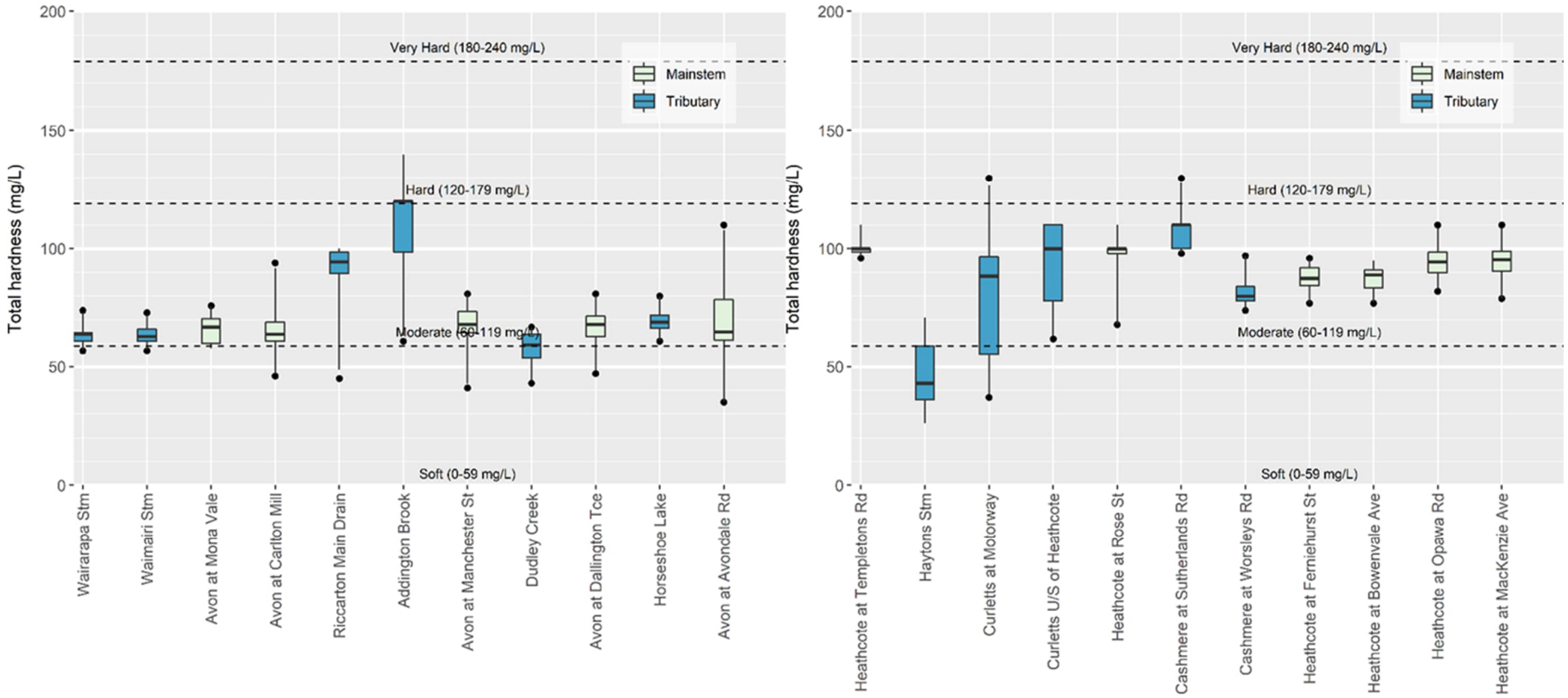

Figure 1. Total hardness (as $CaCO_3$) levels in water samples taken monthly from non-tidal sites within the Ōtākaro/Avon (left graph) and Ōpāwaho/Heathcote (right graph) River sites, for the monitoring period January to December 2019. No monitoring was undertaken at the Haytons Stream site in March and June, as the site was dry. Sites are ordered from upstream to downstream (left to right). The dashed lines represent the ANZECC (2000) delineations between water hardness categories.

