# Ihutai/Estuary and Coastal Stormwater Management Plan

June 2022

# Ihutai/Estuary and Coastal Stormwater Management Plan

Three Waters Unit
Christchurch City Council

June 2022

TRIM ref 22/1536729

## Table of Contents

## List of Figures



## List of Tables

**List of Acronyms**

| Acronym | Definition |
|---|---|
| ANZG | Australian and New Zealand Guidelines for fresh and marine water quality |
| BMP | Best Management Practice |
| Council | Christchurch City Council |
| CHI | Cultural Health Index |
| CLM | Contaminant Load Model |
| DIN | Dissolved Inorganic Nitrogen |
| DRP | Dissolved Reactive Phosphorus |
| ECan | Environment Canterbury |
| *E. coli* | *Escherichia coli* |
| GWL | Groundwater Level |
| HAIL | Hazardous Activities and Industries List |
| ISQG | Interim Sediment Quality Guidelines |
| LLUR | Listed Land Use Register |
| LTP | Long Term Plan |
| LWRP | Land and Water Regional Plan |
| PAH | Polycyclic Aromatic Hydrocarbon |
| QMCI | Quantitative Macroinvertebrate Community Index |
| RL | Reduced Level (Council Datum) |
| RMA | Resource Management Act |
| SMP | Stormwater Management Plan |
| TOC | Total Organic Carbon |

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# 1. Executive Summary

Water quality and water environments of this catchment's inland waters have deteriorated over time as a result of urban development. Contaminants most often noted are sediment, copper, zinc and bacteria. It can be difficult to separate effects in the estuaries from effects in the three major rivers. Bacteria concentrations can be high in the inner estuary and the metals appear to be accumulating in estuary floor sediments. The ecological health of the few waterways in this catchment is poor.

The cultural health of the catchment is also poor. Food gathering sites affected by pollution and other indicators of cultural degradation and modification are also widespread. Low scores for indigenous vegetation diversity and cover are commonplace, and coastal and estuarine sites typically contain limited native vegetation in the riparian zone.

The Christchurch City Council has developed a stormwater management plan (SMP) for the Ihutai Estuary and Coastal catchment to comply with conditions of the Comprehensive Stormwater Network Discharge Consent 2019. The goal of the Consent is progressive stormwater improvement. Part of the task of progressive stormwater improvement will occur through the SMP and part will be effected through a future Surface Water Implementation Plan (SWIP) c2022/23.

In combination the SMP and SWIP will set out methods the Council will implement to progressively improve stormwater toward meeting standards and receiving environment targets in the consent. Mitigation strategies have been considered for stormwater contaminants that regularly exceed water quality targets and cause poor stream health, principally metals and sediment. The preferred strategy for the future is that the Council prioritise the control of contaminants at source. This should principally occur through education and regulation. The Council will seek to move over time toward capturing and treating contaminants (where necessary) as close to source as practicable.

Stormwater treatment systems and operational activities will play a part in water treatment, depending on space and the outcome of efficiency investigations. Planning measures, education and enforcement also need to be part of an integrated strategy.

Under the SMP the Council will:

- Continue to build or require facilities to mitigate the quality and quantity effects of urban development.
- Ensure the quality of stormwater from all new development sites or re-development sites is treated to best practice, and control sediment loss from consented construction activities
- Consult with key stakeholders to identify a long term zinc strategy consistent with current technologies.
- Collaborate with local and regional councils to approach central government seeking national measures and industry standards to reduce the discharge of building and vehicle contaminants.
- Investigate the feasibility of a District Plan rule to discourage copper and zinc claddings.

The SMP programme will contribute over time, with other strategies, toward delivering on Ngāi Tahu and Regional Plan objectives by stopping some contaminants from entering rivers and streams.

Waterway restoration, sediment removal and riparian planting (for temperature control, bank stability, shading, ecological habitat and recreational uses) also need to occur to create a healthy environment. These measures are not part of the SMP programme, but will be considered as part of the SWIP.

There are some risks of flooding which are area dependent. In general the risks are low in day-to-day and medium severity events, but they are expected to increase with time as sea level rise, driven by climate change, affects stormwater outfalls. The strategy for managing flooding is to:

- Require new buildings to be elevated above flood levels;
- Maintain accurate hydraulic (flooding) models and flood maps; and
- Maintain the functioning of existing stormwater outfalls.

# 1 Background to the Stormwater Management Plan

## 1.1 Purpose and scope

The purpose of a Stormwater Management Plan (SMP) is defined in condition 6 of the Comprehensive Stormwater Network Discharge Consent (CSNDC), CRC231955, and includes contributing to meeting contaminant load reduction standards, setting (and meeting) additional contaminant load reduction targets and demonstrating the means by which stormwater discharges will be progressively improved toward meeting receiving environment objectives and targets.

The aim of the CSNDC is to limit the adverse effects of stormwater discharges on surface and groundwater quality and quantity. The CSNDC promotes progressive water quality improvement toward targets in the Canterbury Land and Water Regional Plan through the use of best practicable options for stormwater quality improvement and peak flow mitigation.

Stormwater management plans set out the means by which the Council will comply with the conditions in the CSNDC. However due to governance processes the SMP cannot address all environmental improvement targets signaled in the consent. The SMP is given effect through the Council's Long Term Plan (LTP), which is a statutory process. The relative timing of LTP processes and the SMP do not permit this SMP to commit to unfunded, new initiatives to achieve aspirational targets.

The Council proposes to respond to the CSNDC by adding a second stream of improvement planning.

***COMPLIANCE STREAM***

Comprehensive Stormwater Network Discharge Consent (standards and targets)

⇩

**Stormwater Management Plan**

⇩

A plan to meet standards and targets set by consent conditions to limit stormwater contaminant discharges

***IMPROVEMENT STREAM***

Integrated Water Strategy 2019 (aspirations, improvements)

⇩

**A Surface Water Implementation Plan** (anticipated commencement 2022)

⇩

A plan identifying best practicable options to deliver at-source contaminant control and desired improvements in ecology and stream health over the long term

Both plans inform and are funded through the **Long Term Plan**

The SMP process includes:

1 Identify the existing state of the environment in the catchment.

2 Identify the contributions by existing and future activities to stormwater quality and quantity.

3 Estimate trends from urban growth, technology, lifestyle, climate, etc on water quality and quantity.

4 Devise measures (including planning, education, enforcement, source control, etc as funded in the LTP) to control or mitigate effects.

5 Confirm the effectiveness of chosen mitigation measures through contaminant load and flood modelling.

The Surface Water Implementation Plan process includes:

- Prepare a plan that will permit the Council to meet or exceed consent condition targets.
- Engage with Council teams and external stakeholders responsible for contaminant generating activities; obtain agreement about control measures.

### 1.1.1 Stormwater Management Plan coverage

This SMP is one of seven plans being prepared over the period 2020 to 2024 for the Ōpāwaho-Heathcote, Huritini/Halswell, Pūharakekenui/Styx, Ōtākaro/Avon, Ihutai/Estuary and Coastal, and Ōtukaikino catchments and Te Pātaka-o-Rākaihautū/Banks Peninsula Settlements (Figure 1).

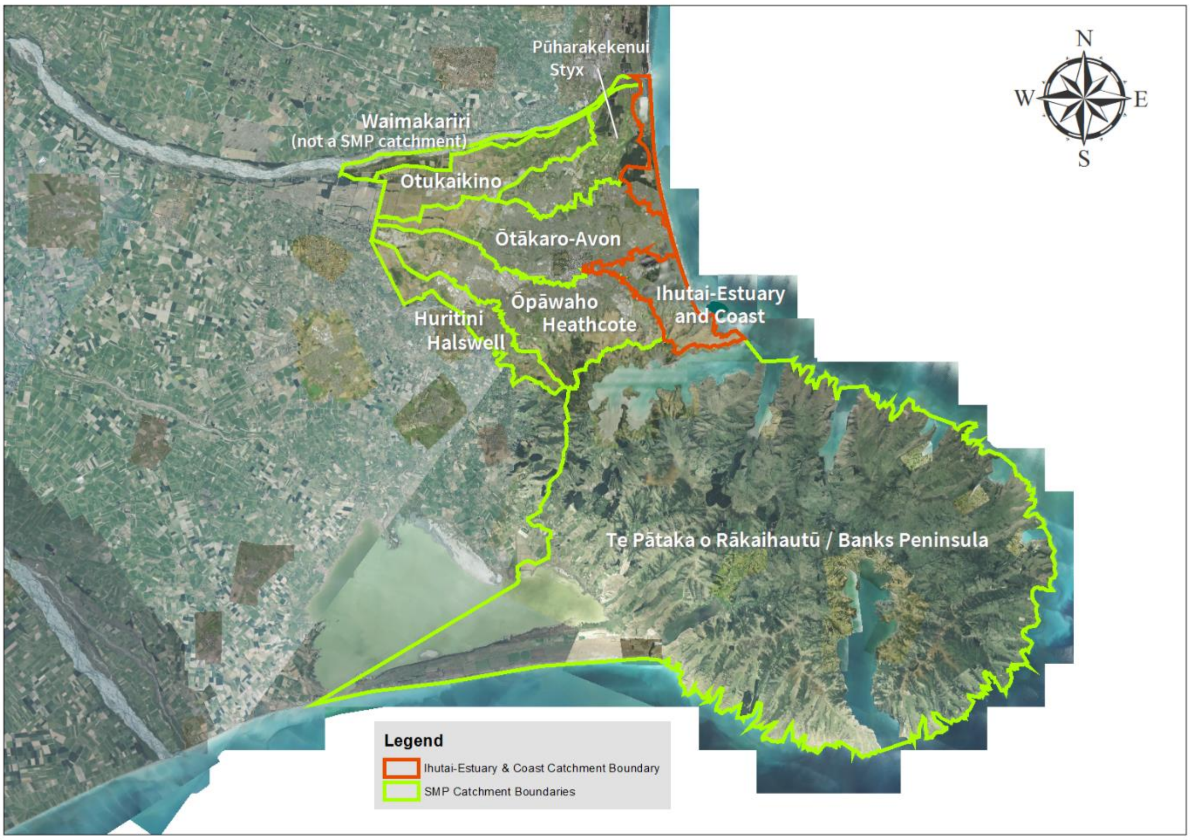


Figure 1: Area covered by the Comprehensive Stormwater Network Discharge Consent

While the larger part of the area comprises small catchments discharging directly to the coast, there are significant influences from the Ōtākaro/Avon and Ōpāwaho/Heathcote catchments whose rivers discharge into Ihutai and influence its processes and water and sediment quality. The Pūharakekenui-Styx River affects Te Riu o Te Aika Kawa-Brooklands Lagoon by discharging through it and possibly contributing sediment and contaminants.

## 1.2 Regional Planning Requirements

### 1.2.1 Canterbury Regional Policy Statement

The Canterbury Regional Policy Statement (CRPS) sets out how natural and physical resources are to be sustainably managed in an integrated way. The needs of current and future generations can be provided for by maintaining or improving environmental values. The CRPS requires that objectives, policies and methods are to be set in regional plans, including the setting of minimum water quality standards.

### 1.2.2 Canterbury Land and Water Regional Plan

The Canterbury Land and Water Regional Plan (CLWRP) 2015 encourages the development of stormwater management plans under Rule 5.93. The intention of the rule is that SMPs will be developed to show how local authorities will meet the relevant policies on water quality.

### 1.2.3 Greater Christchurch Urban Development Strategy

The Greater Christchurch Urban Development Strategy (UDS) Partnership has been working collaboratively for over a decade to tackle urban issues and manage the growth of the City and its surrounding towns.

The strategy was prepared under the Local Government Act 2002 and it is to be implemented through various planning tools, including:

- Amendments to the Canterbury Regional Policy Statement (CRPS);
- Changes to regional and district plans to reflect the CRPS changes;
- Stormwater planning to give effect to the CLWRP; and
- Outline Development Plans for new development areas (‘Greenfield areas’) and existing re-development areas (‘Brownfield areas’).

Preparation of this SMP plays a role in implementing the UDS.

## 1.3 Non-Statutory Documents

- Integrated Water Strategy 2019
- Surface Water Implementation Plan 2022 (to be developed)
- Mahaanui Iwi Management Plan 2013
- Ngāi Tahu Freshwater Policy Statement (Te Runanga O Ngāi Tahu 1999)
- Infrastructure Design Standard (Christchurch City Council 2010)
- Waterways, Wetlands and Drainage guide (Christchurch City Council 2003)
- Erosion and Sediment Control Toolbox for Canterbury (Environment Canterbury)
- Estuary Management Plan 2020 – 2030 (Avon-Heathcote Estuary Ihutai Trust)
- Greater Christchurch Urban Development Strategy (UDS) (Christchurch City Council 2007)

## 1.4 The Council's Strategic Objective for Water

The Christchurch City Council has adopted Community Outcomes to promote community wellbeing. The Water Outcome Healthy Environment includes:

Healthy water bodies "Surface water quality is essential for supporting ecosystems, recreation, cultural values and the health of residents."

## 1.5 The District Plan

The Christchurch District Plan promotes responsible stormwater disposal through Policy 8.2.3.4 – Stormwater Disposal, which states:

a. District-wide:
   i. Avoid any increase in sediment and contaminants entering water bodies as a result of stormwater disposal.
   ii. Ensure that stormwater is disposed of in a manner which maintains or enhances the quality of surface water and groundwater.
   iii. Ensure that any necessary stormwater control and disposal systems and the upgrading of existing infrastructure are sufficient for the amount and rate of anticipated runoff.
   iv. Ensure that stormwater is disposed of in a manner which is consistent with maintaining public health.

b. Outside the Central City:
   i. Encourage stormwater treatment and disposal through low-impact or water-sensitive designs that imitate natural processes to manage and mitigate the adverse effects of stormwater discharges.
   ii. Ensure stormwater is disposed of in stormwater management areas so as to avoid inundation within the subdivision or on adjoining land.
   iii. Where feasible, utilise stormwater management areas for multiple uses and ensure they have a high quality interface with residential activities or commercial activities.
   iv. Incorporate and plant indigenous vegetation that is appropriate to the specific site.
   v. Ensure that realignment of any watercourse occurs in a manner that improves stormwater drainage and enhances ecological, mahinga kai and landscape values.
   vi. Ensure that stormwater management measures do not increase the potential for bird-strike to aircraft in proximity to the airport.
   vii. Encourage on-site rain-water collection for non-potable use.
   viii. Ensure there is sufficient capacity to meet the required level of service in the infrastructure design standard or if sufficient capacity is not available, ensure that the effects of development are mitigated on-site.

District Plan Policies 8.9.2.2 and 8.9.2.3 make earthworks subject to a consent. Conditions of consent for earthworks over a threshold include the requirement for an Erosion and Sediment Control (ESC) Plan. An ESC Plan is submitted and approved with a consent application and its implementation is verified by building consent officers.

## 1.6 Bylaws

The Stormwater and Land Drainage Bylaw 2022 restricts discharges of any material, hazardous substance, chemical, sewage, trade waste or other substance that causes or is likely to cause a nuisance, into the stormwater network.

The Traffic and Parking Bylaw 2017 empowers Council to require offenders to remove material (mud, stones, etc) spilled onto streets.

## 1.7 Building Act

The Council can use powers under the Building Act to require ESCPs to be submitted when an associated land use consent is not required.

## 1.8 Integrated Water Strategy

Objectives 3 and 4 of the Christchurch City Council's draft Integrated Water Strategy are summarised as "enhancement of ecological, cultural and natural values and water quality improvement." The preferred Strategy option for achieving the objectives is to "continue … the implementation of the current approach to stormwater management (embodied by the development of the Stormwater Management Plans) …"

## 1.9 Mahaanui Iwi Management Plan

The Mahaanui Iwi Management Plan "… is an expression of kaitiakitanga and rangatiratanga…(It) provides a values-based, … policy framework for the protection and enhancement of Ngāi Tahu values, and for achieving outcomes that provide for the relationship of Ngāi Tahu with natural resources across Ngā Pākihi Whakatekateka o Waitaha and Te Pātaka o Rākaihautū (the Canterbury Plains and Banks Peninsula)". The Ihutai Estuary and Coastal SMP acknowledges the Iwi Management Plan policies, and can contribute to policies which fall within the scope of a stormwater management plan. There is more detail in section 9.6.2.

## 1.10 Infrastructure Design Standard

The Infrastructure Design Standard 2016 (IDS) is the Council's development code and is a revision of the Christchurch Metropolitan Code of Urban Subdivision 1987. The IDS promotes environmental protection via a values based design philosophy and consideration of bio-diversity and ecological function (Section 5.2.3 "Four Purposes").

## 1.11 Goals and Objectives for Surface Water Management

The Ihutai/Estuary and Coastal Stormwater Management Plan and the Surface Water Implementation Plan will together be consistent with the Integrated Water Strategy 2019 which identifies overall goals and objectives for surface water management. Jointly these plans will support so far as is practicable the Mahaanui Iwi Management Plan objectives for the Ihutai/Avon-Heathcote Estuary catchment (see Jolly et al, 2013).

The Council's high-level goals in the Integrated Water Strategy are:

Goal 1: The multiple uses of water are valued by all for the benefit of all;
Goal 2: Water quality and ecosystems are protected and enhanced;

Goal 3: The effects of flooding, climate change and sea level rise are understood, and the community is assisted to adapt to them; and
Goal 4: Water is managed in a sustainable and integrated way in line with the principles of kaitiakatanga.

Te Rūnanga o Ngāi Tahu Freshwater Policy (Ngāi Tahu, 1999) lists several water quality and water quantity policies that apply throughout the Ngāi Tahu Takiwā. The Iwi Management Plan lists objectives for Te Waihora catchment are directly relevant to the Ihutai/Estuary and Coastal SMP. These are:

4) Discharges of wastewater and stormwater to waterways in the urban environment are eliminated, and a culturally appropriate alternative to the discharge of urban wastewater to the sea is developed.

7) Urban development reflects Low Impact Design (LID) principles and a strong commitment to sustainability, creativity and innovation with regard to water, waste and energy issues.

The CSNDC sets freshwater outcomes based on CLWRP targets. The CSNDC Environmental Monitoring Programme (EMP) will assess the ecological and cultural health of waterways and coastal areas, and progress made under the SMP. The EMP assesses a range of parameters, and progress can be measured against CLWRP guidelines for macroinvertebrate indices, macrophytes, periphyton, siltation and a range of water quality parameters.

The SMP programme will contribute toward delivery on these objectives through improving water quality in the streams, rivers, estuary and coast. Other plans and programmes must play a part in improving water quality, restoring riparian margins, and protecting and restoring springs and mahinga kai sites in order to deliver on Tangata Whenua and CLWRP objectives. Stormwater quantity effects considered in this SMP include mitigation of additional runoff generated by urban intensification and the reduction in network level-of-service in the east of the catchment as sea levels rise over the SMP planning period.

Other sources and reports that have informed the SMP include:

- State of the Takiwā;
- Surface water and sediment quality monitoring;
- Contaminated sites database (ECan);
- Groundwater and springs study;
- Ecological survey;
- Review of flood management matters through the various chapters of the District Plan;
- Contaminant load model.

The duration of this stormwater management plan is ten years. It indicates a direction for surface water management under the CSNDC. To make a difference to the existing fair to poor water quality in receiving waters, it will be necessary to not only mitigate any adverse effects from new urban growth, but also implement stormwater quality mitigation measures in existing developed areas.

Flooding is being investigated, with the first step being completion of an improved stormwater model. The Council is separately planning for coastal hazards associated with sea level rise.

# 2 Principal Issues

## 2.1 Water Quality and Ecological Health

Water quality and ecological health have declined during 160 years of urban development. Metals (e.g. copper and zinc) in stormwater deplete or kill many instream species and sediment smothers and deoxygenates stream beds.

Failure to meet indicator values in the CLWRP for urban spring-fed plains rivers is common throughout Christchurch and is observed in the City Outfall Drain (which is the only continuously flowing waterway in this catchment). Common contaminants of concern include sediment, zinc, copper and *Escherichia coli* (an indicator of faecal contamination). Suspended sediment, zinc and copper levels can be high, especially during wet weather. Elevated levels of the nutrients nitrogen and phosphorus, which are partially derived from sources other than stormwater, have caused excessive aquatic weed growth in the past and may still contribute to the amount of algae and weed in the estuary. The contaminants of concern have an adverse effect on biota, result in excessive aquatic weed growth, or pose a risk to contact recreation depending on the particular contaminant.

The issue for the SMP is to do what it can to reverse the decline in surface water quality and the health of the estuary despite continuing urban development.

## 2.2 Flood Risk

Low lying houses can be flooded in large rainfall events and some coastal streets experience tidal flooding. Land subsidence during the 2010/11 earthquakes has increased the flooding vulnerability of many properties, some of them distant from a river or the coast.

The Council has improved its knowledge about the impacts of the earthquakes on increasing vulnerability to flooding through the (post-earthquake) Land Drainage Recovery Programme, and is working to revise a stormwater network (flood and capacity) model.

Sea defences (e.g. sea walls) can interrupt the free outflow of storm water and lead to near-coastal ponding.

The Council has initiated a programme of coastal hazards adaption planning which will start with communities in Whakaraupō / Lyttelton Harbour in 2022. The intention is to progressively cover all parts of the Christchurch District that will be affected by increased inundation, erosion and groundwater levels increasing following sea level rise.

# Section Two
# The Catchment

## 3 Catchment Description

### 3.1 Geography

The Ihutai/Estuary and Coastal catchment is 4,700 hectares in area comprising ⅔ coastal plains and ⅓ hills. The catchment comprises the coastal fringe from Te Riu O Te Aika Kawa/Brooklands Lagoon to Godley Head. Plains sub-catchments include Parklands, parts of North and South New Brighton, Linwood east of the central city and Bromley. Hill catchments Mount Pleasant and Redcliffs drain into Ihutai, and Clifton Hill, Sumner and Scarborough drain to the open ocean.

The coastal plains formed within the last 6,000 years in response to seaward extension of the Canterbury Plains. Sediments washed down the Waimakariri River built up the shore in a series of dune ridges and inter-dune swamps during a period of sea level recession. The Brighton Spit formed within the last 1,000 years and depends on a supply of sand from the Waimakariri River for its continued existence (Brown & Weeber, 1992) (Figure 2).

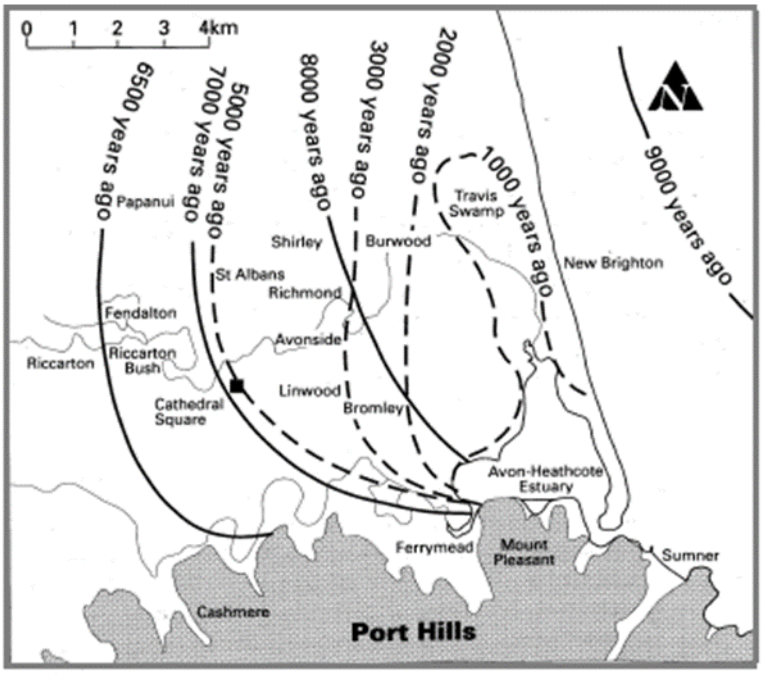


Figure 2: Changing coastline near Ihutai, last 9,000 years (Brown & Weeber, 1992)

The Port Hills, which consist of basalt lava and agglomerate, form the northern rim of a volcanic crater centered in Lyttelton Harbour. The hills rise from sea level to 500 m with the greater part of the summit rim over 400 m. Northern slopes are dissected into steep-sided valleys whose streams are small and only flow intermittently. Stream divides are narrow at high levels but below 300 m they broaden into smooth rolling spurs. Valley heads are steep and rocky but at low levels the valley sides are short and broken by basalt bluffs. Runoff from the hills carries sediment from under-runners, slips and surface erosion.