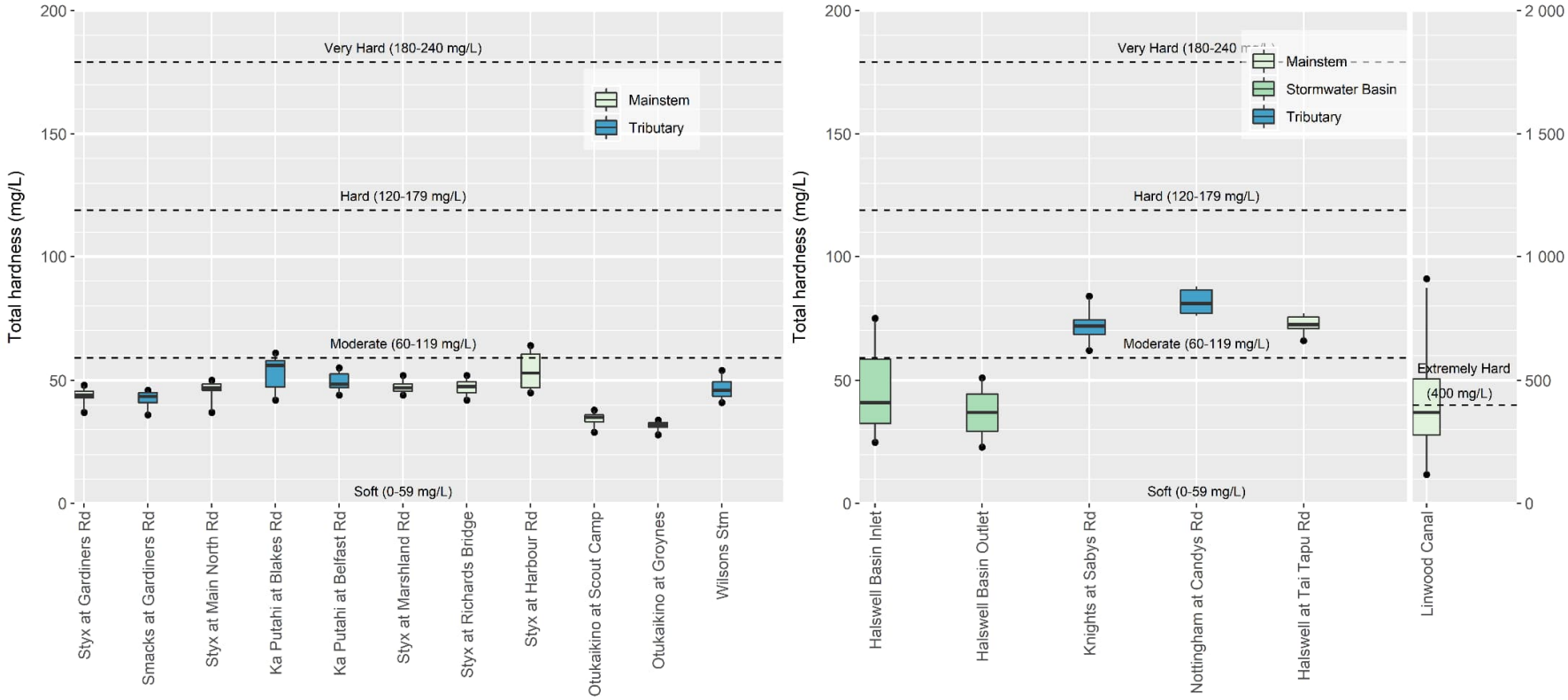

Figure 2. Total hardness (as $CaCO_3$) levels in water samples taken monthly from non-tidal sites within the Pūharakekenui/Styx and Ōtūkaikino Rivers (left graph), and the Huritini/Halswell River and Linwood Canal sites (right graph) for the monitoring period January to December 2019. No monitoring was undertaken at the Kā Pūtahi Creek at Blakes Road site in August and the Ōtūkaikino Creek at Omaka Scout Camp site in February, as these sites could not be accessed. Sites are ordered from upstream to downstream (left to right). The dashed lines represent the ANZG (2000) delineations between water hardness categories.