### 3.2 Soils

#### 3.2.1 Soils of the Port Hills

Wind-blown silt (loess) mantles all the hill slopes and is the principal material from which soils on rolling and hilly lands are derived. It lies deepest on the sides and tops of spurs and on rolling slopes at high levels but it is thin and discontinuous where slopes increase from rolling to steep. Steep-land soils are derived from mixtures of basaltic materials with loess. Alluvial fans which occupy the floors of the valleys of the Port Hills consist of material derived from basalt and loess and can be distinguished from other types of alluvium by the brownish colour.

Rural hill catchments can be slow to respond to rainfall until a large soil moisture store – equivalent to about 25 - 30 mm of rain where soils are deep – has been filled.

### 3.2.2 Soils of the Coastal Plain

Waikuku loamy sand, formed on dune sand accumulated within the last 1 – 2,000 years, occurs up to 3 km inland of the coastal dunes. This shallow soil accumulated over time under coastal vegetation. Kairaki sand occurs on a narrow strip of dunes bordering the shore and extending inland to a maximum width of 1½ kilometres (Raeside, 1974). These soils are free-draining except in lower lying areas (e.g. much of Parklands) where the water table is close to the surface and can impede drainage.

Soils of Linwood and the central city parts of the catchment are a heavy Taitapu deep silt loam that is poorly draining.

## 3.3 Drainage Network

### 3.3.1 Streams and drainage channels

Water features in coastal plains areas historically took the form of inter-dunal swamps or intermittently wet areas. With urban development these areas have been drained by pipes discharging to the shore. Most hill catchments discharge via open waterways and most waterways in built-up areas have been lined (Figures 3 to 6).

Waterways in the Ihutai/Estuary and Coastal catchment are typically ephemeral or intermittent. These include the more prominent waterways including Sumner Stream, Charlesworth Drain, Mt Pleasant Waterway and Rifle Range Stream, along with many other ephemeral waterways on the Port Hills. Notable exceptions are the City Outfall Drain and Linwood Canal, which are fed by groundwater throughout the year.

The Ōtākaro/Avon and Ōpāwaho/Heathcote Rivers are important contributors of water, nutrients, sediment and other contaminants to Ihutai/Estuary and the coast and are influenced by tidal flows and the movement of wildlife.

### 3.3.2 Stormwater system

At the top end of the public stormwater network are road side channels which receive discharges from private property and the carriageway. The primary function of side channels is to maintain dry traffic lanes. Side channels lead to street sumps (catchpits) which discharge into the pipe network. The pipe network is optimised to convey flow without sedimentation. Its level of service is the provision of road drainage to avoid traffic hazards in a five year average recurrence interval rainfall. Occasional road and property flooding occurs due to sump blockage or system capacity. Stormwater quality treatment is not provided by the network, except for a few small infiltration basins, and rain gardens along the McCormacks Bay Causeway.

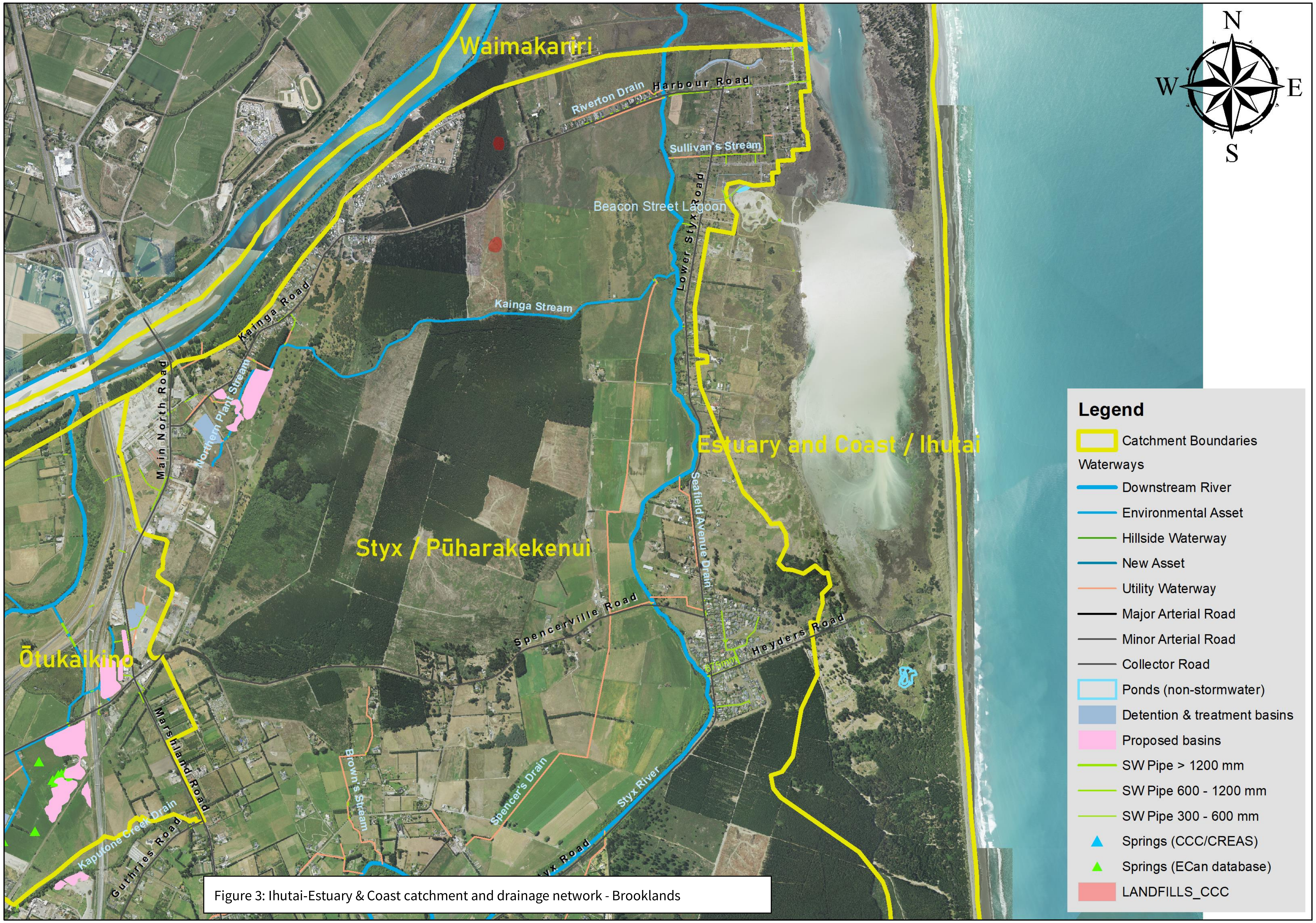

Figure 3: Ihutai-Estuary & Coast catchment and drainage network - Brooklands

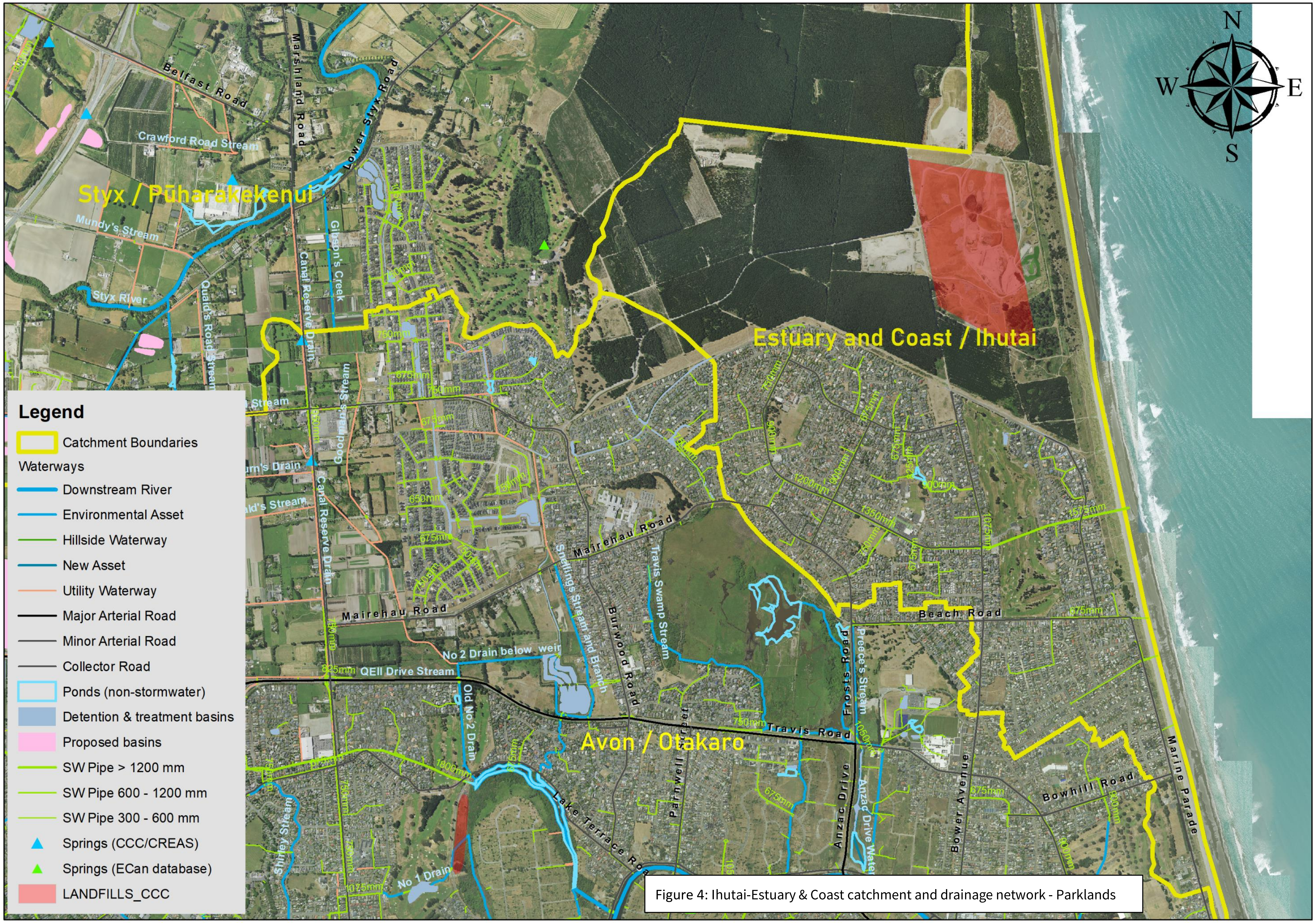


Figure 4: Ihutai-Estuary & Coast catchment and drainage network - Parklands

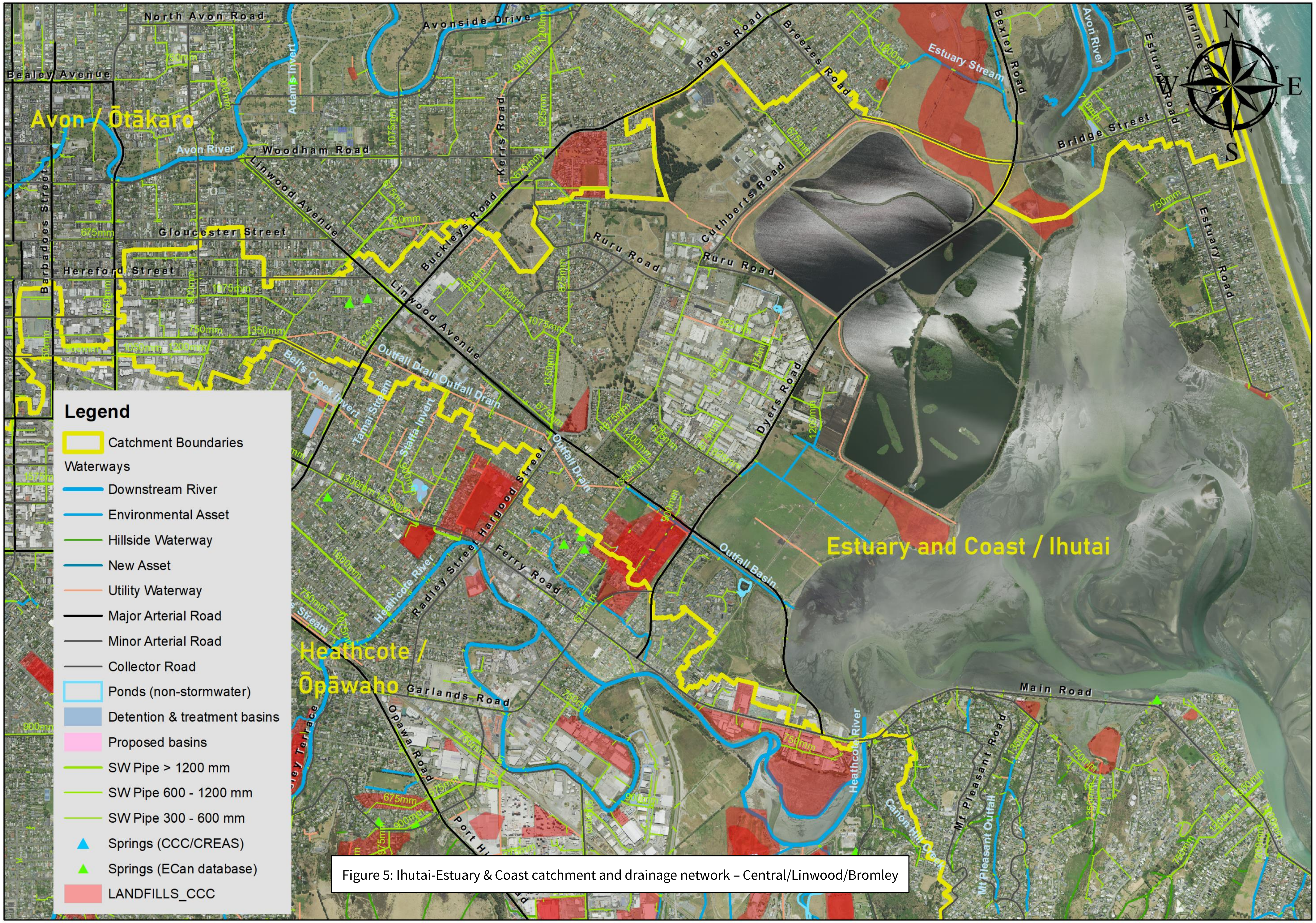


Figure 5: Ihutai-Estuary & Coast catchment and drainage network – Central/Linwood/Bromley

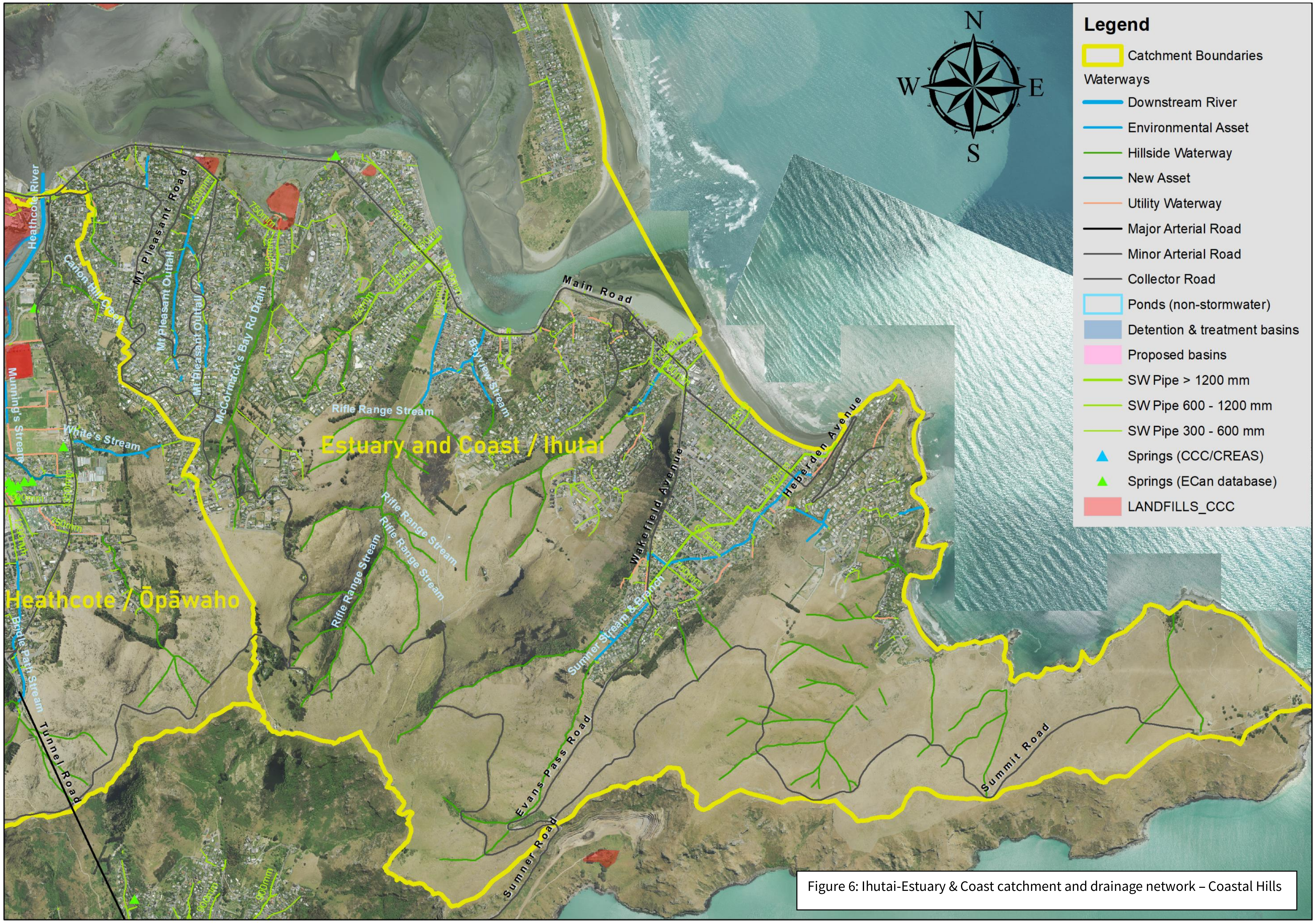


Figure 6: Ihutai-Estuary & Coast catchment and drainage network – Coastal Hills

## 3.4 Groundwater

The flat-land part of the catchment lies over the seaward end of Christchurch's artesian aquifer system. There is a tendency for upward leakage to be occurring from the aquifer system, potentially elevating groundwater levels and preventing contaminant infiltration to the aquifers (Figure 7).

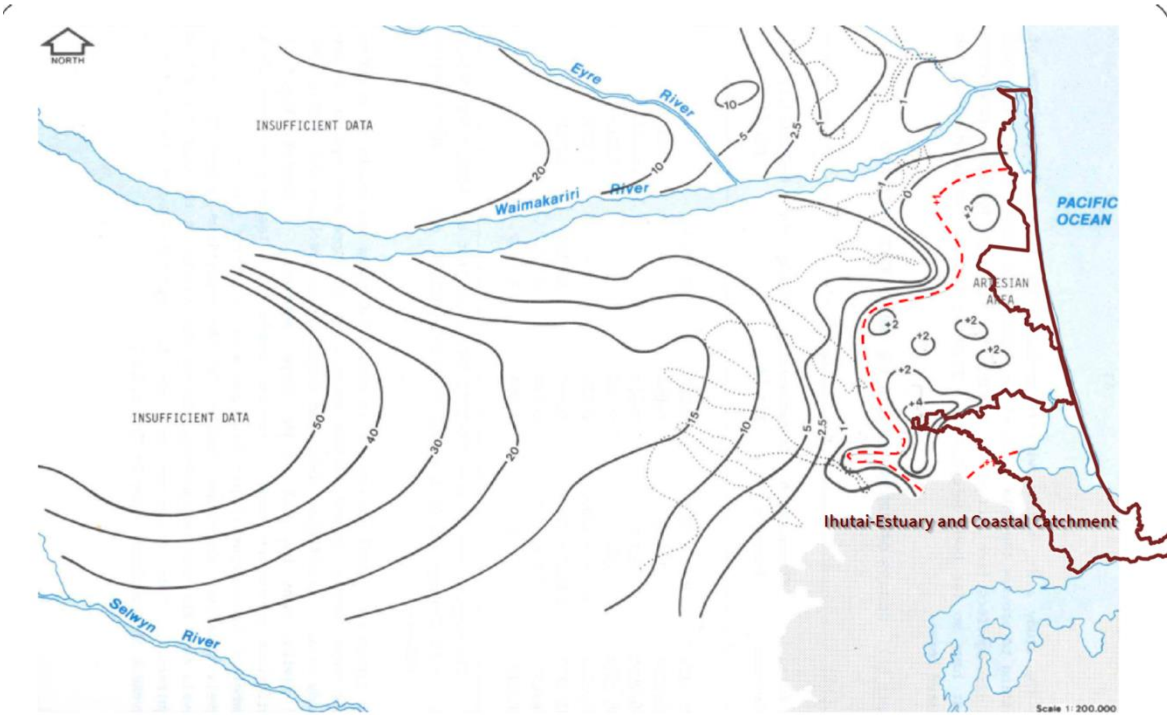


Figure 7: Piezometric surface contours: indicating positive aquifer pressure

Most urban contaminants enter the stormwater network along with stormwater runoff and are discharged to the ocean or into the estuary. Some urban contaminants may be able to affect shallow groundwater through infiltration. It is likely that some roof water is discharged into ground soakage in sandy areas such as New Brighton and Southshore. Urban contaminants should not be able to enter artesian aquifers.

# 4 Tangata Whenua Cultural Values

## 4.1 Values

Water is a taonga (a natural resource which is highly prized). In its Whakapapa water is referred to as the vines of Papatuanuku and represents the life blood of the environment. Traditional values and controls on water are included in spiritual beliefs and practices. Maori hold absolute importance to water quality in relation to Mahinga kai and hygiene. The Whakapapa of a waterway would determine its use for Tohunga (spiritual), Waiwhakaheketupapaku (burial sites), Waitohi (Tohunga use i.e. removal of Tapu), Waimataitai (coastal sea mix of fresh and salt water, estuaries), Waiora (Tohunga healing water), and Mahinga kai (food source).

The maintenance of water quality and quantity is perhaps the paramount resource management issue for Tangata Whenua. All waterways are a predominant feature within the landscape and should remain as a feature. A few would say that some waterways are more important than others because Tangata Whenua Whakapapa directly relates to it, and it is part of their identity. However, to do so would be to miss those waterways that feed into, and are part of that main waterway. A holistic approach culturally then is that all waterways are significant. Waterways begin as rain drops connecting together as streams, lake estuaries, and wetlands, all leading out to the coast; all is one.

The links to natural resources directly determined the welfare and future of the tribe. Those with resources flourished, while those without perished. Therefore, the management and maintenance of resources was the foremost concern. This acknowledged inter-dependence with the environment is central to Maori creation stories, religious belief, and resource management techniques.

The land, water and resources in a particular area are representative of the people who reside there. They relate to the origin, history and tribal affiliations of that group, and are for them, a statement of identity.

As a mahinga kai area, Ōtautahi/Christchurch provided freshwater and saltwater fish species and shellfish. There was an abundance of bird life for kai and raranga (weaving), numerous plant and natural materials for building whare, waka, and rongoa species. The estuaries and swamps provided raupo, harakeke and pingao, mud, soils, tree bark and berries for dyes, and plant seeds for oils. Tangata Whenua also used plants and birds as Tohu (sign) to stop harvesting a species such as titi, change of season, or, a marking spot for Wahi Tapu or Nga Wahi Taonga sites, such as a special placement of a number of cabbage trees.

## 4.2 Traditional history of Ihutai Estuary

The migration story of Ngāi Tahu from the east coast of the North Island to Canterbury is often told through the oral tradition of the accounts of Moki and his elder brother Tūrakautahi. Moki was the war chief of this expedition and the youngest son of Tūāhuriri, the senior Ngāi Tahu chief of the Ngāi Tūhaitara hapū (later to become Ngāi Tūāhuriri). Moki led the war party south to avenge the death of his father's wives at the hands of Tutekawa.