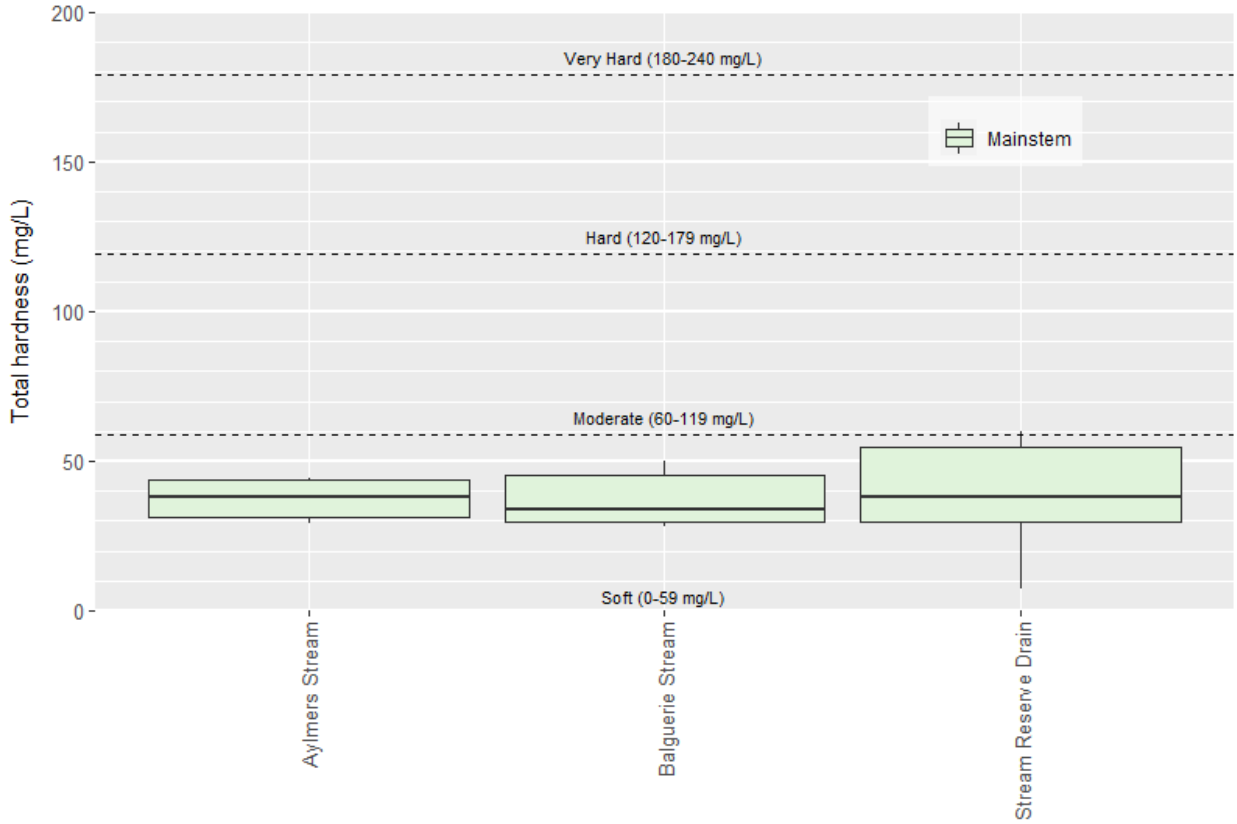

Figure 3. Total hardness (as $CaCO_3$) levels in water samples taken from three waterway sites in Bank Peninsula (Zephyr Stream, Balguerie Stream, and Aylmers Stream) for the monitoring period January to December 2021. The dashed lines represent the ANZG (2000) delineations between water hardness categories.

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20th June 2022

Appendix A: Site locations

Table i. Water quality monitoring sites for the water hardness investigations in the Avon and Heathcote River catchments.