The arrival of Ngāi Tūhaitara/Ngāi Tahu around the late 17th/early 18th century saw the establishment of a network centred on Te Pa o Tūrakautahi/Kaiapoi Pā, established by Tūrakautahi.

Tau (2003) translates oral tradition about the dispersal of hapū of Ngāi Tahu to various areas of Canterbury, establishing mana whenua:

"…After a time…. the population increased and because of the 'warrior like' (ngākau toa) natures the people began to fight amongst themselves. Therefore, some of them decided to look for a better place. Turakautahi sent out the word that the people were to be separated into their (hapū) groups. Ngāti Hinekakai, Ngāti Hurihia (Urihia) separated to Tuahiwi here, to stay in their own Pā. Afterward the other people were separated, Turakipo to Opawaho, Manuhiri to Koukourārata right down to Whakaraupō. Makō went to Wairewa on the way to Whakaroa and Te Ruahikihiki together with his in-law, Kaweriri were sent to Taumutu. Te Ariki went to Arowhenua together with most of his people Kāti Huirapa…."

**Ihutai and Coastal sites of occupation**

The Ihutai/Estuary and Coastal area was extensively used by Ngāi Tahu whanau for mahinga kai and multiple kāinga nohoanga existed along the coastline of Te Tai o Mahaanui. The Ōtākaro River had two main pā sites, Puāri and Tautahi (Ōtautahi). These were seasonally used to collect mahinga kai from the Ōtākaro River. The Ōpāwaho River had a waho (outpost) near where it meets Ihutai and was an important mahinga kai site to manawhenua. The upper part of the Ōpāwaho River is known as the Ōmokihi. Both of these rivers contributed to the abundant mahinga kai resources that Ihutai was renowned for. When mana whenua first arrived Ihutai would have been open bay, with Te Karoro Karoro/New Brighton spit being formed following a change in position of the Waimakariri river between 1250-1500AD.

There are significant signs of occupation around Ihutai with many middens, former burial areas and horticultural and fishing areas. Many sites of occupation are associated with caves and rockshelters along the northern slopes of the Port Hills. These sites include Te-Ana-o-Hineraki/Moa Bone Point Cave, Redcliffs flat and Moncks Cave. The remains of an eeling weir on the western shore of Te Ihutai demonstrates the importance of the estuary for mahinga kai practices. Te Riu o Te Aika Kawa/Brooklands lagoon, Pūharakekenui/Styx river and Kā Putahi/Kaputone creek are home to many recorded middens and umu (firepits) indicating a series of nohoanga (encampments) evidencing the seasonal harvesting of resources. Other kāinga ta upua (temporary village) sites have no physical evidence remaining and their former locations are only known through whakapapa and stories.

**Mahinga kai and Ihutai Estuary**

The importance of the larger Ihutai catchment to mahinga kai practises is evidenced by Ngāi Tahu claims to the Native Land Court in 1868. These claims attempted to have traditionally significant sites set aside as mahinga kai reserves. These sites included Waikakariki (Horseshoe Lake), Pūtaringamotu (Riccarton Bush), Te Kai a Te Karoro (Jellicoe Park), Ōtautahi (Kilmore street), Waitākari (Bottle Lake), Pūrai (Worcester Street), Ohikaparparu (mudflats on the beach near Sumner), and Ōruapaeroa (Travis Wetland). These attempts were unsuccessful and Ngāi Tahu were denied access to the mahinga kai resources of the Ihutai catchment, preventing the sustainable management and harvest of these taonga species.

## 4.3 Cultural Position Statement

A cultural position statement for the draft Ihutai/Estuary and Coastal Catchment Stormwater Management Plan was carried out by MKT. The position statement assessment completed in November 2022 is with Te Ngāi Tūāhuriri Rūnanga for approval. The assessment made a number of recommendations to improve recognition of Ngāi Tahu cultural values, modify catchment management and monitor progress. The SMP has been modified as indicated in Table 1.

Table 1: Response to Cultural Position Statement Assessment

| Mana Whenua Requirements | Response through the SMP | Reason |
|---|---|---|
| Engage with mana whenua prior to any proposed changes, enhancements, translocations and/or diversions as opposed to being consulted retrospectively. | Yes, the Council expects to engage with mana whenua in this way | |
| Ensure mana whenua are able to implement their own management strategies which include practices such as rahui, or other customary tools and therefore is also in keeping with treaty principles. | Where mana whenua management strategies can be effected through stormwater management plans the Council will engage with mana whenua in good faith and will implement what is achievable | |
| Ensure that the Ihutai/Estuary and Coastal SMP area is managed in conjunction with the SMPs for Ōpāwaho, Ōtākaro and Pūharakekenui. This is in keeping with the principle of ki uta, ki tai. | Within the limits of what can be achieved the SMPs are managed with reference to the effects of one on another | |
| Increase riparian planting throughout the catchment, especially including planting of the saltmarsh areas and buffer planting in areas of historically contaminated land. | Council Units will be made aware of this recommend-ation directly and through two proposed plans:<br><br>Healthy Water Bodies Action Plan,<br><br>Strategic plan for surface water. | |
| Ensure that all waterways in the catchment are treated to | We understand that this recommendation means “all | Agreement with the principle of Ki uta ki tai. |

| | | |
|---|---|---|
| the same standard and managed for mahinga kai collection in the future. | waterways are equally important", and agree. More contaminated waterways are likely to be treated differently to capture contaminants, with the intention to raise water quality standards everywhere. | |
| Conduct studies to investigate the effectiveness of current stormwater treatment facilities e.g. Stormwater basins. | Yes, this is happening | The Council is required to do this by a consent condition. |
| Ensure the protection and enhancement of known spring sites. | Policy 9.5.2.2.3 – Ngā wai in the Christchurch District Plan protects the natural character of springs. Section 8.7.4.6 (CDP) allows conditions to control the extent to which springs are protected. Council projects will always protect springs near water bodies. | |
| Where stormwater treatment facilities can't be installed, ensure that stormwater is diverted into the wastewater system, especially in industrial areas. | This should be effective in principle. The Council is investigating feasibility, however it seems unlikely to become widely used. | Stormwater flows are much larger than wastewater flows and in most places there is insufficient capacity in the wastewater network. |
| Commence monitoring in Cashmere Stream of kākahi population. | Yes | Part of the Environmental Monitoring Programme |
| Support State of the Takiwā reporting in the catchment; however, this requires coastal sites to be monitored with the streams that contribute to Ihutai, Te Riu o Te Aika and Te Tai o Mahaanui in order to capture the cultural value of ki uta, ki tai. | A State of the Takiwā framework is being developed in consultation with Mahaanui Kurataio and a MKT employee is being funded to do this (and other duties).<br>An additional monitoring site at Garlands Rd bridge will be | Part of the Environmental Monitoring Programme |

| | | |
|---|---|---|
| | considered for inclusion next year. | |
| Conduct a survey of stormwater basins to ensure fish do not get trapped in stormwater treatment facilities. | Existing stormwater basins are being surveyed and a recommendation will be made listing priorities for fish passage improvement. The legal requirement to maintain fish passage is understood. Fish generally excluded from contaminated areas. | |

## 4.4 Monitoring

Cultural monitoring will enable the Council and Ngāi Tāhu to compare future condition against the State of the Takiwā Report, 2007. Cultural monitoring is required by a consent condition. Cultural monitoring is expected to be based on the methodology and sites for 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).

Sites are to be sampled five-yearly in conjunction with the monitoring of surface water quality, instream sediment quality and aquatic ecology. The sites to be monitored are based on previous State of the Takiwā sites, and some additional sites are proposed. Some sites overlap with other monitoring sites (e.g. instream sediment and aquatic ecology).

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.

# 5 The Receiving Environment

## 5.1 Introduction

The permanent water environments in this catchment are Ihutai/the Estuary, the City Outfall Drain/Linwood Canal, Te Riu O Te Aika Kawa /Brooklands Lagoon and the coast. Water quality, sediment quality and aquatic ecology in the estuaries are influenced by the water quality of the Ōtākaro/Avon and Ōpāwaho/Heathcote Rivers and the Pūharakekenui/Styx River.

The ecological information below is based on monitoring that has previously been undertaken by ECan and the Council, generally as part of long-term monitoring programmes. Some information not relevant to the effects of stormwater discharges may have been omitted. Additional state of the environment monitoring is available from other sources.

Poor water quality can negatively affect the ecology (plant, invertebrate and fish communities) of freshwater, coastal and estuarine areas. Nutrients (i.e. nitrogen and phosphorus) encourage the prolific growth of aquatic plants and algae, while other contaminants (e.g. copper, zinc, sediment and ammonia) can cause negative effects on the physiology and behaviour of biota. Excessive macroalgae growths can smother seagrass beds and muddy intertidal areas of estuaries, and trap fine sediment as well as causing anoxia of the seabed. Decaying macroalgae can wash up onto the shoreline becoming unsightly and smelly. High pathogen numbers (using *E. coli* and enterococci as indicators) can create a human health risk during contact recreation such as swimming or boating and making shellfish unsafe for human consumption.

## 5.2 Environmental Monitoring

Water quality is monitored by Environment Canterbury in Ihutai (monthly) and open coast (quarterly) as part of its state of environment monitoring program. Intertidal sediments, macrofauna and macroalgae monitoring is undertaken annually by Environment Canterbury at one site in Brooklands Lagoon, and by the Council at five sites in Ihutai. Environment Canterbury has also undertaken broad-scale mapping of sediments and aquatic vegetation in Ihutai in 2016 and Brooklands Lagoon in 2014, as well as sediment quality monitoring at between 2010 and 2015.

In addition to the numerous other studies undertaken by students and researchers in the Ihutai and Brooklands Lagoon, these monitoring programs provide a long-term data set that can show the changes in water quality trends and estuarine health over time in response to stressors.

### 5.2.1 Water quality

**Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon**

Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon is a prominent coastal estuary, fringed with saltmarsh and contained within sand ridges that run along the eastern boundary. The lagoon receives freshwater inputs from Pūharakekenui / Styx and Waimakariri rivers, and sea water flows up the Waimakariri River and into the lagoon with the incoming tide. It is an identified Site of Ecological Significance in the Christchurch District Plan.

There is no on-going water quality monitoring in Te Riu-o-Te-Aika-Kawa , but previous reports have described it as a well-flushed estuary that is increasingly being exposed to pressures of urban development (Bolton-Ritchie, 2007a). Some stormwater inputs have substantially ceased since the retirement of residential properties in Brooklands following the Canterbury Earthquakes.

Monitoring of the Pūharakekenui / Styx River indicates that the lagoon may be receiving high loads of nitrogen, phosphorous and faecal contamination (Hodder-Swain & Urlich, 2021, www.lawa.org.nz). The river receives stormwater from the urbanised parts of its catchment, from time to time bringing contaminants such as metals and sediment into the lagoon (Bolton-Ritchie, 2018). Water quality is also affected by upstream developments in the Waimakariri River Catchment (Bolton-Ritchie, 2007a).

### Ihutai / Avon-Heathcote Estuary

Ihutai is an identified Site of Ecological Significance in the Christchurch District Plan. It receives freshwater inputs from Ōtākaro/Avon and Ōpāwaho/Heathcote Rivers and other constructed and natural waterways, stormwater inputs from the surrounding catchment and coastal water from Pegasus Bay. These inputs influence the estuary's water quality as do waterfowl and wading birds which are likely contributors to faecal contaminants. ECan has monitored the water quality of the estuary at 11 sites (9 within the estuary and 2 just outside the estuary mouth) since 2007.

Comprehensive analyses of these data (Gadd et al., 2020) show that water quality of the estuary has improved since 2007, with nitrogen, phosphorus and suspended solids decreasing at almost all sites. The diversion of Christchurch City's wastewater discharges from an estuary to an ocean outfall in 2010 has played a key role in improving water quality.

Nevertheless, water quality is still poor at many sites and particularly in the inner estuary where the Ōtākaro/Avon and Ōpāwaho/Heathcote Rivers are strong influences. Ihutai is considered to be in an eutrophic state[1] (Bolton-Ritchie, 2020a; Gadd et al., 2020). Nutrient inputs causing eutrophication are related to river flows, which are variable, and there is no definite trend in the data. The most recent data show that nitrogen and phosphorus frequently exceeded guidelines at many sites between 2015 and 2019, except those closest to the estuary mouth and coast. This is confirmed by significant increases of chlorophyll-a, an indicator of phytoplankton abundance, at all sites between 2015-2019. During this period Sandy Point, near the oxidation ponds, had nutrient concentrations much higher than would be expected based on riverine inputs. This site probably receives additional nutrient inputs from the waterways around the wastewater treatment ponds (Gadd et al., 2020).

Between 2015 and 2019, heavy metal concentrations were generally within guidelines except for copper concentrations at Cave Rock, where guidelines were exceeded in over 20% of samples. Faecal indicator bacteria measurements collected in those same years indicated that there was a high risk of bacterial infection in the inner estuary and that shellfish gathering was unsafe at most sites. High bird numbers appear to be adding little to the nutrient content of the estuary but are probably major contributors to faecal contaminants (Gadd et al., 2020). Faecal contamination consistently exceeded safety guidelines at inner estuary sites between 2015 and 2021 (Gadd et al. 2020). Water quality was much better in proximity of the estuary mouth (Arthur, 2020, www.lawa.org.nz).

Shellfish suitability for consumption varies within the estuary. Shellfish collected at the estuary mouth (from the Southshore Spit) in summer 2019-2020 were deemed safe to eat, however this was based on low coliform contamination in the overlying water (Arthur, 2020). In 2019, EOS Ecology measured bioaccumulation of bacteria and contaminants in shellfish and fish collected within the

[1] Measured by the Estuary Trophic Index Tool 1 after Zeldis et al. (NIWA)

estuary (McMurtrie, 2019). Mullet and flounder had levels of contaminants within food safety guidelines; contaminants within flesh of cockles were variable, with some locations meeting safety guidelines but at an inner-estuary site by the oxidation ponds cockles had high levels of bacterial contamination, making them unsafe to eat (McMurtrie, 2019).

The nearby former Bexley Landfill, which borders the estuary on its western shoreline, presents a threat to the health of the estuary as historic landfill waste was becoming increasingly exposed for some time (Boffa Miskell, 2018). The Council has recently undertaken remediation works around the edge of the landfill to ensure that the landfill material is retained within the former landfill and not discharged into the estuary during storm events[2].

**Linwood Canal**

Linwood Canal (also known as City Outfall Drain upstream of St Johns Street) is monitored by the Council and ECan. The waterway is approximately 3.8 km long (2.5 km Outfall Drain and 1.3 km Linwood Canal), draining residential and commercial areas in eastern Christchurch, before discharging to Ihutai. The waterway is an unclassified waterway, but for the purposes of comparisons of surface water quality to ANZECC standards it is considered as a 'spring-fed – plains – urban' waterway.

The 5-year median for *E. coli* is 302.5 n / 100 ml, putting it in the worst 25% of all sites monitored (www.lawa.org.nz). *Escherichia coli* is used as an indicator of faecal contamination in fresh waters (and therefore indicates potential presence of other harmful pathogens). Other parameters regularly measured and reported by LAWA[1] include turbidity (worst 25%), total nitrogen (worst 50%), ammoniacal nitrogen (worst 25%), dissolved reactive phosphorus (DRP) (worst 25%) and total phosphorus (worst 25%).

The Council's 2019 monitoring included monthly measurements of various water quality indicators through 2019 and is reported in the city-wide surface water quality report (Margetts & Marshall, 2020). Of the heavy metals monitored, only dissolved copper was found to exceed the guideline level. (However, monitoring does not necessarily happen during rainfall and may miss contaminants typical of stormwater runoff.) Water temperature was variable and sometimes exceeded the guideline of 20°C.

The Water Quality Index (WQI), which is based on copper and zinc concentrations, pH, total suspended sediments (TSS), dissolve oxygen, biological oxygen demand, total ammonia, nitrate and nitrite nitrogen, dissolved reactive phosphorus and *E. coli* can provide an overview of the waterway's water quality.

From the monitoring conducted from 2013 to 2019, Linwood Canal has "poor" water quality ranging from a WQI of 55 to 69 (Margetts & Marshall, 2020).

Instream Consulting (2020) reported anoxic sediments and a hydrocarbon sheen at the Linwood Canal long-term monitoring site, suggesting oxygen-depleted groundwater entering the site. The authors suggested this may reflect either a natural wetland source or locally contaminated groundwater.

Water quality in the three main waterways that discharge into the Estuary and Coastal Stormwater Management Area (Pūharakekenui/Styx River, Ōtākaro/Avon River and Ōpāwaho/Heathcote River) is

[2] https://www.stuff.co.nz/environment/119813163/plan-to-save-christchurch-estuary-from-old-hospital-waste-and-car- parts-in-eroding-dump

also monitored by ECan and Council. The water quality in these waterways will be reported in their respective stormwater management plans.

**Open coast**

ECan has monitored water quality along 800 km of coastal marine area since 2007, from Willawa Point to the Waitaki River mouth. Five sites fall within this catchment. Three (Spencerville, New Brighton Pier and Scarborough) are near-shore sites and two are located 3 km offshore from the Waimakariri River and the New Brighton Pier.

Monitoring between September 2007 and June 2019 shows that freshwater inputs from rivers, land runoff, industrial discharges and two municipal outfalls (Christchurch City and Waimakariri District) are important sources of nutrients and particulate matter to coastal waters of Pegasus Bay (Bolton-Ritchie, 2020b).

Despite decreasing trends in nutrient concentrations at some sites, nearshore water in Pegasus Bay is mesotrophic (an intermediate level of productivity) to hypereutrophic (very nutrient-rich): high nutrient concentrations can trigger algal blooms and affect ecosystem health. All sites within the Ihutai Estuary and Coastal Stormwater Management Area had median concentrations of nitrate-nitrite nitrogen, total nitrogen and chlorophyll-a above guideline trigger values for marine waters. (Bolton-Ritchie, 2020b).

Total ammoniacal nitrogen and dissolved reactive phosphorus concentrations have reduced relatively recently (2012-2019) in comparison to previous years. This may be due to the Council diverting wastewater discharges via ocean outfall since March 2010 (Bolton-Ritchie, 2020b). Until 2010 treated sewage was discharged into the estuary, which then flowed into Pegasus Bay and was correlated to reduced water quality both within Pegasus Bay and at the estuary mouth (Bolton-Ritchie, 2007b). However, total ammoniacal nitrogen and dissolved reactive phosphorus concentrations have been higher at Scarborough than at the other Christchurch sites, since 2012. This may be due to nearshore effects, including stormwater discharges and wastewater overflows in the Scarborough area, as well as nutrient inputs from the estuary (Bolton-Ritchie, 2020b).

Weekly summer sampling of water quality at eight beaches within the catchment showed that faecal enterococci contamination did not meet safety guidelines during the summer of 2020-2021 (www.lawa.org.nz). Faecal contamination was within safety guidelines over the five previous summers at all sites, except at Scarborough and Waimairi beaches where guidelines were exceeded occasionally between 2018 and 2019 (www.lawa.org.nz). At Scarborough, shellfish was deemed unsafe to eat in summer 2019-2020. Two other sites (Southshore Spit and Spencerville) were deemed safe for shellfish gathering in summer 2019-2020 (Arthur, 2020).

### 5.2.2 Benthic Sediment Composition and Quality

Environment Canterbury has undertaken sediment quality monitoring at 18 muddy intertidal sites near stormwater drains and other contamination sources in 2010. One site in Brooklands Lagoon and 5 sites in Ihutai were sampled for heavy metals, PAH's and TOC. Additionally, as part of the annual estuary intertidal monitoring program sediment grain size has been monitored annually at Brooklands Lagoon (by Environment Canterbury) and at 5 sites in Ihutai (by the Council) and heavy metals have been monitored at one site in Brooklands Lagoon in 2018 and 2021 and five sites in Ihutaiin 2011, 2016 and 2021.

### Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon

ECan has monitored sediment composition and concentrations of zinc, copper and lead at one site in Te Riu-o-Te-Aika-Kawa (adjacent to the Styx River channel across the intertidal flat) since 2010. The mud content of the sediment at Brooklands Lagoon is high but the concentrations of heavy metals are low (https://www.lawa.org.nz/explore-data/canterbury-region/estuaries/brooklands-lagoonte-riu-o-te-aika-kawa/brooklands-at-styx-river ). Further sediment quality sampling has also been undertaken at this site Between 2010 and 2016; concentrations of heavy metals and PAH have met sediment quality guidelines (Bolton-Ritchie, 2018). Substrate mapping carried out in 2014 showed that firm mud/sand and mobile sand substrates were abundant at the lagoon's mouth, whilst soft mud/sand dominated the inner reaches (Bolton-Ritchie et al., 2018).

### Linwood Canal

The quality of instream sediment within Linwood Canal was assessed in 2014 (Gadd, 2015). Of particular note to stormwater, samples were analysed for total recoverable metals (arsenic, cadmium, copper, chromium, nickel, lead and zinc), TOC and PAH.

Metals and PAH were below the ANZG (2018) guideline levels, with the exception of lead and zinc (Gadd, 2015). TOC was low at 1.7% (Gadd, 2015). Compared to a previous study in 1980, lead appears to have decreased and zinc increased, although no grain size data were provided in the earlier study, so these figures could not be normalised to allow accurate comparison (Gadd, 2015). It is likely that higher lead concentrations are due to historical stormwater inputs from leaded petrol, as lead is generally no longer recorded in stormwater sampling.

The results of this study suggest that lead and zinc (a common contaminant in stormwater) may be having adverse effects on biota in this waterway. However, TOC and PAH levels are likely not having adverse effects on this receiving environment.

### Ihutai/Estuary

ECan and the Council have monitored sediment composition and concentrations of zinc, copper, lead and arsenic at four sites (Discharge Point, Humphreys Drive, Plover Street and Pleasant Point Jetty) within the estuary since 2007, and an additional site at the Causeway since 2015, as part of the sediments and biota annual monitoring program. At all sites the proportion of mud ranges from low to moderate, and the concentration of heavy metals in the sediment is below ANZG (2018) guideline values Land, Air, Water Aotearoa (LAWA) - Avon-Heathcote Estuary/Ihutai

Sediment quality has also been monitored by ECan between 2010 and 2016 at five estuary sites (South of Bridge Street, Charlesworth Drain, City Outfall Drain, Mount Pleasant Yacht Club, Causeway) near stormwater drains and road run-off. The samples have been analysed for TOC (which indicates organic matter, but also synthetic sources such as detergents, pesticides, fertilisers, herbicides, and industrial chemicals that might be in stormwater), metals (arsenic, cadmium, chromium, copper, lead mercury, nickel and zinc) and 16 different types of PAH.

The concentrations of metals were above background soil concentrations for some contaminants at some sites in the 2010 ECan study, indicating inputs from human activity. Of particular note were chromium, mercury and zinc at South of Bridge Street site, chromium and zinc at Charlesworth Drain, chromium and zinc at Linwood Canal, and zinc at Mount Pleasant Yacht Club. However, metal concentrations at all sites were below the guideline levels (ANZG, 2018). The levels of metals in the Council unpublished data were also all well below the guideline levels (ANZG 2018). Therefore, based on these two surveys, metal levels in sediment within the estuary are unlikely to be adversely impacting on aquatic life.

The 2010 ECan survey also found that TOC levels were low at all sites, with the highest concentration of 0.7 g/100g at Charlesworth Drain. The TOC samples collected by Council in 2015 were higher, ranging from 1.12 - 2.4 g/100g. There is no guideline level for this parameter, but these concentrations are considered to be low (Bolton-Ritchie & Lees, 2012).

PAH levels in the ECan study exceeded ANZG (2018) guideline levels at the Mount Pleasant Yacht Club, Linwood Canal and Causeway sites, but not the other two estuary sites. This may mean that this contaminant is having adverse effects on biota at these sites. The Linwood Canal discharge channel site recorded the highest levels of PAH and it is thought to be a significant source of PAHs to the estuary (Bolton-Ritchie, 2018). The PAH is thought to come from road runoff (Bolton-Ritchie & Lees, 2012).

The results of these two studies indicate that stormwater is not having adverse effects on biota, with the exception of PAH in some parts of the estuary.

Sediment quality in the estuary improved following diversion of Christchurch City's wastewater to the ocean in 2010. Despite decades of heavy nutrient loading and excessive algal growth, eutrophication did not leave a legacy in the estuary sediments. The sandy, well-flushed sediments of the estuary rapidly responded to improved water quality with significant declines in pore-water nutrient concentrations between 2010 and 2013. Sediments were resilient to additional nutrient inputs during the 2010-2011 earthquake series (Zeldis et al., 2020).

The Canterbury Earthquakes caused liquefaction within the estuary, bringing 5000-year-old sediment to the surface and diluting the existing contaminated sediments. This dilution resulted in reduced metal, metalloid and polycyclic aromatic hydrocarbon (PAH) contamination in surface sediments immediately post-earthquake, but the concentrations of some metals have since began to increase probably because of stormwater and road runoff. The City Outfall Drain / Linwood Canal and Charlesworth Drain are significant sources of stormwater contaminants to the estuary.

Substrate mapping shows that the estuary is dominated by firm mud / sand (Bolton-Ritchie et al., 2018; Bolton-Ritchie, 2019), while two sites in close proximity to Ōtākaro/Avon and Ōpāwaho/Heathcote river mouths have a greater proportion of fine sediment fractions (i.e., silt and clay from riverine inputs).

### Open coast

Marine sediments near the New Brighton area and the Ihutai mouth were examined by Kingett Mitchell in 2003 as part of environmental monitoring for the Council's wastewater ocean outfall. A summary from Kingett Mitchell's report is further summarized here.

Surface sediments were dominated by sands in depths out to 14 m. Beyond 2,000 m from the shoreline the mud content increases with marked variability between survey transects (10 – 50% mud). Inshore, sediment texture is influenced by near-shore processes including wave break in the surf zone and long-shore drift (Kingett Mitchell, 2003).

Trace elements in sediments showed that the concentrations of virtually all elements can be explained by the variation in key physical factors such as the grain size of the sediments (i.e. there are more metals associated with mud than with sand).

Concentrations of metals in seabed mud and sand were similar to metal concentrations in Canterbury soils as presented by Landcare Research (2015) in https://www.envirolink.govt.nz/assets/Envirolink/R10-420Background20soil20concentrations20of20selected20trace20elements20and20organic20contaminants20in20New20Zealand20.pdf

Concentrations of organic compounds were low. Concentrations of relatively ubiquitous compounds such as PAHs indicates that concentrations in the sediments may reflect the proximity to the main urban part of Christchurch.

## 5.3 Aquatic Ecology

The ecology of freshwater, coastal and estuarine areas is typically assessed by looking at algae and plants, invertebrates and fish. More diverse and abundant communities of aquatic life reflect healthier environments.

### Aquatic Plants

**Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon**

Macroalgal blooms are known to occur in Te Riu-o-Te-Aika-Kawa (Hodder-Swain & Urlich, 2021) and substrate mapping carried out in 2014 showed that macroalgae were widespread in areas of soft mud/sand in the inner reaches of the lagoon (reference not available).

**Ihutai/Estuary**

There are a number of aquatic plants present within the estuary (including McCormacks Bay, which also receives stormwater inputs), such as species of the green alga *Ulva* (commonly called sea lettuce), various red algae, including *Agarophyton* spp. (formerly *Graciliaria* spp.), and the seagrass *Zostera muelleri* (McMurtrie, 2011; Sutherland, 2015; Woods et al., 2016). The seaweeds *Ulva* and *Graciliaria* are prevalent in the estuary (Sutherland, 2015) and have been monitored by the Council during the summer growth season for a number of years, as they are considered nuisance weeds that impact on aesthetic, recreational and ecological values. Their proliferation is often associated with increased nutrient loading, in particular nitrogen. The historic discharge of treated wastewater from the Christchurch Wastewater Treatment Plant was considered to be the main cause of excessive growth within the estuary. Overall, there have been some reductions in these species within the estuary since the discharge was redirected offshore, as well as within McCormacks Bay following the installation of a new culvert (c2013) that allows more effective flushing of the bay (Sutherland, 2015).

However, macroalgal growth (driven by *Ulva* and *Agarophyton* species) is still extensive and high compared to other New Zealand estuaries with similar physical properties. ECan's summer monitoring (2019-2020) showed that around 40% of the available intertidal habitat of the estuary had more than 5% coverage by macroalgae, with very high (>75%) macroalgal cover in large areas. Nutrient inputs from Ōtākaro/Avon and Ōpāwaho/Heathcote Rivers may be contributing to these high macroalgal abundances (Bolton-Ritchie, 2020a; Bolton-Ritchie et al., 2018; Gadd et al., 2020).

**Linwood Canal**

The aquatic ecology of Linwood Canal was assessed in 2015 at a site just upstream of Dyers Road (Blakely, 2015). This survey recorded moderately abundant algae cover that just exceeded the LWRP guideline for 'spring-fed – plains – urban' waterways (30%, Environment Canterbury, 2015). Aquatic plants (macrophytes) were abundant, with the community dominated by the exotic curly pond weed.

### Invertebrates

**Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon**

Environment Canterbury monitors benthic macroinvertebrates at one site in Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon annually during summer. The site is the same assessed for sediment composition and aquatic plants. There has been a slight decrease in the number of taxa at the site over time and a lower number of individuals since 2015 than from 2009-2015. The number of individuals present were highly variable over time. The taxa that were abundant were *Potamopyrgus estuarinus*, oligochaetes, *Paracorophium* sp. and *Cyclomactra ovata*. The distribution of these taxa is likely because these taxa are tolerant and survive in the lower salinity conditions that occur at this site (Bolton-Ritchie, 2022, unpublished). The Benthic Model Health score has shown a significant decrease in time, which indicates an improvement in the health of the estuary Land, Air, Water Aotearoa (LAWA) - Brooklands at Styx River, however, the macrofaunal communities are still highly impacted by the proportion of mud at the site.

**Ihutai /Estuary**

The Council monitors invertebrates within the estuary annually, during summer, at five sites:

(a) Discharge Point (adjacent to the old discharge from the Christchurch Wastewater Treatment Plant),
(b) Humphreys Drive,
(c) Plover Street,
(d) Pleasant Point Jetty and
(e) The Causeway.

These sites are the same as those assessed for sediment composition, aquatic vegetation and sediment quality in 2015 referred to in the section above (with the exception of the Discharge Point site), and are influenced by stormwater to varying degrees. Invertebrates are collected from the surface (epifauna) and within the sediment (infauna) during these surveys.

In the 2015 Council survey, species diversity was found to be variable between the five sites (Bolton-Ritchie, 2016). The lowest diversity was 16 species at Humphreys Drive and the highest was 35 at Plover Street, although no one site was singled out as being either much better or worse than the others. Worms typically dominated the invertebrate community. Humphreys Drive was the only site dominated by snails and shellfish.

Invertebrates have also been caught incidentally from within the estuary during Council fish surveys. Snails, shellfish and crustacea have been caught while seine netting from the beach, as well as crabs, sea-stars and shellfish during trawling (Woods et al., 2016).

Epifauna and infauna were assessed at 24 sites within three zones of McCormacks Bay in 2010 for a Council study (McMurtrie, 2011). These sites are influenced by stormwater to varying degrees.

Invertebrate taxa richness varied from approximately 9 to 18. The most abundant types of invertebrates were polychaete worms, with 22 taxa present. The snail *Zeacumantus* was the most numerically abundant species.

The metal content in cockles and pipis was assessed by ECan in 2014 to assess the safety of food gathering (Bolton-Ritchie, 2015). Cockles were collected from near the old discharge point of the Christchurch Wastewater Treatment Plant, the western side of the Southshore spit and the southern end of the causeway by Beachville Road, which is a popular shellfish gathering site. Pipis were collected from alongside the shoreline east of the Beachville Road boat ramp. These sites, with the exception of the discharge point, are influenced by stormwater inputs and waterways to varying degrees. The invertebrates were tested for mercury, cadmium, lead and arsenic. Concentrations were below the maximum acceptable levels for safe consumption (Bolton-Ritchie, 2015).

**Open coast**

Very few animals live on the Pegasus Bay beach foreshore, but species diversity increases closer to the low-tide mark. Small, mobile crustaceans and surf clams dominate the surf zone. Close to shore the subtidal soft sediments are inhabited by bivalves including pipi and tuatua, and support high densities of surf clams. Offshore, invertebrate communities are dominated by burrowing animals (Department of Conservation & Ministry of Fisheries, 2011; Rowden et al., 2012; Walls, 2006).

Epibenthic (near-bottom) biota are small, permanently swimming crustaceans that feed on and live in close association with the seafloor. The epibenthic communities (dominated by opossum shrimps), are broadly similar to those on other sandy substrates in New Zealand.

The infaunal survey found that polychaete worms were the most abundant group of animals in the sediments. Molluscs (gastropods, bivalves and similar) were the next most abundant group. Overall species diversity and abundance was broadly similar to those found at other exposed sandy sites in New Zealand and tended to increase with increasing distance from the shoreline.

Rocky reefs between Sumner and Taylors Mistake do not extend far offshore but support diverse benthic communities comprising large brown algae (including the at risk / declining bladder kelp *Macrocystis pyrifera*), mussels, paua, sponges, anemones, snails, starfish, crustaceans and sea tulips (Morton, 2004; Schiel & Hickford, 2001; Shears & Babcock, 2007; Walls, 2006).

**Linwood Canal**

The 2015 survey also assessed the macroinvertebrate community of the waterway and found that the canal was in poor health, with a QMCI score of 3.0 (Blakely, 2015). This score is below the LWRP QMCI guideline of 3.5 for 'spring-fed – plains – urban' waterways (Environment Canterbury, 2015). This site was non-wadeable and tidal, and the QMCI may be less appropriate for such sites, which have different habitats from wadeable sites for which the index was developed. Although there was a reasonable number of taxa (14), there were no pollution sensitive taxa and total abundance of macroinvertebrates was low.

## Fish

**Te Riu-o-Te-Aika-Kawa / Brooklands Lagoon**

Historic records (1980 - 1982) from the NZ Freshwater Fish Database (National Institute of Water and Atmospheric Research, n.d.) show a number of estuarine, coastal and migratory freshwater fish species present within the lagoon at that time. Species recorded include Stokell's smelt (at risk - declining), inanga, longfin eel, torrentfish, giant bully, bluegill bully, common smelt, black flounder, yellow-eye mullet, shortfin eel and the introduced and naturalised chinook salmon and brown trout.

**Ihutai/Estuary**

Fish within the estuary have been monitored by the Council seven times since 2005, primarily to assess changes in the fish community due to the decommissioning of the treated wastewater estuary discharge. Fish were surveyed by carrying out 12 beach seine tows at stations evenly distributed along the eastern, western and southern shorelines of the estuary, as well as carrying out 13 trawl tows in the permanently watered main channel of the estuary (Woods et al., 2016).

The 2015 study recorded seventeen fish species (Note: Inanga have a conservation status of 'At Risk - Declining' (Goodman et al., 2013).

Table 2). Yellow-eyed mullet and common smelt dominated the catch, followed by yellow-belly flounder and sand flounder, with these four species making up 96.5% of the total catch. Results are similar to previous findings. Comparison of data from all seven surveys showed no clear evidence of large-scale changes in the fish community of the estuary as a result of either the decommissioning of the wastewater discharge, or the disruption caused by the 2010–11 Canterbury earthquakes.

Inanga spawn in the lower reaches of Ōtākaro/Avon River and Ōpāwaho/Heathcote Rivers, as well as Linwood Canal and the western edges of Ihutai.

Note: Inanga have a conservation status of 'At Risk - Declining' (Goodman et al., 2013).

Table 2: Fish taxa recorded from Ihutai - Avon Heathcote Estuary 2015 fish survey.

| Common Name | Scientific Name | 2005 | 2006 | 2007 | 2010 | 2011 | 2013 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Ahuru | *Auchenoceros punctatus* | - | - | - | - | - | Y | - |
| Black flounder | *Rhombosolea retiaria* | - | - | - | - | - | - | Y |
| Chinook salmon | *Oncorhynchus tshawytsha* | - | Y | Y | - | - | - | - |
| Clingfish | *Gobiesocidae* | Y | - | Y | - | Y | - | Y |
| Common bully | *Gobiomorphus cotidianus* | - | - | - | - | Y | Y | - |
| Common smelt | *Retropinna retropinna* | Y | Y | Y | Y | Y | Y | Y |
| Common sole | *Peltorhamphus novaizeelandiae* | Y | Y | Y | Y | Y | Y | Y |
| Estuary stargazer | *Leptoscopus macropygus* | Y | Y | Y | Y | - | Y | Y |
| Giant bully | *Gobiomorphus gobioidies* | Y | - | Y | - | Y | - | - |
| Globefish | *Contusus richiei* | - | Y | - | - | - | - | Y |
| Inanga | *Galaxis maculatus* | - | - | Y | - | Y | Y | Y |
| Kahawai | *Arripis trutta* | Y | Y | Y | - | Y | Y | Y |
| Sand flounder | *Rhombosolea plebeia* | Y | Y | Y | Y | Y | Y | Y |
| Short-finned eel | *Anguilla australis* | Y | Y | Y | Y | Y | Y | Y |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slender sprat | *Sprattus antipodum* | Y | - | - | - | Y | Y | Y |
| Slender stargazer | *Crapatalus angusticeps* | - | Y | Y | Y | Y | Y | Y |
| Speckled sole | *Peltorhamphus latus* | - | Y | - | - | - | - | - |
| Spotted stargazer | *Genyagnus monopterygius* | Y | Y | Y | Y | Y | Y | Y |
| Spotty | *Notolabrus celidotus* | Y | Y | Y | Y | Y | Y | Y |
| Sprat | *Sprattus muelleri* | Y | Y | - | - | - | - | - |
| Triplefin | *Tripterygiidae* | Y | Y | Y | Y | Y | Y | Y |
| Yellow-belly flounder | *Rhombosolea leporina* | Y | Y | Y | Y | Y | Y | Y |
| Yellow-eye mullet | *Aldrichetta forsteri* | Y | Y | Y | Y | Y | Y | Y |
| Number of species | 23 | 15 | 16 | 16 | 11 | 16 | 16 | 17 |

(Table 3-1 from Woods et al., 2016)

The metal content in fish was assessed by ECan in 2014 at the same time as the cockle and pipi study mentioned above, to assess the safety of food gathering (McMurtrie, 2015). Yellow-belly flounder and yellow-eye mullet were collected from within the estuary near the old treated wastewater discharge point from the Christchurch Wastewater Treatment Plant and the western side of the Southshore spit. The flesh of these fish were tested for mercury, lead and arsenic. All concentrations were well below the maximum acceptable levels.

**Linwood Canal**

Fish within Linwood Canal site were also assessed during the Council 2015 study (Blakely, 2015). Three species were recorded: common bully, shortfin eel and inanga.

**Beacon Street Lagoon**

A survey of the fish in Beacon Street Lagoon was carried out in June 2016 to assess the environmental effects of the repair of the outlet of the wetland (Taylor & Marshall, 2016). Baited fyke nets were set in the lagoon. Three juvenile yellow-belly flounder were caught, as well as seven hairy-handed crabs.

## 5.4 Groundwater Quality

Each year 31 bores in the Christchurch-West Melton area are sampled by ECan for signs of changing groundwater quality. The information below reports selected information from *Christchurch Groundwater Monitoring 2015* that relates to shallow groundwater quality. Shallow groundwater could be impacted by stormwater discharges, and other land uses.

ECan is interested in detecting early signs of contamination, so most monitoring wells are shallow and have been selected because they are screened close to the water table. The Council is making increasing use of deeper wells for drinking water. (There are still a few shallow wells in the Council's public supply network but none in this catchment.)

Artesian groundwater quality is generally described as very good and the majority of samples meet New Zealand drinking water standards without treatment. This reflects the absence of bacteria and viruses, which is typical for water abstracted from a well-managed aquifer.

The best water quality occurs across the northern part of the city thanks to seepage of clean water from the Waimakariri River into the aquifer (Figure 8: Groundwater quality, Christchurch-West Melton zone, as measured by dissolved solids concentrations (2005)). Groundwater quality in the south is still good, but the water contains more dissolved substances picked up during infiltration through the land surface (Figure 8). Some areas near the estuary and old coastal swamps have low dissolved oxygen due to oxygen depletion by biological activity.

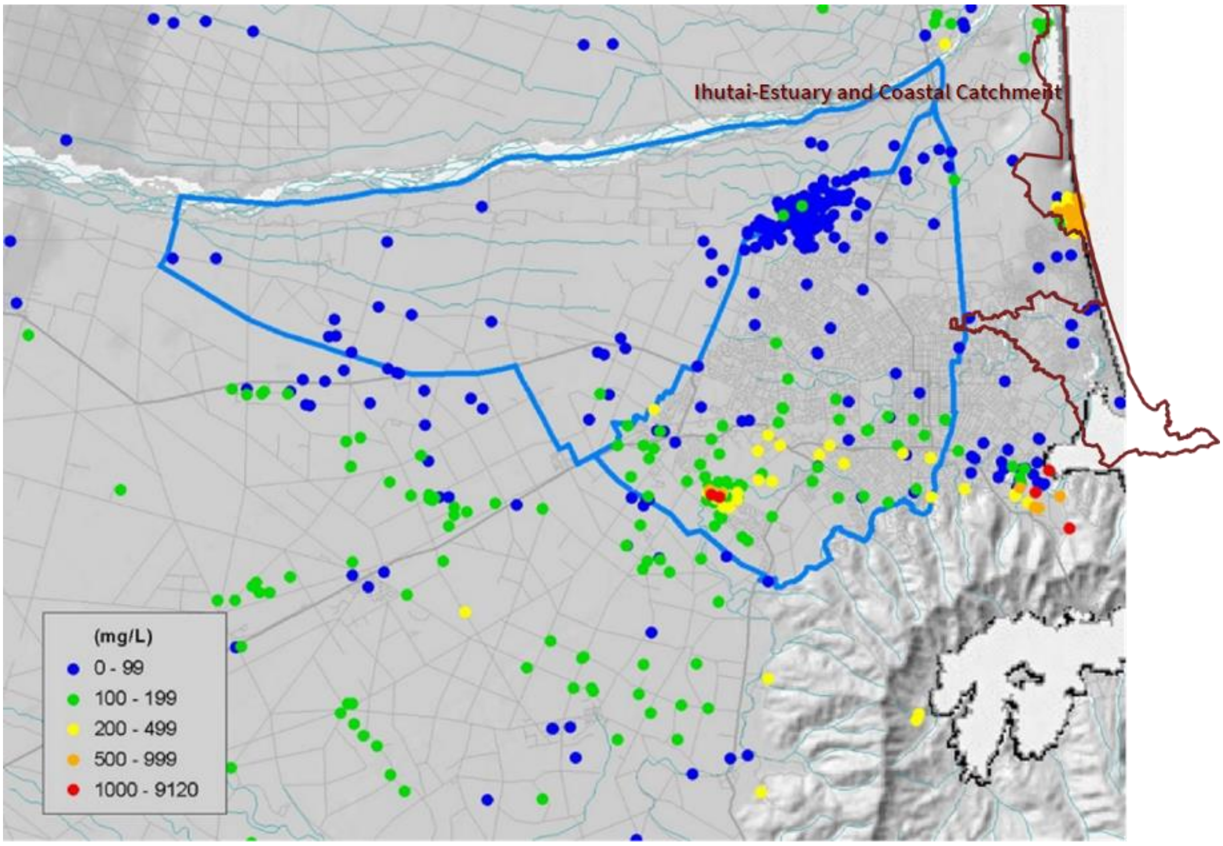


Figure 8: Groundwater quality, Christchurch-West Melton zone, as measured by dissolved solids concentrations (2005)

Figure 9 shows a map of monitoring wells in the Christchurch network. Most of the wells are in the Christchurch Groundwater Protection Zone, which covers the gravel deposits to the west of the city. Groundwater in this zone is most vulnerable to contamination from the surface. There is a high concentration of monitoring wells along the western edge of the city. To the east the surface sediments become finer-grained and the hydraulic gradient in the groundwater system changes from downward to upward flow (Weeber, 2008). Quarterly monitoring wells are mostly to the west of this transition. ECan monitors a number of wells across the industrial areas of southern Christchurch.

Targeted monitoring wells measure effects related to historic waste disposal (M35/5353, M36/2961, M36/3085, M36/1160) and the intrusion of brackish water estuary in the Woolston-Heathcote area (M36/1045 and M36/4906) (ECan 2015). ECan also monitors for seawater intrusion in wells near the coast and the estuary.

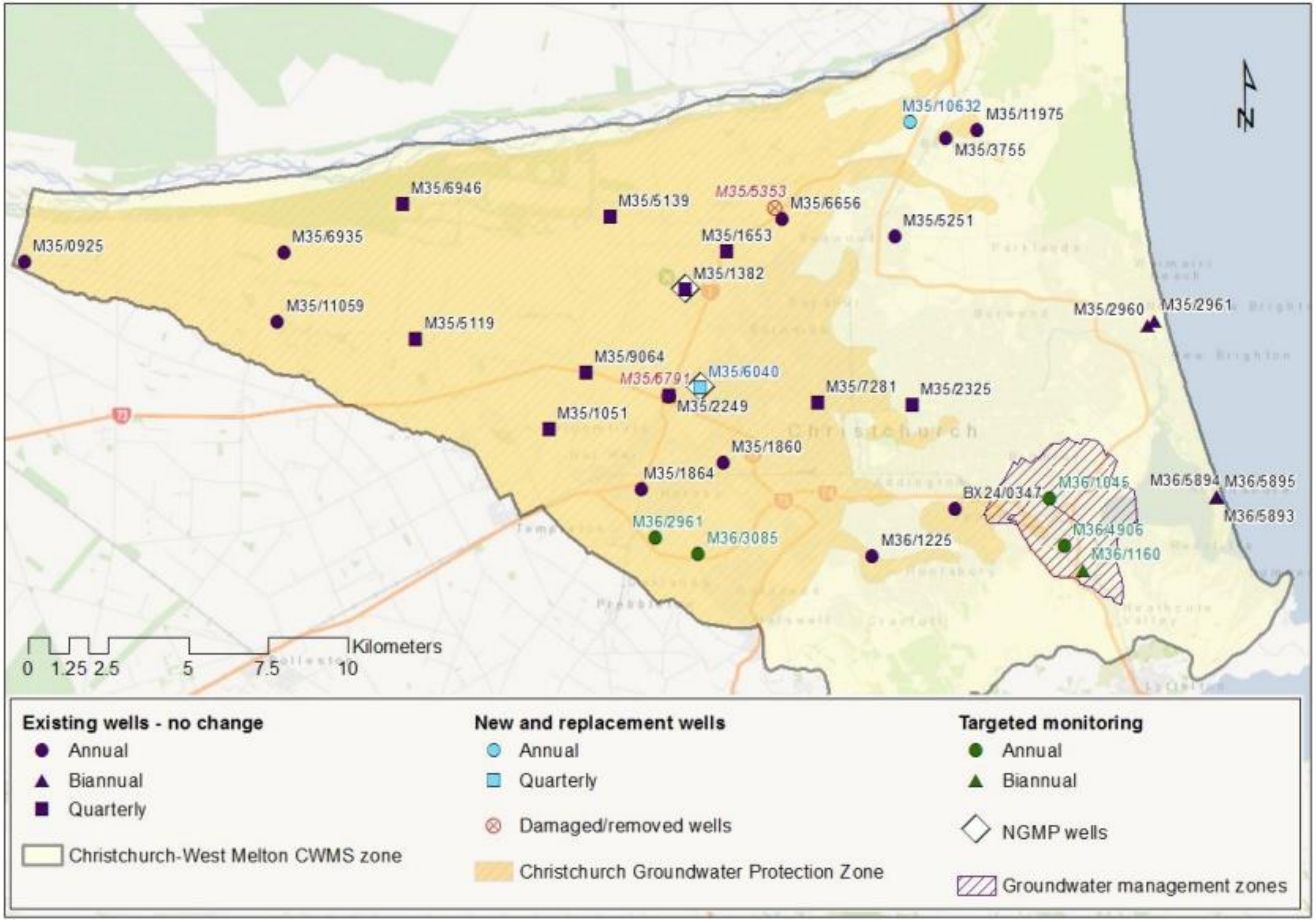


Figure 9: Well network and sampling frequencies for Christchurch monitoring wells

# 6 Land Use

## 6.1 Present Situation

Ihutai/Estuary and Coastal Catchment land zonings include commercial (CC, CMU), rural Port Hills (RuPH), residential suburban (various), hills & large lot (RS, RSDT, RMD, RH, RLL), special purpose school, Burwood Landfill & land recovery (SPS, SPB, SPLR), general & heavy industrial (IG, IH), various open space (OCM, OCN, OCP, OCWM, OMF) as shown in Figure 10.