Catchment	Site	Easting (NZTM)	Northing (NZTM)
Ōtākaro/ Avon	Avon River at Dallington Terrace/Gayhurst Road	1573560	5181210
	Avon River at Manchester Street	1570890	5180481
	Wairarapa Stream	1568250	5181303
	Waimairi Stream	1568233	5181172
	Avon River at Mona Vale	1568334	5181046
	Riccarton Main Drain	1568683	5180019
	Addington Brook	1569427	5179826
	Dudley Creek	1572574	5182150
	Horseshoe Lake Discharge	1574342	5183294
	Avon River at Carlton Mill Corner	1569737	5181259
	Avon River at Avondale Road	1574752	5183557
Ōpāwaho/ Heathcote	Heathcote River at Opawa Road/Clarendon Terrace[4]	1573071	5177615
	Heathcote River at Bowenvale Avenue	1571198	5175780
	Cashmere Stream at Worsleys Road	1569030	5175155
	Heathcote River at Rose Street	1568701	5175918
	Heathcote River at Ferniehurst Street	1569157	5175612
	Heathcote River at Templetons Road	1565915	5176897
	Haytons Stream at Retention Basin	1566020	5177596
	Curletts Road Stream Upstream of Heathcote River Confluence	1566928	5177711
	Heathcote River at Mackenzie Avenue Footbridge	1573520	5177917
	Curletts Road Stream at Southern Motorway	1566405	5178358
	Cashmere Stream at Sutherlands Road	1566086	5173988

Table ii. Water quality monitoring sites for the water hardness investigations in the Styx River, Halswell River, Ōtūkaikino River and Linwood Canal catchments.

Catchment	Site	Easting (NZTM)	Northing (NZTM)
Pūharakekenui/ Styx	Smacks Creek at Gardiners Road near Styx Mill Road	1566804	5187956
	Styx River at Gardiners Road	1566790	5187226
	Styx River at Main North Road	1569066	5187219
	Kā Pūtahi Creek at Blakes Road	1570401	5188030
	Kā Pūtahi Creek at Belfast Road	1572194	5188267
	Styx River at Marshland Road Bridge	1572358	5187778
	Styx River at Richards Bridge	1573975	5189640
	Styx River at Harbour Road Bridge	1574998	5194749
Huritini/ Halswell	Halswell Retention Basin Inlet	1561701	5177022
	Halswell Retention Basin Outlet	1561796	5176914
	Nottingham Stream at Candys Road	1564532	5173080
	Halswell River at Akaroa Highway (Tai Tapu Road)	1564446	5171721
	Knights Stream at Sabys Road	1563723	5172852
Ōtūkaikino	Ōtūkaikino River at Groynes Inlet	1567878	5188869
	Wilsons Drain at Main North Road	1571241	5190793
	Ōtūkaikino Creek at Omaka Scout Camp	1565664	5188038
Linwood	Linwood Canal/City Outfall Drain	1575952	5178026

Table iii. Water quality monitoring sites for the water hardness investigations within Banks Peninsula waterways (Zephyr Stream, Balguerie Stream, and Aylmers Stream).

Catchment	Site	Easting (NZTM)	Northing (NZTM)
Zephyr Stream	Stream Reserve Drain Above Outfall to Governors Bay	2482036	5731805
Balguerie Stream	Balguerie Stream Downstream of Settlers Hill (road)	2507759	5711175
Aylmers Stream	Aylmers Stream Downstream of Rue Jolie, Next to Bruce Terrace	2506930	5710693

14 Appendix D: Surface Water, Instream Sediment, Aquatic Ecology and Mana Whenua Values Monitoring Schedule

Table i. Five-yearly rotational monitoring schedule (for wet weather water quality, sediment quality, aquatic ecology and mana whenua values) for waterway and coastal sites, within Christchurch and Banks Peninsula

Catchment	Next Survey Due
Ōtākaro/ Avon River	2019
Opāwaho/ Heathcote River Linwood Canal Banks Peninsula Review of hardness-modified metal values	2020
Huritini/ Halswell River	2021
Ōtūkaikino River Coastal Waters	2022
Pūharakekenui/ Styx River	2023