Thirty percent of the catchment is zoned for residential use. Three percent (Bromley, Phillipstown) is industrial. There are significant areas of open space both on the flat and on the Port Hills.

## 6.2 Development and Trends

Statistics NZ SA2 population projections to 2048, from base year 2018, estimate small to moderate population increases in this catchment. Growth averaging 15% is projected for hill areas (Mt Pleasant, Clifton, Redcliffs), 7% in Sumner and New Brighton, and sub-5% in the northern area.

### 6.2.1 Residential Growth

Future urban growth in the Ihutai-Estuary & Coastal catchment is expected to be limited to minor expansion at the upper fringes of hill residential areas and some infill. The Replacement District Plan identifies small areas on the hills where new residential development is still to take place.

### 6.2.2 Industrial Growth

Both industrial and commercial areas are described as Business Zones in the operative Christchurch District plan and **Error! Reference source not found.**. Within this catchment the area of land zoned Business is predominantly industrial: industrial areas are Bromley, a part of the central city and a small area near the mouth of the Heathcote River. Business zones are almost fully taken up (by observation from aerial photography) but business expansion and evolution is leading to increasing site coverage, site paving and overall imperviousness.

## 6.3 Contaminated Sites and Stormwater

### 6.3.1 Background

The SMP differentiates between two types of sites which may release contaminants:

- Sites with in-ground contaminants that may be entrained in stormwater, typically when soil is disturbed; and
- Sites where on-site activities, usually industrial in nature, may release chemical or metal contaminants into stormwater (or into the ground).

The National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations (NES) help to identify potentially hazardous activities and industries which are listed in the Hazardous Activities and Industries List (HAIL), found at

**http://www.mfe.govt.nz/land/hazardous-activities-and-industries-list-hail#hail-web**

Such sites are included in a Listed Land Use Register (LLUR) when they become known to ECan either through a consent application (to ECan or the Council) or through investigations. Sampling, excavation, subdivision, removal of fuel storage tanks and changing land use on such sites may require a resource consent and remedial action.

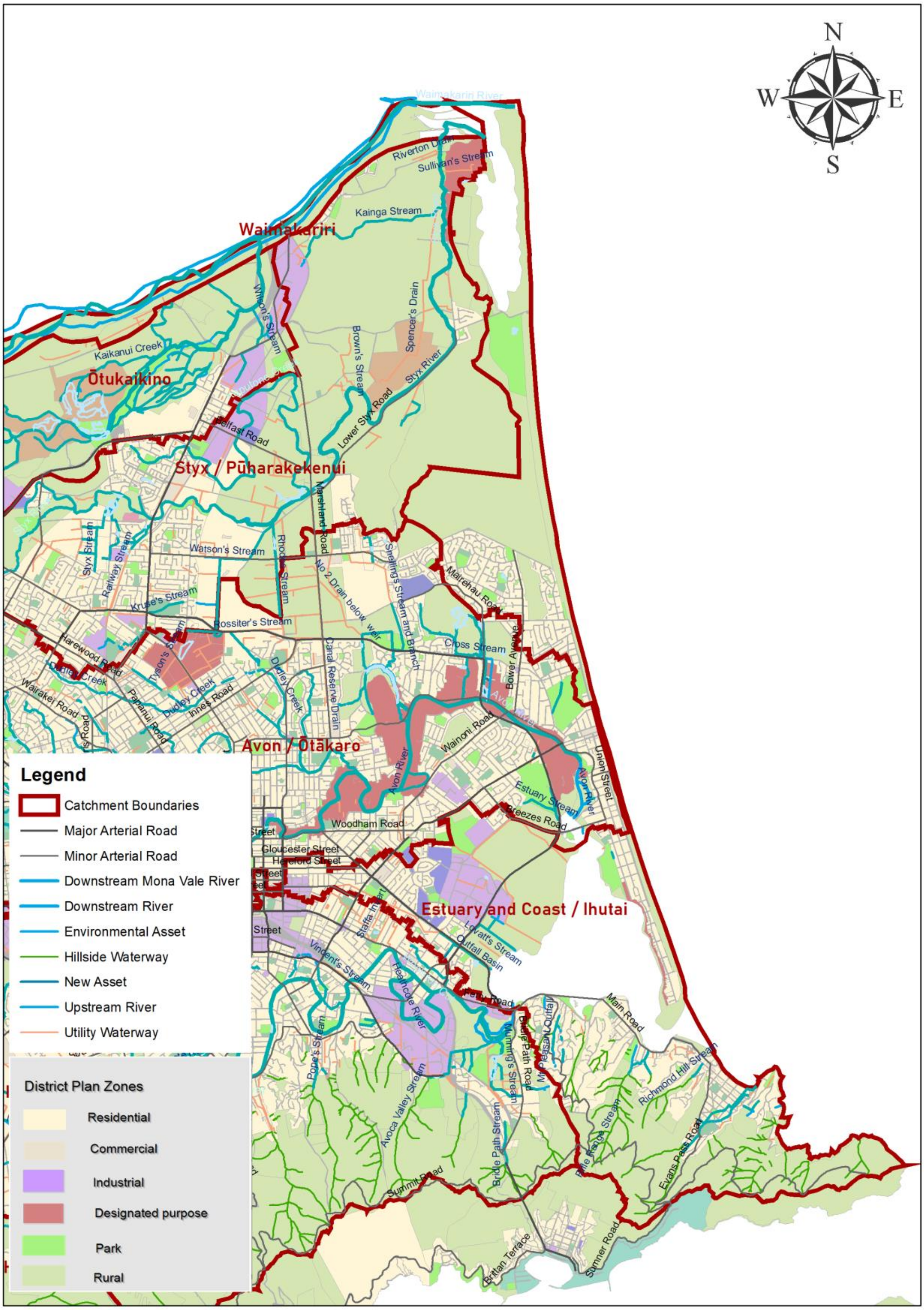


Figure 10: Land Use – Christchurch District Plan land use categories.

### 6.3.2 Low Risk Sites

A Memorandum of Understanding (MoU) was agreed between Council and ECan in July 2014 to allow stormwater discharges from low risk residential rebuild sites listed on the LLUR and/or identified as having had HAIL activities to be processed by Council rather than ECan. It is anticipated that as confidence grows over time in the operation of the MoU, the list of "low risk" situations that Council can process will be extended. For example, sites on the LLUR where only a portion of the site has had a hazardous activity and the construction will not disturb that part of the site is considered low risk. Stormwater consents for the management of all but the most extreme risk sites will progressively transfer to Council from 2025 as required in the CSNDC.

### 6.3.3 Higher Risk Categories

"High risk sites" generally refers to sites with persistent or hazardous chemical in the soil or in use on site. High risk sites include contaminated sites and some industrial sites.

Many contaminants adhere to sediments and can be mobilised into surface or ground-water when soils are disturbed. These contaminants can be managed if there is good sediment control during earthworks and by taking care with where soil is disposed of. More specific measures, including on-site treatment, may be needed for more mobile contaminants that cannot be controlled by typical sediment control practises.

All land use consent applications are checked against the LLUR. Where development is proposed on a site listed in the LLUR the application is referred to the Council's Environmental Health Team. Conditions are attached to the resource consent to deal with short term and long term exposure of contaminants.

### 6.3.4 Industrial Sites

Industrial sites will be managed in accordance with CRC231955 Conditions 47 and 48 in a process that will occur in parallel to this SMP. The Council will:

- Gather information about and develop a desktop-based identification of industrial sites, ranking sites for risk relative to stormwater discharge;
- Audit at least 15 (principally high risk) sites per year;
- Inform audited industries of the results of audits and work closely with these industries to achieve outcomes in line with the Stormwater and Land Drainage Bylaw 2022;
- Communicate with industries about stormwater discharge standards and the means of meeting these standards.

The Council is empowered to do these actions by the Stormwater and Land Drainage Bylaw 2022.

### 6.3.5 Landfills

There are a number of closed landfills in the catchment and other closed landfills in the Heathcote Valley, immediately outside the catchment. Stormwater from landfills is runoff from the surface and as such it should not be contaminated by the landfill contents. Landfill leachate is not generated by stormwater but may impact stormwater in waterways.

Landfills vary in size, contents and ages. Some are large and have mixed contents or higher-risk contents and present a possible risk of discharge of leachate to surface water which may affect water quality within the catchment. Higher-risk landfills are monitored but the majority are unmonitored.

GHD Limited undertook a desktop assessment of the potential effects of leachate discharging from closed landfills on stormwater quality within the Ihutai-Estuary and Coastal catchment. The assessment comprised a review of:

- Groundwater and surface water quality data contained in the 2020 annual monitoring reports for the closed landfills in the area.
- Reviewing readily available surface water quality data from the ECan and Council databases.

GHD concluded that the impact of leachate discharging from the identified closed and operating landfills was difficult to clearly identify from the data reviewed. Three of the four monitored landfills discharge leachate, if any, directly to the estuary. The mixing action of waves and tide would be expected to attenuate contaminants. The results for sampling in Estuary Drain, which discharges into the Bexley Wetland, do indicate a slight impact from landfill leachate. With attenuation, this effect cannot be distinguished at a nearby monitoring location in the Ōtākaro/Avon River close to Bridge Street. Surface water monitoring upstream and downstream of the Bexley landfill does not indicate that landfill leachate is having an effect on water quality (Summarised from GHD 2021).

Known landfills, historic or otherwise, are believed to be consented.

The unexpected discovery of a landfill or buried material should be treated according to the Christchurch City Council Unexpected Contamination Discovery Procedure 2016 (revised 2019) TRIM 19/70165

## 6.4 The Port Hills as a Sediment Source

### 6.4.1 Deforestation History

"The predominant vegetation of the rural part of the Port Hills is a mixture of over-sown and top-dressed short tussock (mainly silver tussock) grasslands, with some limited indigenous bush remnants, as well as small areas of exotic forest." (ECan, 1997).

(Despite the current land cover) the Port Hills are still situated in a forest climate and in natural post glacial circumstances would be largely forest or shrub covered." (McMillan, 2015)

Most Port Hills grassland is owned by the Council, the Port Hills Park Trust Board, and the Department of Conservation, however there are significant privately owned areas above Avoca Valley and Mt Pleasant. Those parts of the Port Hills in public or trust board ownership are protected from development in order to:

- protect remnant indigenous biodiversity;
- enhance biodiversity;
- conserve landscape values and the city's rural backdrop; and
- increase recreation opportunities.

"The majority of the Port Hills grasslands have been classified as an outstanding natural landscape in the 2015 District Plan review. 'Natural' in this context largely relates to the unbuilt character, topographical features and large areas of indigenous tussock." (McMillan)

"Grazing management of the Port Hills has been the norm for over 150 years" (McMillan). Council land is leased for grazing with the purpose of controlling weeds and limiting fire danger. Pastoral use continues largely because of the cost of native forest revegetation but also because the risk and consequences of fire are considered to be reduced in grassland areas.

"By the mid-20th century, it was apparent that conversion of otherwise fertile and productive lowland hill country from indigenous forest to pasture had triggered severe soil erosion in many parts of New Zealand" (Bloomberg & Davies).

### 6.4.2 Erosion

Bruce Trangmar of Landcare Research was engaged to assess erosion risk on the Port Hills after the October 2000 storm had caused many large slips. His report mapped approximately 312 hectares within the Ihutai-Estuary and Coastal Catchment at severe risk of tunnel gully or slip erosion (**Error! Reference source not found.**). Trangmar's "severe" erosion areas coincide with sediment sources known to Port Hills Rangers.

## 6.5 The Value of Replanting for Land Stabilisation

"Vegetation works in many ways; it stabilises soil by its root system, it provides a ground cover that improves microclimate and soil conditions as well as acting as a protective layer for bare soil against rain splash, it may enrich the soil by fixing nitrogen in its roots, and it may act as a filter or barrier to sediment-laden runoff." (Phillips, 2005). Phillips also comments that "…research and investigation on the use of indigenous vegetation specifically for erosion and sediment control has, in general, received little attention in New Zealand." Nevertheless permanent native forest is considered to be a desirable and stable land cover for New Zealand hillslopes (Walls, 2014). Native plants contribute to biodiversity and landscape character, are adapted to the climate and do not pose a risk of invasive species spread.

Regional Parks Rangers have carried out replanting on unstable areas since c2004, at an average rate of 5 Ha per year, achieving a total planted area of 79 Ha on selected "severe risk" sites including Sumnervale. The planting programme has received increased funding in the current Long Term Plan. Erosion and sediment control will be carried out on unstable parts of the Port Hills, although that programme will be separate from SMP activities.

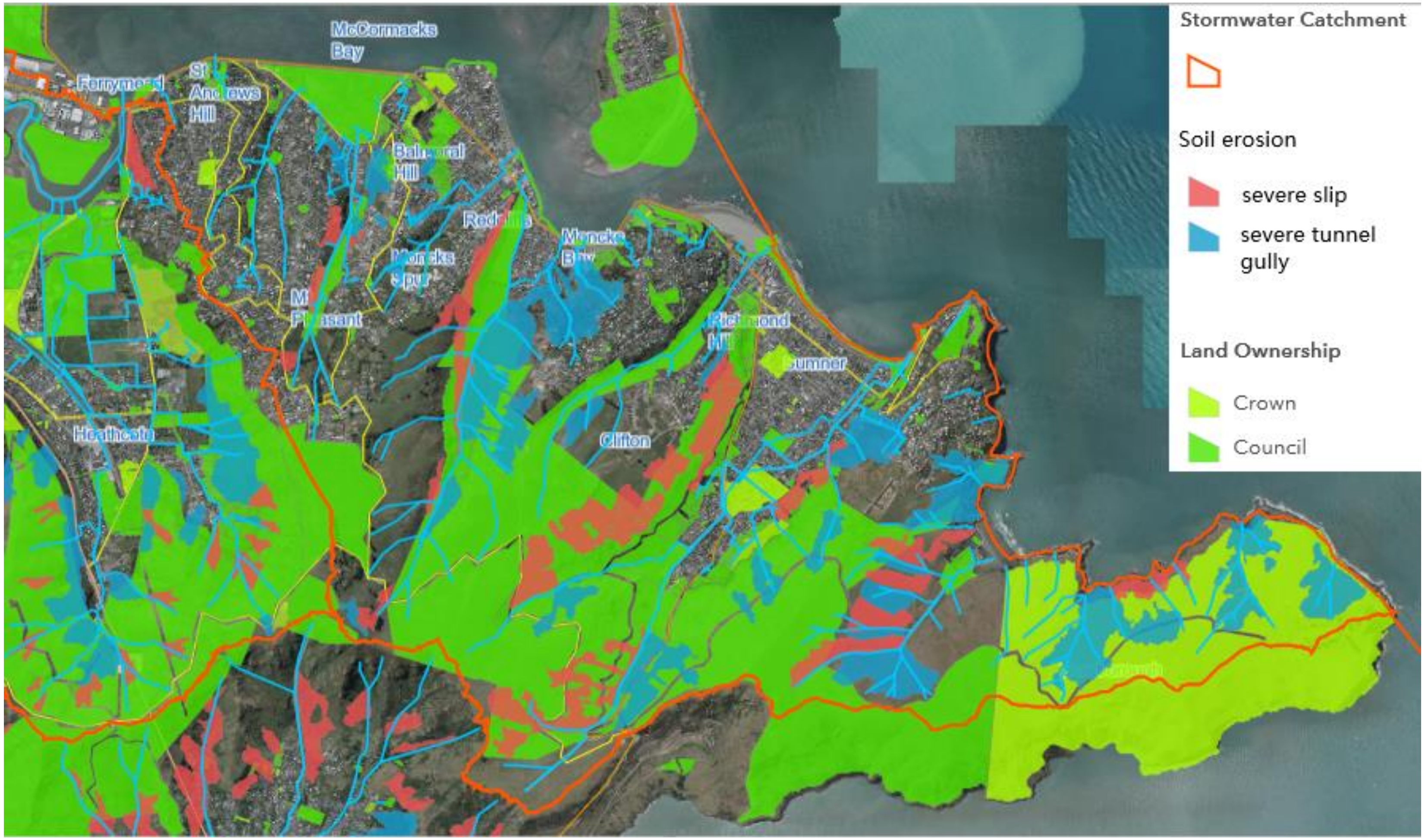


Figure 11: Areas on the Port Hills highly susceptible to erosion

# 7 Contaminants in Stormwater

## 7.1 Introduction

Urban activities cause environmental effects either by shedding more or faster stormwater runoff or by discharging contaminants into stormwater that are harmful to the environment. Most urban surfaces have some form of coating (e.g. paint or galvanising) and a transient layer of wind-blown dust, combustion products, cleaning compounds, etc. Most of these substances are soluble or slightly soluble in rainwater and are transported in dissolved and particulate form into the stormwater network.

## 7.2 Contaminants and Contaminant Sources

The Council and ECan monitor rivers, streams and stormwater for a range of water quality indicators. Contaminants of most concern are:

- Dust, sediment, grit, and particles of all types capable of being transported in stormwater, referred to as total suspended solids (TSS). Suspended solids include metal particles, aggregates of metallic compounds, and charged (e.g. clay) particles with attached metal ions.
- Dissolved and particulate zinc.
- Dissolved and particulate copper.
- Polycyclic aromatic hydrocarbons (PAHs).
- Bacteria.
- Nutrients (phosphorus and nitrogen).

Lesser contaminants, which generally do not exceed guidelines in routine sampling, are:

- Hydrocarbons (usually oil and grease but including Polycyclic Aromatic Hydrocarbons).
- Cadmium and lead.

### 7.2.1 Suspended Solids

Particle sources include construction activity, land cultivation, combustion, industrial products, tyre and brake wear and paint coating breakdown. Some particles are natural materials and some are artificial (e.g. paint chips). Natural particles are not necessarily non-polluting, as they often carry adsorbed chemicals.

Suspended solids are damaging because they deposit on stream beds and fill the spaces between stones, greatly reducing the refuge options for instream life. Fine particles release attached toxic compounds which harm the food chain.

The most important particulate sources are considered to be:

- Roads - a combination of road surface wear, vehicle emissions and wind deposition.
- Construction sites including road works.
- Unstable parts of the Port Hills.

Vehicle traffic generates particles by abrading the road surface and depositing particles from tyre and brake wear. Many construction sites and road works lose sediment into stormwater runoff by erosion or from truck wheels onto roads, from where it enters the stormwater network. Port Hills sediment enters streams in overland flow from slips and tunnel gullies.

### 7.2.2 Zinc

Zinc is used as a protective coating for steel on corrugated iron roofs, rooftop ventilators, lighting poles and various barriers and fences. Although a zinc layer is long lived it is slowly being dissolved by rain water. Industrial and commercial areas have large areas of unpainted galvanised roofs and are a major source of zinc. Residential areas typically have painted or tile roofs, but many of these have older paint coatings in poor condition. Because residential areas are so extensive these old roofs are also a major source of zinc.

Zinc makes up about 1% by weight of tyres in which zinc oxide is a vulcanising catalyst. Tyre wear releases zinc onto roads. Roofs create approximately ¾ of urban zinc. Roads create approximately ¼, much of which is from tyres. Other zinc sources include galvanised fencing and posts, fungicides, paint pigments and wood preservatives.

Many sources such as Timperley et al (2005) report that tyre-derived zinc is transported onto other surfaces, including roofs, by wind. Stormwater sampling in Christchurch supports this, showing zinc runoff occurring from nominally zinc-free surfaces such as concrete tile roofs.

### 7.2.3 Copper

The largest amount of exposed urban copper is a binding and anti-vibration element in brake pads where it may comprise from a few percent to 10% by weight. The majority of copper in urban stormwater comes from fine copper particles abraded from brake pads. These particles are so fine that a large proportion can be quickly dissolved by rainfall to become bioavailable, often at toxic concentrations.

Copper is used in luxury roof cladding, spouting and downpipes, fungicides and moss killers. Architectural copper could become a significant copper source if usage increases.

### 7.2.4 Polycyclic aromatic hydrocarbons

PAHs are created when products like coal, oil, gas, and garbage undergo an incomplete burning process. PAHs are a concern because they do not break down readily and can stay in the environment for a long of time. PAHs may also come from coal tar sealants, diesel or industrial combustion. A number of old streets were surfaced with coal tar, although they have been resurfaced with bitumen, which does not contain PAHs. Edge frittering and surface deterioration can still release coal tar particles. There can be high PAH concentrations in nearby stream and river sediments.

### 7.2.5 Pathogens

*Escherichia coli* are sampled routinely as an indicator of the potential presence of other faecal-sourced pathogens. *Escherichia coli* sources include faecal material from water fowl, dogs, ruminant animals, birds and humans. *Escherichia coli* is assessed in conformity with national microbiological water quality guidelines as an indicator of human health risk.

Although there is persistent concern that wastewater overflows introduce pathogens into rivers, recent studies show there are other and potentially more significant sources such as water fowl.

Since wastewater overflows occur infrequently, and only during heavy rain when dilution and flushing also occur, they can be considered an infrequent and minor source of pathogens. Canine sourced faecal material is also less likely to be found in rivers, because of compliance with the Dog Control

Bylaw 2016 (part 5; owners disposing of dog faeces), and because dog faeces enter rivers only indirectly when washed in during rainfall.

Environmental Science and Research Limited (ESR) was engaged to investigate *E. coli* sources. Moriarty & Gilpin, (2015): commented that water fowl are the major cause of pathogen numbers exceeding recreation guidelines.

### 7.2.6 Nutrients

Nitrogen (nitrate, Nitrate-Nitirite-Nitrogen and Dissolved Inorganic Nitrogen) concentrations decrease downstream. This trend has been observed for many years in Christchurch rivers and has been attributed to nitrogen-rich spring input in the upper catchment deriving from rural land uses (such as fertilisers and animal waste). Recent research by the Council in the Ōtākaro/Avon River catchment has confirmed that springs contribute high levels of nitrogen and phosphorus into waterways, accounting for this downstream trend in nitrogen concentrations (Munro, 2015). Spring flows entering the upper river arise from shallow groundwater that is more influenced by agricultural inputs. Deeper groundwater containing more seepage from the Waimakariri River enters downstream parts of the river. This water contains less nitrogen and progressively dilutes in-river nutrients.

Nitrogen very seldom exceeds LWRP toxicity guidelines with respect to ammonia (this guideline varies depending on pH) and nitrate (3.8 mg/L), but frequently exceeds a non-LWRP guideline (ANZG, 444 µg/L) set to avoid excessive instream plant growth. The recent PDP instream springs study (PDP, 2016) also showed substantial nitrogen inflows to Ōtākaro/Avon tributaries via spring flows, suggestive of non-urban sources (i.e. agricultural catchments).

Phosphorus can exceed guidelines in Christchurch during wet weather. Higher phosphorus levels are found in Haytons and Paparua Streams, indicating that industrial sources can be important. A weak-to-moderate positive correlation was recorded between suspended solids and phosphorus in the 2015 Council surface water monitoring report (Margetts & Marshall, 2016) indicating that this increase may be related to cumulative sediment inputs downstream. Leaf decomposition can be a major source of phosphorus. Phosphorus inputs can also come from fertilisers, detergents and faecal matter.

Phosphorus concentrations increase downstream in both the Ōtākaro/Avon and Ōpawāho/Heathcote Rivers, indicating that there are urban sources. Potential sources are historical and ongoing inputs of phosphorus and organic matter into river sediments and the occurrence of anoxic conditions that release phosphorus (and ammoniacal nitrogen) (Pattle Delamore, 2022). Port Hills' sediment may be an important phosphorus source.

### 7.2.7 Emerging contaminants and other contaminants

Unknown contaminants or contaminants that are not sampled for may have consequences for stream ecology that will only be discovered over time. Potential new contaminants include microplastics, hormones, herbicides and cleaning products (e.g. moss killers).

6PPD-quinone was found recently in stormwater samples. 6PPD-quinone is an antiozonant[3] in tyres. It has been found to kill Coho Salmon before they spawn in freshwater streams in the USA. The Council will keep up-to-date with national and international research on emerging contaminants.

[3] Stabilises tyre rubber against ozone attack

Asbestos has been found in river bed sediments in small quantities. Asbestos is not known to be harmful to aquatic life. Asbestos in bed sediments is not harmful to humans unless the sediments are removed from the river and dried, such as during dredging. The Council is aware of the risk and takes appropriate precautions during dredging operations.

## 7.3 Contaminant load model

An annual contaminant load model was developed by DHI and Tom Cochrane (University of Canterbury) for the coastal catchment (DHI 2021). Total suspended solids, copper and zinc were modelled in each of the 22 sub-catchments with urban and rural contributions assessed separately.

Urban loads were estimated using MEDUSA, which is an event-based, pollutant load, process model used to predict amount of TSS, Cu and Zn contributed by impermeable surfaces during a rain event. Predictions are based the surface area, material type, average rainfall intensity, pH, rainfall duration, and length of antecedent dry period (Charters et al. 2020).

Rural estimates were modelled for rural land areas contributing to the nearest waterway reach identified in the (NIWA) River Environmental Classification. A sediment yield (in $kg/m^2/yr$) was estimated from *Updated sediment load estimator for New Zealand. NIWA Client Report No. 2018341CH* (Hicks et al. , 2019), and assigned to each rural land parcel. Total sediment load for each coastal sub-catchment was then derived by summing the yield estimate from the area associated with each land parcel. Sediment yield estimates were combined with soil metals concentration data to estimate rural metal loads.

Background estimates of soil Zn and Cu concentrations (in mg metal/kg sediment) from Cavanagh et al. (2015) were mapped onto each of the Coastal Catchments and an area-weighted average value was calculated**Error! Reference source not found.**.

Model results are tabled in Appendix D.

### 7.3.1 Model estimates of TSS (sediment) loads

The largest modelled contributors of rural sediment are sub-catchments with large areas of rural hillside, consistent with real world observations. Sediment discharged from roads dominates urban TSS discharges per unit area. Sub-catchments with proportionately more road area and more highly trafficked roads are estimated to generate more urban TSS.

Some residential sub-catchments such as Sumner, Moncks Bay and Rifle Range model high TSS loads based on roads being a relatively high proportion of urban area. This result may be an over-estimate. Sub-catchments with significant industrial and commercial areas show high urban loads that, however, might under-predict. As commercial/industrial block sizes are larger than residential block sizes the proportion of road-sourced TSS is proportionately lower. This may be an artefact of the model setup.

### 7.3.2 Model estimates of copper loads

The major source of urban copper is vehicle brake pads, so roads generate most of the modelled copper load. Brake dust is transported by wind onto other surfaces such as roofs, and model inputs are set accordingly. However, it can be expected that sub-catchments with greatest traffic volumes will generate the most copper.

Model estimates of copper loads are mostly determined by the proportion of urban area that is 'road'. The largest modelled copper loads per hectare are from Taylors Mistake, Sumner and Rifle Range. All three sub-catchments have a relatively high proportion of road area to urban area, although the Taylors Mistake result appears to be an artefact of model assumptions and setup. Bromley, Linwood Canal (partly central city) and Tidal View (at the intersection of Humphreys Drive and Ferry Road) have relatively lower modelled copper loads, because of a relatively sparse road network caused by large block sizes. Copper loads per urban hectare are otherwise within a fairly close range.

In general copper can be captured by treating road runoff where roofs and paved areas discharge onto roads, as is usual in residential areas.

### 7.3.3 Model estimates of zinc loads

Commercial and industrial areas are estimated to contribute the largest amounts of zinc due to their relatively high proportions of roof and paved areas. Bromley, Tidal View and Linwood Canal (partly central city) are the largest contributors per hectare of zinc. Sumner, McCormacks Bay and Rifle Range model larger zinc discharges than other residential catchments, influenced by higher roof zinc discharges, perhaps because of higher housing density or generally larger dwellings.

### 7.3.4 Indicated priorities for treatment

Model results suggest that priority areas for treatment are:

- Areas with a dense and highly trafficked road network;
- Areas with a higher than normal proportion of roof area;
- Steep, erodible hillsides.

Based on the results in Appendix D the priority urban catchments having high discharges of TSS and metals per hectare appear to be:

- Bromley;
- Tidal View;
- Linwood Canal.

Secondary catchments of interest, subject to verification of model results by monitoring, are:

- Urban parts of Sumner, Rifle Range and McCormacks Bay.

Rural hill sub-catchments that model the highest sediment loads, both total and per hectare, are Sumner, Taylors Mistake, Rifle Range (Barnett Park) and Godley Head. These sub-catchments could be priorities for hillside stabilisation planting.

# 8 Flood Hazards

## 8.1 History

Stormwater drainage in Christchurch was under the control of the Christchurch Drainage Board from 1875 until 1989. The Drainage Board had relatively wide powers for its time, to maintain or modify natural watercourses and construct sewers and drains.

In April 1878 William Clark, a British drainage engineer engaged to advise the Board presented a “Drainage Scheme for Christchurch and the Suburbs”. The key points of Clark's 1878 report to the Drainage Board were the separation of wastewater and stormwater and recommendations for drainage improvements. The Board mostly constructed sewage works for the next 70 years, with some open drain construction and stream widening.

Some decades of relatively dry weather came to an end in December 1963 when rainstorms caused serious flooding, especially near the Port Hills and in Waltham. There were further floods in March and August of 1965 and in January and November of 1966. Storms in April (the Wāhine storm), May and June of 1968 "highlighted the inadequacies in many sections of the drainage system and stressed the need for major relief works". Subsequently the Sumner Flood Relief Pipe of 2.1 metres diameter was constructed between Wakefield Avenue and The Esplanade in 1972, and the City Outfall Drain was deepened and lined in the early 1980s.

## 8.2 Land and property flooding

Sections 8.4 to 8.13 summarise risks of flooding in sub-catchments.

## 8.3 Tidal flooding dealt with separately

The SMP does not deal with or plan for flooding from the sea. The Council has separately initiated a programme of coastal hazards adaption planning starting with communities in Whakaraupō / Lyttelton Harbour in 2022. Comments from the *Coastal Hazard Assessment – Summary Report 2021* are included in some sections from 8.4 to 8.13 where relevant. More about adaptation planning can be found at *https://Council.govt.nz/environment/coast*

## 8.4 Brooklands Lagoon and Bottle Lake Forest

Some rural land east of Lower Styx Road drains to Brooklands Lagoon and is in the Coastal catchment. Further south including through Bottle Lake Forest the land is a little higher and, being sandy, drains into the ground (but is still nominally within this catchment).

### 8.4.1 Brooklands Drainage Issues

Rural land between Brooklands and Brooklands Lagoon is low lying, but protected from normal tides by low sand hills. The land drainage system is protected by tide gates. An extreme, once-in-a-decade tide could flood farm land. A small number of new houses have been built in Earlham Street in the Flood Management Area. One of these houses settled during the 2010/11 earthquakes and is in a poorly drained area, so will in future be exposed to tidal flooding.

In the longer term almost all of the area could become prone to coastal flooding in a one year return period event if sea level rise continues.

## 8.5 Parklands/North New Brighton

Parklands and North New Brighton is flat coastal plain, protected from the sea by sand hills. The area has free-draining soils, but seasonally high groundwater can inhibit drainage. It is served by a piped drainage network, including some subsoil drains, discharging to the ocean.

### 8.5.1 Drainage Issues

Flooding can occur in Parklands/North New Brighton residential areas due to rainfall. Extreme tides may occasionally impede stormwater drainage but neither the tide nor the Ōtākaro/Avon River are expected to flood the area. Water in excess of system capacity (nominally 5 year return period) tends to pond where it falls due to the flat terrain. Ponding may occur in numerous places during rainfall, indicated in Figure 12: 50 year average recurrence interval flooding extent (pale blue) – from model results.. Ponding is generally shallow. (Figure 12 is a result file from a Rain-on-grid model.)

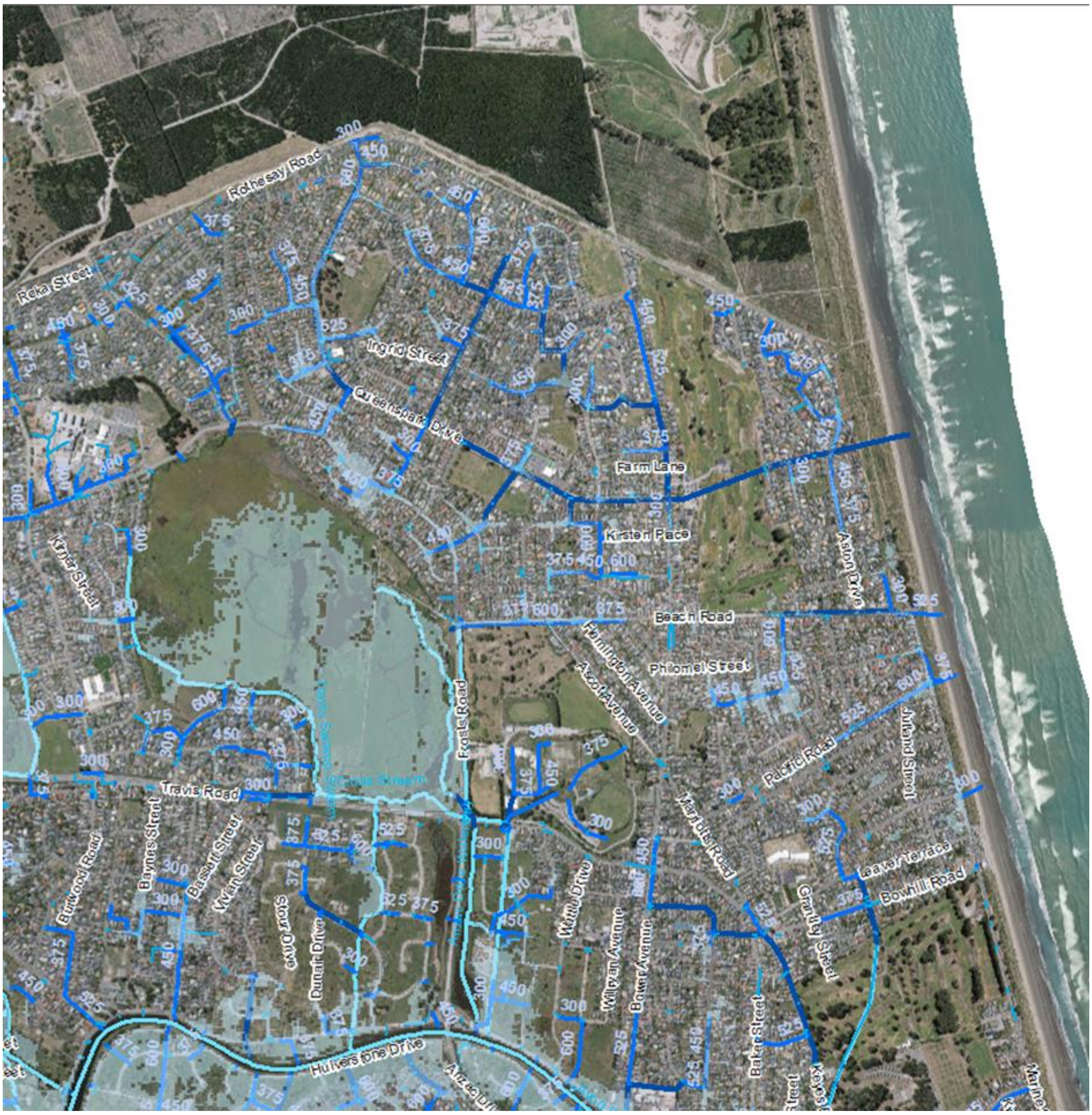


Figure 12: 50 year average recurrence interval flooding extent (pale blue) – from model results.

### 8.5.2 Flood Risk Summary

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in "possibly floodable" |
|---|---|---|---|
| 10 | 0 | 0 | High |
| 50 | 0 | 6 | Moderate.<br>Modelled flood levels, inferred floor levels. |

From modelling and historical observation there is understood to be a low risk of flooding to a small number of houses.

### 8.5.3 Current Response to Flood Risk

In this sub-catchment the flooding risk is dealt with by:

- The stormwater network.
- Christchurch District Plan rules. New builds within the Fixed Minimum Floor Level Overlay (District Plan definition) (i.e. Flood Hazard Management Areas) are required to have a floor level above the 200 year Average Return Interval (ARI) flood level plus 400 mm. (Full definition including tidal influences found in District Plan section 5.4).
- The Building Act 1991. Outside the Fixed Minimum Floor Level Overlay all new builds are required to have a floor level that is above the 50 year ARI flood level plus 400 mm.
- The Council maintains and is revising a hydraulic (flood) model for the catchment.

### 8.5.4 Future Response to Flood Risk

An improved prediction could be made with better information about the relationship between floor levels and modelled flood levels. A hydraulic (flood) model for the catchment is expected to be completed in 2023. It is proposed that the Council obtain floor levels where a credible risk of above-floor flooding exists. The Council could use this information to inform prospective home owners.

## 8.6 Linwood Canal Sub-catchment

Linwood Canal is the seaward end of City Outfall Drain whose headwaters are near the Christchurch Multi Use arena. The catchment area is 460 hectares. Aside from some remnant sand hills in Avonside, all of the catchment is flat or gently sloping. The central area (Wainoni and Linwood) is an inter-dunal coastal plain lying between sand hills to the west in Avonside (west) and Bromley (east). The open portion of City Outfall Drain conveys stormwater through this area from Olliviers Road into Linwood Canal. The City Outfall Drain's capacity is restricted by a flat gradient which can allow water to flood out of the channel at approximately 10 year return period frequency (Figure 13).

### 8.6.1 Drainage Issues

Flooding in this sub-catchment is most likely to occur as a result of local rainfall. In a large event when system capacity is exceeded the water ponds in hollows that are fairly shallow (0.25 – 0.5 m) and of moderate extent, and often distant from the City Outfall Drain. Ponding may occupy private land as well as streets.

### 8.6.2 Flood Risk Summary

There is understood to be a low risk of rain-generated flooding to a small number of houses.

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in “possibly floodable” |
|---|---|---|---|
| 10 | 0 | 0 | High |
| 50 | 0 | Few or none | Moderate.<br><br>Based on modelled flood levels and inferred floor levels. |

Figure 13: 50 year average recurrence interval flooding event – from model results.

### 8.6.3 Responses to Flood Risk

In this sub-catchment the flooding risk is dealt with by:

- The stormwater network.
- District Plan rules. New builds within the Fixed Minimum Floor Level Overlay (District Plan definition) (i.e. Flood Hazard Management Areas) are required to have a floor level above the

200 year ARI flood level plus 400 mm. (Full definition including tidal influences found in District Plan section 5.4).

- The Building Act 1991: Outside the Fixed Minimum Floor Level Overlay all new builds are required to have a floor level that is above the 50 year ARI flood level plus 400 mm.
- The Council maintains a hydraulic (flood) model for the catchment.

Improved predictions could be made with better information about the relationship between floor levels and modelled flood levels. It is suggested that the Council obtain floor levels where a credible risk of above-floor flooding exists. The Council could use this information to inform prospective home owners.

Since c2003 the Council has acquired seven properties along the City Outfall Drain to facilitate drain widening and naturalisation. This process could be continued as a long term drain renewal project. Drain naturalisation would assist in future-proofing this catchment against growth.

## 8.7 South New Brighton and Southshore

South New Brighton / Southshore is a narrow sand spit protected from the ocean by three metre high sand hills on the eastern side. The area is relatively open to the estuary on the western side, and the Southshore residential area is low lying. Most of Southshore's residential area and parts of South New Brighton are lower than an extreme (20 to 50 year recurrence interval) tide level. During post-earthquake site clearance in the (abandoned) Red Zone[4] a discontinuous low mound of soil was left in the cleared zone to mitigate the loss of pre-existing informal tide protection. In 2017 the Council joined mounds to form a continuous bund across road ends to prevent tidal flooding. The current exposure to tidal flooding is similar to what existed pre-earthquakes.

Residential properties often drain to ground because of the sandy soil. Roads are drained to the estuary by stormwater pipes which have check valves to exclude the tide.

### 8.7.1 Drainage Issues

Stormwater drainage can be hampered by high tides, since a high Spring Tide reaches the same level as much of Rocking Horse Road (Figure 14). Minor leakage can enter through tide valves and accumulate in side channels. Elevated sea levels often coincide with heavy rainfall and the combination can cause road and land flooding.

Information available to the Council suggests that stormwater alone will not flood house floors, i.e. flooding is a predominantly tidally driven risk.

The *Coastal Hazard Assessment – Summary Report* comments that within the (10 year) timeframe of this SMP "Coastal flooding from the estuary and river could reach 150 to 400 m inland on an occasional ("10-year") event" with a 1% annual chance of deeper water within a similar area.

### 8.7.2 Risk of flooding from stormwater alone

The table below is an estimate of the risk of flooding from stormwater alone. Stormwater flooding to houses is understood to be a low risk.

[4] Southshore Red Zone: a strip of land one property wide that was purchased by the Crown and evacuated and cleared in recognition that the land is unsuitable for building.

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in “possibly floodable” |
|---|---|---|---|
| 10 | 0 | 0 | High |
| 50 | 0 | 0 to 2 or 3 | Moderate |

There is a risk from tidal flooding if tidal defences are overtopped. The risk is low, and is being dealt with by the Council separately as an earthquake recovery project; see bullet point 6 in section 8.7.3.

Figure 14: 50 year average recurrence interval flooding – (‘Rain-on-grid’ model, 11.1 m tide)

### 8.7.3 Responses to Flood Risk

In this sub-catchment the flooding risk is dealt with by:

- The stormwater network.
- District Plan rules.
- New builds within the Fixed Minimum Floor Level Overlay (District Plan definition) (i.e. Flood Hazard Management Areas) are required to have a floor level above the 200 year ARI flood level plus 400 mm. (A full definition is in the Christchurch District Plan section 5.4).
- Additional restrictions exist (on changes to building plan area) within the High Flood Hazard Management Area, which is a high percentage of the total residential area.
- The Council maintains and as necessary updates a hydraulic (flood) model for the catchment.
- A stopbank to protect against elevated tide levels is being constructed from Bridge Street to Jellicoe Marsh (Ebbtide Street vicinity). Further south; the Council has resolved to strengthen the bund along the western edge of Southshore in 2024. Design crest levels match the Ōtākaro/Avon stopbanks, equivalent to a 50 year return period tide with 400 mm freeboard.

Improved knowledge about flooding risks to houses could be made with more extensive floor level information. It is proposed that the Council obtain floor levels where a credible risk of above-floor flooding exists. The Council could use this information to inform prospective home owners.

Recent (2017) advice from the Ministry for the Environment predicts an estimated 0.2 metre of sea level rise by 2040. With 0.2 metre of sea level rise there will be some tidal flooding on roads during high tides and rainfall will pond on roads over the peak of the tide. By this time the Council is expected to have considered the installation of stormwater pumping stations, however pumping stations may not be an appropriate means to protect Southshore. Groundwater pumping stations may be installed to lower groundwater levels beneath roads and avoid damage to road foundations.

## 8.8 Bromley Industrial Area

A 110 hectare industrial area occupies slightly elevated sandy ground which slopes toward the estuary. It is drained by a network of pipes and open drains.

### 8.8.1 Drainage Issues

Drainage issues include ponding on streets during rain and limited capacity in some open drains, leading to ponding on low lying land near drains. Flat gradients on streets inhibit street drainage and the number of street inlets may also limit drainage. Groundwater levels are relatively high, especially in winter. Building flooding has not been reported.

### 8.8.2 Risk of Flooding From Stormwater

| Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in “possibly floodable” |
|---|---|---|---|
| 10 | 0 | 0 | High |
| 50 | 0 | 0 | Moderate |

## 8.9 McCormacks Bay

McCormacks Bay residential area and its catchment are mostly steep hills, with a narrow coastal fringe. Stormwater from houses and roads is typically piped into vegetated valleys.

### 8.9.1 Drainage Issues

Stormwater flooding is not reported in this sub-catchment. Drainage issues include:

- Road or hillside runoff causing erosion during storms.
- Road runoff spilling through private property, with potential to enter houses.
- High tide levels threatening some house floors on the coastal fringe.

Coastal flooding from the estuary can cover McCormacks Bay Road and could reach 30 – 100 m inland in an occasional (10-year average recurrence interval) event.

### 8.9.2 Risk of Flooding From Stormwater Alone

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in “possibly floodable” |
|---|---|---|---|
| 10 | 0 | 0 | High |
| 50 | 0 | A few hillside houses | Moderate |

### 8.9.3 Summary of Flood Risk

Stormwater flooding to houses is understood to be a low risk, as indicated in the table above. There is a risk that McCormacks Bay Road can flood in high Spring Tides. There is also a risk to some low-lying houses although it is less than the risk of road flooding, as floors are somewhat elevated. Some houses rebuilt since the Christchurch earthquakes may have floor levels lower than the current minimum permitted level. Protection for some houses may need to be considered in future as sea levels rise.

### 8.9.4 Responses to Flood Risk

This sub-catchment is close to fully developed. The flooding risk is dealt with by:

- The stormwater network.
- Prudent road, section, driveway and house design with a view to controlling hillside water.
- Christchurch District Plan rules.
- New builds within the Fixed Minimum Floor Level Overlay (District Plan definition, i.e. Flood Hazard Management Areas) are required to have a floor level above the 200 year ARI flood level plus 400 mm. (Full definition including tidal influences found in Christchurch District Plan section 5.4).

Recent (2017) advice from the Ministry for the Environment predicts 0.2 metre of sea level rise by 2040. With 0.2 metre of sea level rise there will be some houses on McCormacks Bay Road at moderate risk of occasional tidal flooding. While this is not stormwater driven it is more likely to occur during storm events and could be associated with rain-induced flooding.

## 8.10 Redcliffs

Redcliffs is a small sub-catchment of approximately 100 hectares that is part hillside and part coastal plain. Runoff is captured into pipes which discharge to the estuary. Hillside pipes nominally have a 20 year return period capacity: runoff in excess of capacity travels overland to the foreshore where it must pond until it can be drained by the pipe network. The lowest lying areas, in Celia Street and Beachville Road (R.L. 10.75 metre to Council Datum) are approximately 1.35 metre above mean sea level and approximately 0.5 metre above mean high water. A stormwater pumping station PS 209 in Redcliffs Park operates when high tides impede normal discharge.

### 8.10.1 Drainage Issues

The drainage network appears to have capacity to meet the (5 year return period) level of service, however the secondary flow path[5] is obstructed by a sea wall. Excess stormwater will pond in and near Celia Street and Beachville Road when network capacity is exceeded, tides are extreme, or stormwater catchpits are obstructed. A number of houses in this area are observed to have low floor levels.

### 8.10.2 Risk of Flooding From Stormwater Alone

Likelihood of house flooding is estimated based on LiDAR land levels (which are considered accurate to ± 0.15 m), observed foundation types, and estimated foundation height (0.15 m for concrete slab foundations and 0.45 m for piled foundations). Ponding levels are judged unlikely to exceed RL 11.0 metre at a 50 year recurrence interval. “Possibly or near floodable” houses are those with estimated floor levels below 11.0 metre.

Hydraulic modelling is pending.

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in “possibly floodable” |
|---|---|---|---|
| 10 | 0 | 0 | High |
| 50 | No reliable information | 1 to 10 | Moderate |

### 8.10.3 Flood Risk Summary

Stormwater flooding to houses is believed to be a moderate to low risk.

### 8.10.4 Responses to Flood Risk

Redevelopment is occurring in this sub-catchment, particularly near the coast. At the time of redevelopment the Council can apply minimum floor levels through District Plan rules.

The flooding risk is dealt with by:

- The stormwater network and pumping station.

[5] The path for flood water when the primary stormwater network capacity is exceeded

- Prudent road, section, driveway and house design to properly manage hillside water.
- Christchurch District Plan rules.
  - New builds within the *Fixed Minimum Floor Level Overlay* (District Plan definition) (i.e. Flood Hazard Management Areas) are required to have a floor level above the 200 year ARI flood level plus 400 mm. (Full definition including tidal influences found in District Plan section 5.4).

As the sea level rises the frequency of on-road flooding will increase, however such events will generally be of short duration. Within 20 years it will probably be noticeable that high tides impede the discharge of heavy rainfalls to the extent of causing carriageway flooding on Celia Street and Beachville Road. A pumping station PS 209 serves these two streets when high tides coincide with rainfall.

Increased pumping capacity could be introduced in the short term to control nuisance flooding. Over the longer term the Council and community will need to develop a coastal hazard mitigation strategy that takes into account rising sea levels, tsunami risk and stormwater flooding.

## 8.11 Rifle Range Drain / Moncks Bay

Rifle Range Drain has a sub-catchment of 314 hectares that is part hillside, part valley and part coastal plain. Open waterways are significant features of the drainage network. Rifle Range Drain passes through a residential area and is culverted under Main Road. It was once the catchment's primary outlet but that function is now shared with Rifle Range Drain Overflow in Barnett Park.

It is inferred that Rifle Range Drain was once a small natural channel that accommodated the flows from smaller rain events, while larger flows spilled over the valley floor. The channel has been lined and perhaps narrowed in places to accommodate development. Rifle Range Drain Overflow now diverts the greater proportion of flood discharges down a swale within Barnett Park to a pipe inlet outlet near the Moa Kids Early Learning Centre.

### 8.11.1 Drainage Issues

The built network conforms to the Council drainage level of service, having a capacity in excess of the 5 year average recurrence interval. However the secondary flow path across Main Road (the coast road) is seriously impeded by shorefront development and sea walls. Flows in excess of network capacity are retained on Main Road and side streets, and in large events may pond to a level that will flood some houses.

### 8.11.2 Past Flooding

A southerly storm on 12-13 October 2000 storm dropped 130 to 150 mm of rain on this catchment in 30 hours. The rain event was judged to have a 5 to 10 year average recurrence interval. Responses to a postal survey reported 8 houses and 24 garages flooded (Couling, 2000). The number of houses flooded may have exceeded the number reported.

A south-westerly storm brought heavy rain to Banks Peninsula and Christchurch on 4 and 5 March 2014. Hillside runoff ponded on Main Road and within properties. Water levels are reported by the Mayoral Taskforce to have reached 11.24 m, i.e. 0.3 to 0.5 m deep on the road. Seven houses were reported as flooded, with a further nine houses possibly but not confirmed as flooded. (Field staff at that time did not carry out a full survey due to privacy concerns.)

These two events seem to represent approximately 10 year recurrence interval rainfall and flooding events.

### 8.11.3 Risk of Flooding From Stormwater Alone

The likelihood of flooding in this sub-catchment is dependent on whether debris from the upper catchment will cause the drain in Barnett Park to overflow or the pipe inlet to block. Flooding of houses should be a rare event if the network operates flawlessly. However network failures could be caused by unpredictable events such as slip debris blocking major intakes.

Flooding experienced in a March 2014 storm is near the maximum that could be expected with 50 year ARI frequency (Figure 15). Although flood water accumulates on Main Road near Barnett Park, it can flow eastward along Main Road and out to the estuary at the Christchurch Yacht Club, where there are no sea walls. This tends to place an upper limit on ponding levels.

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in "possibly floodable" |
|---|---|---|---|
| 10 | 0 | 4 | Moderate |
| 50 | Could be more than 7 to 10. Information is not reliable. Reduces as houses are rebuilt with higher floor levels. | 10 to 20<br><br>Reduces as houses are rebuilt with higher floor levels. | Moderate |

The likelihood of house flooding is an estimate based on LiDAR land levels, observed foundation types, and estimated foundation height (generally 0.15 m for concrete slab foundations and 0.45 m for piled foundations). Hydraulic modelling has not been carried out.

### 8.11.4 Responses to Flood Risk

Although this sub-catchment is nearly fully developed, particularly near the coast, there is ongoing renewal of old housing. At the time of redevelopment the Council applies higher minimum floor levels through District Plan rules.

The flooding risk is dealt with by:

- Prudent road, section, driveway and house design to properly manage hillside water.
- The stormwater network.
- Christchurch District Plan rules.
- New builds within the Fixed Minimum Floor Level Overlay (District Plan definition) (i.e. Flood Hazard Management Areas) are required to have a floor level above the 200 year ARI flood level plus 400 mm. (Full definition including tidal influences found in District Plan section 5.4).

The likelihood of house flooding will reduce in the medium term as houses are replaced or raised to the Christchurch District Plan minimum floor level of R.L. 12.3 metre. R.L. 12.3 is approximately one metre higher than the floor levels of older houses near the shore.

In the longer term sea levels will rise and it can be expected that sea walls will be raised, or installed where needed, to shield Main Road from waves. This will further impede the exit of flood water and may increase the depth of ponding during periods of flooding.


Figure 15: Estimated extent of rainfall-sourced land flooding experienced once in 20 to 50 years.

Figure 15 is based on the extent of flooding in March 2014. The majority of house floors are higher than the indicated flood level.

Some houses flooded in March 2014 have unusually low floor heights and would be difficult to protect by any means, even with stormwater pumping. However stormwater pumping or house floor raising are the most promising options to relieve flood risk as sea level rise progresses. House floor raising is significantly more certain than pumping.

As a response to the current situation the Council should:

1. Survey the floor levels of houses likely to be at risk.
2. Put in place a maintenance plan for the Barnett Park Drain and Inlet to maintain design capacity at all times.
3. Install additional debris trapping upstream from the Barnett Park Inlet.
4. Investigate the need for and costs versus benefits of sea walls and secondary flow outlets.
5. Investigate the need for and costs versus benefits of stormwater pumping.

## 8.12 Sumner Stream and Richmond Hill Drain

Sumner is a fairly densely developed residential area situated on a slightly terraced valley floor surrounded by steep hills. The catchment area is 450 hectares. The adjacent Richmond Hill Drain has a hillside catchment of 116 hectares.

Sumner Valley is shaped into three shallow basins formed by old beach ridges. Sumner Stream conveys hill catchment runoff through the valley and also drains most of the valley floor. Sumner Stream is ephemeral, and its lower reaches are tidal.

After severe flooding in the Wahine Storm April 1968 the Christchurch Drainage Board constructed a 2.1 metre diameter bypass pipe (the Sumner Flood Relief Pipe) more-or-less aligned to Sumner Stream, from Sumnervale to the eastern end of the beach.

Richmond Hill is served by a lined, open waterway that discharges into a pipe at Nayland Street, and from there onto the beach beside Cave Rock.

### 8.12.1 Drainage Issues

Sumner Stream, like many natural waterways is of a size that will contain 2 to 5 year return period flows. The stream has been lined in some places to enable buildings to be sited close to stream or to protect against stream-bank erosion. Development now occupies the floodplain and land filling, retaining walls, road culverts and buildings have encroached on the stream channel. Runoff in excess of stream capacity spills out of the channel from time to time and ponds on the floodplain. Quite extensive ponding occurs at approximately a 10 year average recurrence interval. Some house flooding can be expected at approximately a 20 year average recurrence interval.

Denser development has the potential to deliver more stormwater into Sumner Stream during flood events and worsen flooding.

### 8.12.2 Past Flooding

A storm in October 2000 brought 130 mm of rain into the van Asch (Sumner) rain gauge, representing a rainfall of between 10 and 20 year average recurrence interval. Two houses were flooded when the Sumner Stream overflowed. At least two houses and two commercial premises received water above floor level from an overflow of Richmond Hill Drain.

A second outlet pipe for Richmond Hill Drain was subsequently installed.

A storm in March 2014 dropped 170 mm of rain at the van Asch rain gauge, representing a rainfall with an indicated 40 - 50 year average recurrence interval. Five or six houses were flooded, along with a significant part – approximately 20% - of the valley floor. No building flooding attributed to the Richmond Hill Drain was reported.

### 8.12.3 Flood Modelling

Preliminary results from the current hydraulic model indicate that of the order of 25% of the land in Sumner Valley would flood in a 50 year average recurrence interval event. Model results are used to predict potential house flooding based on LiDAR ground elevations and conservative estimates of foundation height – see Figure 16.

Over-floor flooding in a 10 year average recurrence interval event: possible 36 houses.

Over-floor flooding in a 50 year average recurrence interval event: possible 119 houses.

These estimates seem high in relation to past events. The prediction is conservative and is sensitive to estimated foundation height: a small change in either could alter the prediction significantly. The prediction is very likely to alter as the model is refined. The Council is revising its flood model for the Sumner Catchment. The model will estimate both rainfall and tidally driven flooding. It will also model the effects of increasing housing density including changes under the Natural and Built Environment Act.

| Average Recurrence Interval (years) | Number of houses known to be floodable | Number of houses possibly floodable or near floodable | Confidence level in "possibly floodable" |
|---|---|---|---|
| 10 | 0 | 6 to 20 | Moderate |
| 50 | Insufficient information | 30 to 120 | Moderate |

### 8.12.4 Responses to Flood Risk

Although this sub-catchment is well developed, there is ongoing infill housing. A building consent is approved subject to safe minimum floor levels through Christchurch District Plan rules. Flooding risks are currently dealt with by:

- The stormwater network.
- Knowledge based on rainfall records and flood modelling
- Christchurch District Plan rules which apply to new buildings.

New builds within the Fixed Minimum Floor Level Overlay (District Plan definition, i.e. Flood Hazard Management Areas) are required to have a floor level above the 200 year ARI flood level plus 400 mm. (Full definition including levels for tidally influenced areas is found in the District Plan section 5.4). Safe (i.e. elevated) minimum floor levels applied since the early 2000s has protected new builds.

### 8.12.5 Discussion

Major factors increasing the flood risk to Sumner properties are:

- The Sumner Stream outlet is restricted, both by its narrow width and by intermittent sand build-up at the outlet;
- Narrow road culverts;
- Privately built obstructions in the stream channel and floodway;
- Hillside debris can block the Sumner Flood Relief Pipe inlet grate;
- Continual sediment accumulation reduces the Sumner Flood Relief Pipe capacity;
- Some floor levels are undesirably low.

In a flood event exceeding approximately 20 year average recurrence interval there is more water entering the Sumner Stream than is able to be discharged to the sea, due to outlet restrictions. Water accumulates in three ponding basins as indicated in **Error! Reference source not found.**. Some low lying houses could be inundated.

Ponding of storm runoff on a floodplain is common in natural catchments and is inevitable on any valley floor in large to extreme events. Christchurch District Plan rules will ultimately lead to most if not all houses being elevated above all but the most extreme flood levels. This strategy protects the home owner's major asset and provides a safe refuge for people. However the nuisance of under-floor flooding, damage to outbuildings, vehicles, etc, or access difficulties may remain. The proposed flood model should test whether provision of additional stream capacity is desirable to limit nuisance and flood damage and improve safety during flood events.

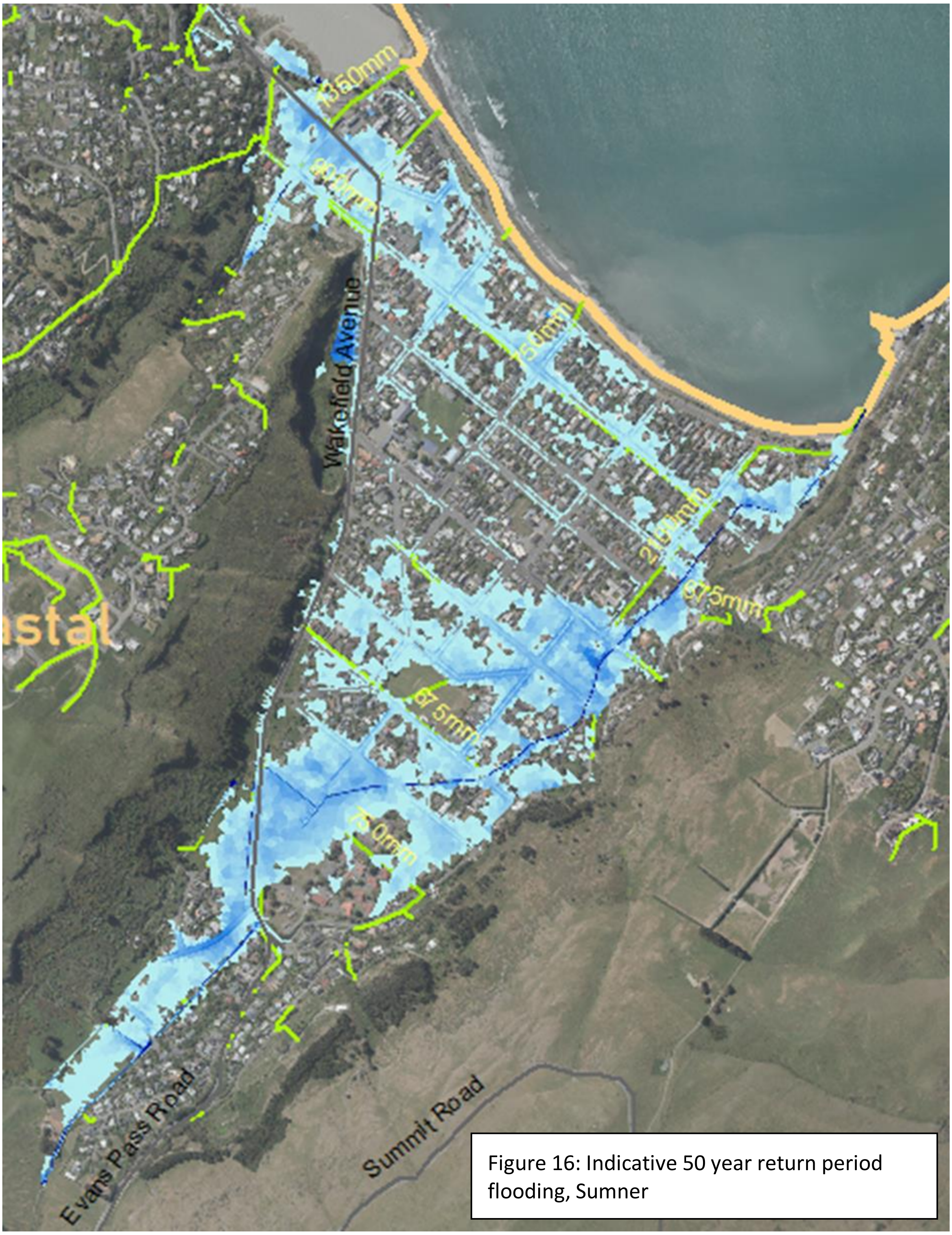

Figure 16: Indicative 50 year return period flooding, Sumner

[Map: SurfaceWaterModels:\04_ROG\Southshore MF D1 50yrCC1hr pt5SLR PostEQ ROG Depth]

## 8.13 Taylors Mistake

Taylors Mistake catchment is rural and there is no Council stormwater infrastructure. The flood plain of Taylors Mistake Stream is not developed. Flooding issues are minor and no flood mitigation plan has been developed for this catchment.

# Section Three
# Objectives and Principles

# 9 The Water Quality Approach

## 9.1 Introduction

Mitigation options have been considered for contaminants that regularly exceed water quality targets and are believed to be significant causes of poor stream health (Table 3: Contaminant sources). Contaminant sources include industrial waste releases which cause pollution, although they are not specifically monitored.

Commonly detected contaminants that can be mitigated through the SMP are:

- Sediment (as consent conditions require control by specified means);
- Port Hills sediment (section 7.3.1);
- Industrial discharges containing oils, cleaning compounds, nitrates/nitrites, chemicals, etc (section 11.4).

Other common contaminants such as metals typically exceed water quality targets for relatively short periods during and after rainfall. It is believed that they affect ecosystem health but the effects are not well quantified. Short term (acute) exceedances are not directly relatable to Australian and New Zealand Guideline (ANZG) trigger levels. The Council feels it must do more investigation before it can establish best practicable mitigation options for short term exceedances of:

- Zinc (section 8.2.3);
- Copper (section 8.2.4).

Table 3: Contaminant sources

| Contaminant | Source | Contribution | Possible Mitigation Methods |
|---|---|---|---|
| Sediment | Port Hills | Very high | Valley retirement & planting |
| | Construction sites | High | Sediment & erosion controls |
| | Road works | High | Sediment controls |
| | Road surface abrasion | Medium | Treat road runoff |
| | Atmospheric deposition | Low | None |
| | Plants (leaves, etc) | Medium (seasonal) | Street sweeping |
| | Vehicle emissions | Low | Treat road runoff |
| | Residential activity (car washing, gardening) | Medium | Behaviour change |
| Zinc | Bare galvanized roofs | Very high | Replace with:<br>Non-metal roofs or<br>Pre-coated Zn-Al[6]<br>Paint with:<br>Low zinc paint |
| | Old painted roofs | Very high | Replace with: |

[6] Pre-painted zinc-aluminium coated steel.

| Contaminant | Source | Contribution | Possible Mitigation Methods |
|---|---|---|---|
| | | | Non-metal roofs or<br>Pre-coated Zn-Al<br>Paint with:<br>Low zinc paint |
| | Bare Zn-Al[7] roofs | High | Replace with:<br>Non-metal roofs or<br>Pre-coated Zn-Al<br>Paint with:<br>Low zinc paint |
| | Vehicle tyres | High | Treat runoff from: busiest roads, car parks, manoeuvring areas |
| | Industrial discharges (inferred from monitoring) | Medium | Controls on industrial sites |
| Copper | Brake pads | High | Use low-copper brake pads; Legislation bans copper in brake pads |
| | Roofs, cladding, spouting, downpipes | Low but increasing | Ban on copper cladding |
| Human sourced bacteria | Sewage overflows | Infrequent but culturally offensive | Improve waste-water system capacity |
| Waterfowl sourced bacteria | Ducks, geese | Major bacteria source | Reduce exotic waterfowl numbers |
| Industrial discharges | Deliberate spills or poorly controlled sites | Medium | Regulation, monitoring and enforcement |
| Polycyclic aromatic hydrocarbons | (Old) coal tar street surfaces.<br>Combustion | High but isolated.<br>Low | Encapsulation or removal.<br>Monitor |
| Nitrogen (nutrient) | Groundwater<br>Fertiliser<br>Faeces (human, dogs, farm animals and waterfowl) | High<br>Believed low<br>Believed moderate | Beyond Council control<br>Education<br>Reduce wastewater over-flows and exotic waterfowl numbers. Owners collect dog droppings. Fence waterways. |
| Phosphorus<br><br>(nutrient) | Industrial sources<br><br>Fertiliser<br><br>Faeces (human and waterfowl)<br><br>Groundwater | Moderate<br><br>Believed to be a minor source<br><br>Believed moderate<br><br>Moderate | Education, enforcement<br><br>Education<br><br>Reduce wastewater overflows and exotic waterfowl numbers<br><br>Beyond Council control |

[7] Zinc-aluminium coated steel. Has commonly replaced galvanised iron since 1994.

| Contaminant | Source | Contribution | Possible Mitigation Methods |
|---|---|---|---|
| Litter | People | High | Education<br>Street sweeping<br>Trapping at catchpits (on road)<br>Litter traps on pipe outlets |

## 9.2 Modelling and considering options

The MEDUSA contaminant model referred to in section 7.3 indicated that the Port Hills is the predominant source of sediment, followed by roads. The model indicates that the predominant source of zinc is from roofs, approximately 2 to 3 times what is discharged from roads. The predominant source of copper is from vehicles using roads. This information is indicative, because of limitations in data (e.g. areas of galvanized, tile, etc roof are not accurately known) and other assumptions about metals discharges from roads and roofs. Model results indicate priority areas for treatment based on per-hectare or total contaminants discharged.

Stormwater is most commonly treated in basins and wetlands, which are most effective in capturing particulate contaminants including sediment and particulate metals. Other forms of treatment such as filters and rain gardens treating road runoff can also perform a useful role in treating zinc and other major contaminants, and capture dissolved metals more effectively. Removal of contaminants at source (e.g. by painting roofs or installing low-copper brake pads) should give significant gains if widely implemented.

Potential mitigation options for TSS, copper and zinc are summarised in Table 4Table 4 .

Some source controls appear promising, and there are suggestions that traditional practices such as street sweeping could be effective mitigation options. However, insufficient information is currently available regarding the costs, benefits and practicability for a number of treatment options. This means that it is difficult to determine the best practicable option (BPO) to be implemented to deal with a range of contaminants across many situations. Some of the reasons for this are as follows:

1. Metals discharges in stormwater are of short duration and there is neither a standard nor substantive scientific research that relates short term (acute) concentrations to measurable in-stream effects.

2. Acute TSS effects are also somewhat unclear, although there is agreement that particulate material on stream beds is visible and measurable.

3. TSS and metals are discharged in some measure from every impervious urban surface, so effective controls may have to be widespread. The many potential mitigations have differing and sometimes uncertain efficiencies. Treatment system performance must often be inferred from overseas research in different climates and situations.

4. Some potential options could mean changes to common building materials or methods and are likely to involve additional costs to individuals and businesses.

5. The Council believes that an option based on incomplete information is not the best practicable option, and that substantial expenditure on an unproven option would not be prudent.

At present the Council does not have sufficient information or legal powers to make a decision on many of the potential options. Considerably more information, such as the long term costs and benefits of maintaining roof coatings, substituting roof materials or installing stormwater filters, would be required before the Council could consult on and select BPOs. Work being carried out under CRC231955 Conditions 59 and 60 should provide better information. It is the expectation that additional work will be initiated through the proposed Surface Water Implementation Plan referred to in section 2.1.

Selected contaminant reduction measures are discussed in section **Error! Reference source not found.**.

## 9.3 Less significant contaminants

Less significant contaminants are sometimes detected at low levels, but do not have a mitigation strategy because they either do not exceed guidelines or have a non-stormwater source. These include:

1. *Escherichia coli* implies a risk of other pathogens harmful to humans. (There are no pathogen targets in the consent. Pathogen controls are likely to be considered in the Surface Water Implementation Plan).
2. Polycyclic aromatic hydrocarbons (PAHs): no consent targets. Do not exceed LWRP guidelines.
3. Nitrate and nitrite: no direct consent targets. Mostly non-stormwater sources.
4. Phosphorus: no direct consent target. Partial control through controls on sediment.
5. Ammonia: no consent target. Does not exceed LWRP guidelines.

## 9.4 Potential Mitigation Options

Table 4 : Potential at-source mitigations for contaminants

(TSS = total suspended solids, BPO = best practicable option)

| Contaminant | Source | Potential Control Option | Comment | How the controls could be implemented |
|---|---|---|---|---|
| TSS, copper, zinc | New subdivisions (large sites) | Facilities in new developments to limit increases in flow rate and capture TSS | Partial mitigation, mostly for new growth (greenfields) | As conditions on subdivision, resource or building consents |
| TSS, copper, zinc | New development (small sites) | On-site (private) devices | Partial mitigation for new development (typically brownfields) | Included in Table 7 Minimum Standards for Development |
| TSS (mostly sediment) | Construction & excavation sites | Council implements and monitors on-site erosion and sediment control | Can be difficult to do and is often poorly managed on site | Effected through conditions on individual resource or building consents |
| TSS (mostly sediment) | Road works | Council implements and monitors on-site erosion and sediment control | Many contractors do this already | Required as a condition of Road Opening (road works) Permits |
| TSS | Vehicle traffic; road surface abrasion and particles shed by vehicles | Rain gardens, tree pits, and filters to treat runoff from busy roads.<br>Road sweeping, catchpit filters | Can also remove some zinc and copper. | Install treatment devices over time to treat stormwater from contaminated catchments.<br>Additional road sweeping. |
| Port Hills sediment | Slips, under-runners, bank erosion | Fence and vegetate unstable valleys, slips, water courses | A programme commenced in 2022.<br>(Would offset erosion that results from urban activity e.g. bike tracks, road cuttings) | Council leads by example on its own land; Council educates and incentivises private land owners. |

| Contaminant | Source | Potential Control Option | Comment | How the controls could be implemented |
|---|---|---|---|---|
| Port Hills sediment | Unprotected road cuttings | Shield from rain and runoff | Council leading by example | Further action may result from trials that are under way |
| Copper | Vehicle brake pads | Educate residents about the value of low/no copper brake pads.<br>Advocate with Government for legislation change | Legislation has occurred in USA. Some low-Cu pads available in NZ | Copper-free brake pads becoming available by market forces. Council educates local auto industry and residents.. |
| Copper | Architectural copper (roofs, spouting, downpipes) | Transparent coating applied to copper surfaces.<br>Contaminated runoff treated on site. | May not be fully effective e.g. inside downpipes.<br>Coating or treatment devices must be maintained in good condition or copper will continue to discharge. | This is a current control effected through building consents. |
| Copper | Architectural copper (roofs, spouting, downpipes) | Investigate the feasibility of a District Plan rule to discourage the use of copper claddings. | | By seeking legal advice about the practicability of such a Rule.<br>Under way. |
| Copper, zinc | Roads, roofs | Divert first flush to the wastewater network | Limited capacity available in WW network. | This option is one of a number of Schedule 4 (CSNDC Condition 40) investigations. |
| Zinc | Bare steel roofs (mostly industrial) | 1. Educate and encourage use of pre-painted roofing<br>2. Potential District Plan rule to require roof runoff treatment on site.<br>3. Potential District Plan rule to discourage the use of bare zinc roofing. | | 1. Educate and encourage use of pre-painted roofing<br>2. Investigate the feasibility of a District Plan rule to require roof runoff treatment on site.<br>3. Investigate the feasibility of a District Plan rule to discourage the use of bare zinc roofing. |

| Contaminant | Source | Potential Control Option | Comment | How the controls could be implemented |
|---|---|---|---|---|
| Zinc | Poorly maintained painted roofs | Education programme re roof maintenance.<br>Possible incentives. | Old paint coatings expose zinc primer and zinc substrate. Can be half as bad as bare roof.<br>Roof re-painting could cost 20-30% of the cost of re-roofing. | Council to investigate the costs & benefits of painting v renewal v civic scale stormwater treatment.<br>Under way. |
| Zinc | Vehicle tyre wear | Treat runoff from major roads | Treatment is partially effective.<br>By one estimate 7% of the city's roads generate 50% of metallic contaminants.<br>Overseas research may discover a less toxic alternative to zinc. | Install road runoff treatment devices.<br>The Council will continue to engage with the government through MfE. |
| Industrial waste and spills | Poorly controlled industrial sites | Surveillance, education, on-site improvements, enforcement | | Council undertakes industrial audits and requires mitigation practices to be followed. If not actioned, Council looks to exclude sites from the CSNDC. Educate industry sectors. |
| Pathogens (bacteria, etc) | Water fowl, dogs, wastewater overflows | Reduce water fowl numbers, dog controls, wastewater overflow controls | Some dog and wastewater overflow controls in place. | Council introduces controls on water fowl to restrict numbers to an agreed limit. Wastewater overflows are progressively being reduced. |
| Phosphorus | Multiple potential sources | Investigate sources.<br>Education and enforcement used to control private/industrial sources.<br>Control sediment discharges | | Education and investigations could be funded through the Community Waterways Partnership |
| Nitrogen | Multiple potential sources | Investigate sources and use education and enforcement to control private/industrial sources. | | Education and investigations could be funded through the Community Waterways Partnership |

## 9.5 Role of Monitoring and Tangata Whenua Values in Setting Targets

### 9.5.1 Environmental Drivers

It is clear from ecological monitoring that waterways and the estuary are significantly affected by urban runoff and are in a poor condition overall. It is inferred that this is a result of altered flow regimes and contaminant discharges associated with urban development. The SMP has adopted the measures available to it (Section 9.8) at this time. The location for the proposed treatment wetland is chosen based on the likelihood that the industrial area is a significant contaminant source, and the availability of land.

### 9.5.2 Mahaanui Iwi Management Plan Objectives

This Plan recognises and is intended to help support the policies and objectives for water and the environment in the Ihutai/Estuary Catchment, from the Mahaanui Iwi Management Plan 2013 (Table 5: Response to the Mahaanui Iwi Management Plan).

### 9.5.3 Lessons from monitoring of treatment basins

Design decisions will be made with reference to the WWDG, international research and current best practice. To date there has been insufficient monitoring of treatment basins to generate a usable body of information. Additional comment on previous monitoring can be found in a memorandum titled *Inferences from Performance of Treatment Basins 1993-2020,* TRIM 22/490757.

Table 5: Response to the Mahaanui Iwi Management Plan

| Iwi Management Plan | Ihutai/Estuary and Coastal SMP response |
|---|---|
| Policy IH3.1 To improve water quality in the Ihutai Estuary catchment by consistently and effectively advocating for a change in perceptions of waterways: from public utility to wāhi taonga. | A *Community Water Partnership* programme is being prepared and will carry out an education and advocacy role once it is funded and implemented. |
| Policy IH3.2 To require that waterways and waterbodies (including Te Ihutai) are managed to achieve and maintain a water quality standard consistent with food gathering. | The SMP can contribute toward this to the extent indicated by the Goals in section 12.1. |
| Policy IH3.3 To require that local authorities eliminate sources of contaminants to waterways in the Ihutai/Estuary catchment, primarily:<br>(a) Sewage overflows in the Ōpāwaho and Ōtakaro Rivers; | 8 significant overflow sites eliminated since the earthquakes. Somerfield WW pumping station due $7.7M upgrade 2022-24; Eastern Tce WW main $1M upgrade 2022 will further reduce overflows. |

| Iwi Management Plan | Ihutai/Estuary and Coastal SMP response |
|---|---|
| (b) Stormwater discharges into all waterways, including small headwater and ephemeral streams, and drains;<br><br>(c) Run-off and discharges into waipuna; | (Wastewater overflows are consented separately under CRC182203.)<br>The SMP is a management tool for reducing contaminant discharges into waterways. The Council does not see an alternative to stormwater discharge into waterways in the near term.<br>The Council cannot currently prohibit discharges into a waterway that flows past/over waipuna. Improving stormwater quality generally is the only approach that seems to be open to the Council in the foreseeable future. |
| Policy IH3.4 To advocate for the following methods for improving water quality in the catchment:<br>(a) Avoiding the infiltration of stormwater into the sewage systems, which results in overflow discharges to the rivers and estuary;<br>(b) Protect and retain margins and set back areas along waterways, and ensure that these are of appropriate width and planted with indigenous species;<br>(c) Restoration of degraded springs and wetlands; and<br>(d) Requiring on site and closed stormwater treatment and disposal techniques (that do not discharge to water) for urban developments, public lands and parks. | (Measures are being implemented to reduce wastewater overflows).<br><br>Waterway margins are generally protected by the District Plan.<br><br>Restoration of degraded springs is an initiative in the proposed Healthy Water Bodies Plan.<br>High groundwater and impermeable soils seem to make this unfeasible in many parts of the city.<br><br>Treatment is required for new development, (although the Council is aware that even best practice treatment is not fully effective.) The volume of stormwater seems to make closed systems not practicable: however the Council is working to remove contaminants of stormwater in the long term. |
| Policy IH5.1 To require that the waipuna in the catchment are recognised and managed as wāhi taonga, as per general policy on wetlands, waipuna and riparian margins (Section 5.3, Issue WM13), with particular attention to:<br><br>(a) Ensuring that waipuna are protected from the discharge of contaminants; | The SMP may not be the right way to control discharges to waipuna and restoration of waipuna.<br><br>The Council tries to prevent direct discharges into waipuna through the District Plan: however such discharges are not prohibited by the consent conditions. Management of waipuna is a District Plan and possibly a Bylaw matter. Asset Planning – |

| Iwi Management Plan | Ihutai/Estuary and Coastal SMP response |
|---|---|
| (b) Ensuring that there are appropriate and effective setbacks from waipuna, to protect from urban development or re-development;<br><br>(c) Restoring degraded waipuna; and<br><br>(d) Enabling flow to return to waterways in naturalised channels. | Stormwater and Land Drainage staff will advocate for this form of protection in District Plan reviews. |
| IH6.2 To require that any physical works on waterways in the urban environment occurs in a manner that does not reduce the width of margins or riparian plantings, and is consistent with the re-naturalisation of the waterway. | Controls re applied through District Plan waterway setbacks and the Stormwater and Land Drainage Bylaw 2022, rather than through the SMP. However RMA provisions do not always permit full control. |

## 9.6 Changes in response to public submissions

Presentations were made to the Christchurch-West Melton Zone Committee and to the Waitai/Coastal-Burwood and Waikura Linwood-Central-Heathcote Community Boards.

Exchanges of information occurred with the Department of Conservation and the Canterbury Regional Council Regional Engineer, as preferred by those organisations.

Mahaanui Kurataiao was asked to prepare a Position Statement on cultural matters. Council staff were advised that consultation with the Rūnanga should be effected through the position statement.

The SMP went out for public consultation from Monday 28 March 2022 until Tuesday 26 May. Submissions were invited.

A predominant theme of submissions was support for actions to reduce sediment discharges and encouragement for the Council to do more. Submitters strongly encourage the Council to be proactive in addressing erosion sites through stabilisation works, planting and greater use of regulatory powers to control construction sites.

The second most common theme is to ask the Council to address coastal flooding caused by the tide or by impeded flow paths (e.g. behind sea walls).

Some submitters advocated on-site mitigation of stormwater quantity and quality.

Feedback from commercial organisations could not be easily summarised into themes and tended to address matters related to the nature or specific interests of the organisation.

Objectives 1.5, 2.2 and 3.3 were added in response to submissions.

## 9.7 Receiving Environment Targets

The two following CSNDC Conditions create contaminant reduction targets.

### 9.7.1 Condition 19 numerical targets:

The Council is to specify target contaminant load reductions to be achieved by proposed facilities and devices.

Numerical targets (Table 6) are proposed based on a contaminant load model. The contaminant load model based on the University of Canterbury's MEDUSA model was run by DHI and the Tom Cochrane (University of Canterbury) (DHI 2021).

Target reductions are estimated by the Coastal catchment model for a proposed stormwater treatment wetland in Linwood Paddocks, adjacent to Dyers Road, treating 90% of the Bromley industrial area.

Table 6: Target reduced stormwater contaminant load from Linwood Paddocks treatment wetland.

| Contaminant | Target reductions in stormwater contaminant load<br>Resulting from construction of a new stormwater mitigation facility<br>Compared to the consent application base year 2018 |
|---|---|
| | On completion of the wetland. c 2027<br>(as a percentage of the contaminant load entering the estuary) |
| TSS | 3.4% |
| Total Zinc | 5% |
| Total Copper | 5.3% |

TSS are reduced less than metals because of the relatively large sediment contribution attributed to untreated hill catchments.

### 9.7.2 Schedule 7 to 10 Targets

Condition 23: "The (Council is to) use best practicable options to mitigate the effects of the discharge of stormwater on:

(a.) Surface water quality, instream sediment quality, aquatic ecology health, and mana whenua values. The extent of mitigation effects shall be measured by Receiving Environment Attribute Target Levels monitoring described in Schedules 7 and 8.

(b.) Groundwater and spring water quality. The extent of mitigation effects shall be measured by Receiving Environment Attribute Target Levels monitoring described in Schedule 9.

(c.) Water quantity. The extent of mitigation effects shall be measured by Receiving Environment Attribute Target Levels monitoring described in Schedule 10."

CRC231955 Schedule 7, 8, 9 and 10 targets are reproduced in Appendix D.

## 9.8 High Risk Sites and Industries

The Council will manage industrial sites through the Stormwater and Land Drainage Bylaw 2022. The Bylaw requires the control of industrial contaminants to meet best practice. In managing high-risk sites the Council will:

- Audit at least 15 high risk sites per year;
- Inform audited industries of the results of audits and work closely with these industries to achieve outcomes in line with the Bylaw;
- Communicate with industries about stormwater discharge standards and the means of meeting these standards.

Change will be sought through a combination of education and enforcement:

- Education will be carried out through an Industry Liaison Group;
- Enforcement will occur as Industrial Audit Officers identify and visit high-risk industrial sites and work with industries to improve site management.

Contamination risks are controlled to a degree by acceptance of trade wastes into the wastewater system. This is authorised through Trade Waste Consents and the monitoring of consents permits a degree of oversight and site control.

The Council's objective is that stormwater entering into the stormwater network is managed according to best practice, especially where the discharge occurs directly into a waterway. On-site pre-treatment may be required unless contaminant levels are less than LWRP Schedule 5 standards.

Where industrial site occupiers do not meet the required standards for discharge into the network, the site will be removed from the CSNDC and will require a separate resource consent from ECan for its discharge. A condition is included in the CSNDC for this process and all industrial sites excluded from the resource consent will be listed on Schedule 1 attached to the consent.

Future needs include:

- More interaction with industries by the Council; communication, awareness and education;
- Improved knowledge of the environmental effects of compounds discharged by industrial sites;
- Ongoing site checks until the Council is confident that all risky sites are controlled adequately;
- Upgrades on non-compliant sites.

## 9.9 New Development

The SMP assumes that there will be minor growth on Port Hills residential areas (Rural Port Hills Zones) shown in Figure 10. From information available at this time the rate of development can only be estimated (Section 7).

Contaminants, particularly sediments, generated by development are controlled by:

- rules in the Christchurch District Plan,
- the Stormwater and Land Drainage Bylaw 2022,
- the Sediment Discharge Management Plan 2020,
- the Erosion and Sediment Control Toolbox for Canterbury,
- requirements of this SMP.

### 9.9.1 Operational controls on stormwater and sediment

The management of sites which may experience erosion and/or discharge sediment during development works is controlled by conditions of either resource consents or building consents, as applicable, for both earthworks and building. The Stormwater and Land Drainage Bylaw 2022 specifies standards for activities not controlled by consents.

Standards for sediment discharges are set by the Sediment Discharge Management Plan 2020 (SDMP). The sediment discharge management process is:

1. Allowable TSS (total suspended solids) concentration trigger levels for discharges to the stormwater network are set by the SDMP.
2. An erosion and sediment control plan (ESCP) is prepared by a 'suitably qualified and experienced professional' as determined by a site risk assessment.
3. The TSS concentration trigger levels for the site are included in authorisations or conditions where possible.
4. The ESC measures are implemented onsite and monitored.
5. If exceedances are detected the builder/developer is required to upgrade ESC measures and a re-inspection is scheduled at the builder's/developer's cost.

### 9.9.2 Constructed stormwater treatment systems

Christchurch District Plan rules require new developments to incorporate stormwater quantity and quality mitigation. Treatment systems may comprise detention basins, infiltration basins, rain gardens, swales and filters. The majority of development in the catchment is expected to be small scale development on hillsides. Both stormwater quantity and quality mitigation will be required:

- Stormwater from development will be detained in storage so that post-development peak flows do not exceed pre-development peaks up to the 2% AEP critical duration event for the catchment.

- Stormwater contaminants are to be treated by the best practicable option as measured by Receiving Environment Attribute Target Levels in CRC231955 Schedule 7.

### 9.9.3 Individual site stormwater

Individual developments are required to treat stormwater to mitigate any change in quantity or quality arising from the development. The minimum standard for stormwater treatment is in Table 7. Developments should also comply with "*Onsite Stormwater Mitigation Guide'* (Council 2021), which gives guidance about onsite storage and treatment for small to medium sites.

The minimum standards for stormwater detention and treatment associated with new development are in Table 7: Minimum standards for stormwater detention and treatment

Table 7: Minimum standards for stormwater detention and treatment

| Source of Stormwater Discharge(s) | Total area of disturbance does not exceed 1,000m$^2$ | Total area of disturbance equals or is greater than 1,000 m$^2$ |
|---|---|---|
| From/during land disturbance activities | An approved Erosion and Sediment Control Plan is required | An approved Erosion and Sediment Control Plan is required |
| From new / re-development **residential** roof and hardstand areas | No discharge onto or into land where average site slope exceeds 5 degrees.<br><br>Sumps collecting runoff from new hardstand areas shall be fitted with submerged or trapped outlets wherever practicable.<br><br>Sites increasing impervious by 150m2 or more to a total coverage in excess of 70% are required to mitigate water quantity effects according to the Christchurch City Council On-site Mitigation Guide.<br><br>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required for sites in the flat (2).<br><br>On-site rain water storage is required for new and redevelopment sites on the hills. | No discharge onto or into land where average site slope exceeds 5 degrees.<br><br>First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m$^2$ and buildings with copper or uncoated galvanised metal roofs or guttering/spouting (1).<br><br>Sites increasing impervious by 150m2 or more to a total coverage in excess of 70% are required to mitigate water quantity effects according to the Christchurch City Council On-site Mitigation Guide.<br><br>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required for sites in the flat (2).<br><br>On-site rain water storage is required for new and redevelopment sites on the hills. |
| From new / re-development **non-residential** roof and hardstand areas | No discharge onto or into land where average site slope exceeds 5 degrees<br><br>First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m$^2$, buildings with copper or uncoated galvanised roofs or guttering/spouting and high-use sites<br><br>Sites increasing impervious by 150m2 or more to a total coverage in excess of 70% are required to mitigate water | No discharge onto or into land where average site slope exceeds 5 degrees<br><br>First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m$^2$, buildings with copper or uncoated galvanised roofs or guttering/spouting and high-use sites<br><br>Sites increasing impervious by 150m2 or more to a total coverage in excess of 70% are required to mitigate water |

| Source of Stormwater Discharge(s) | Total area of disturbance does not exceed 1,000m$^2$ | Total area of disturbance equals or is greater than 1,000 m$^2$ |
|---|---|---|
| | quantity effects according to the Christchurch City Council On-site Mitigation Guide.<br><br>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required (2)<br><br>Site management and spill procedures required for sites that engage in hazardous activities | quantity effects according to the Christchurch City Council On-site Mitigation Guide.<br><br>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required (2)<br><br>Site management and spill procedures required for sites that engage in hazardous activities |
| Any land use with Canterbury Land and Water Regional Plan Schedule 3 activities. | An application for approval under the Stormwater and Land Drainage Bylaw 2022 must be made to authorise connection and discharge into the Council network. | An application for approval under the Stormwater and Land Drainage Bylaw 2022 must be made to authorise connection and discharge into the Council network. |

Explanatory notes for **Error! Reference source not found.**:

(1) "Uncoated" means without a painted or enamelled coating. Council has discretion to waive the requirement for first flush treatment of hardstand areas on large residential sites where the amount and type of pollution-generating hardstand being added is considered to have a less than minor effect.

(2) Quantity assessment and mitigation - The effects of the discharge on the stormwater network capacity and/or the extent or duration of flooding on downstream properties are to be assessed. Where Council considers an increase (including cumulative increases) has a more than minor effect, onsite stormwater attenuation or stormwater network upgrade shall be provided. The details of storage volume and peak discharges or network capacity required to mitigate effects on flooding or network capacity constraints shall be determined by the Christchurch City Council Planning Engineer.

(3) Site management and spill procedures – Procedures are to be implemented to prevent the discharge of hazardous substances or spilled contaminants discharging into any land or surface waters via any conveyance path.

## 9.10 Treatment Facilities

### 9.10.1 Existing facilities

There are no large scale stormwater treatment facilities in this catchment. Five (minor) Council infiltration basins are listed in Appendix C. There are also some private stormwater treatment devices on individual sites.

### 9.10.2 Future facilities

The 'Estuary and Coastal SMP Implementation Programme' (which is one of seven SMP funding streams in the Long Term Plan) represents the capital works which are currently proposed to be carried out. These works are defined at pre-concept level currently, and will be defined in concept from 2024 onwards for implementation from 2026. At this stage both Charlesworth Drain and Linwood Drain are included for consideration within the broad programme scope, with specific project scope to be confirmed during concept definition from 2024 onwards.

A stormwater treatment wetland is being considered to treat stormwater from 90% of the Bromley industrial area. The wetland site would be Council-owned land known as Linwood Paddocks south of the oxidation ponds (Figure 17). The proposal is subject to a number of constraints including:

- Linwood Paddocks is an important feeding and roosting site for native birds,
- Linwood Paddocks is low lying, with approximately 30% of the site at or below high tide level,
- The land was purchased for wastewater treatment purposes and some of the site may be needed for wastewater treatment in the future.

The Council is to consider a report on "benefits and costs of stormwater treatment city-wide" before release of additional LTP funding for further treatment facilities.

It is not proposed to treat stormwater that discharges through sea outfalls (e.g. from Parklands and North New Brighton) under this SMP. The stormwater from these residential areas is less contaminated than from commercial and industrial areas, and low levels of contaminants detected in the ocean make this a lower priority than other locations.

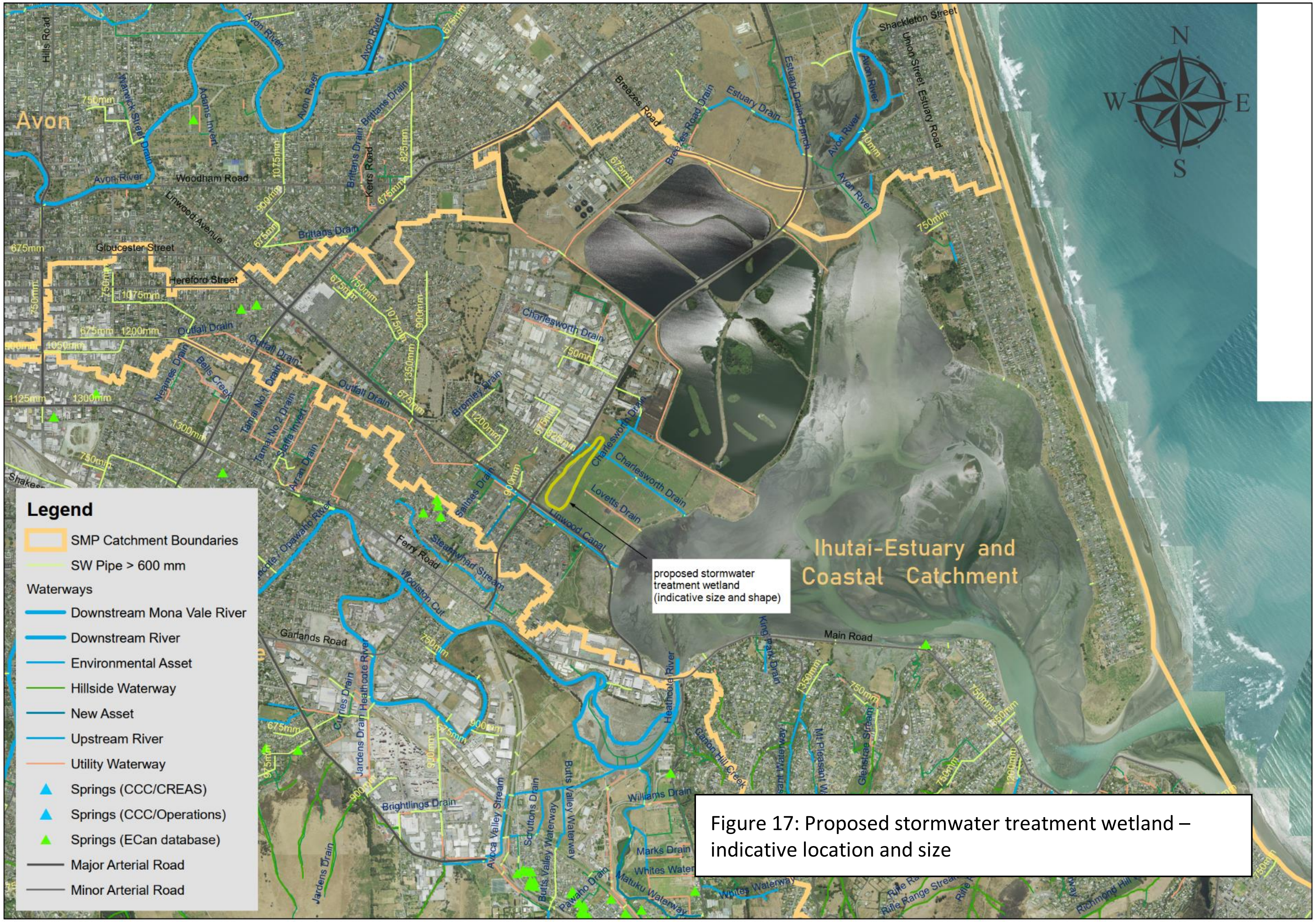


Figure 17: Proposed stormwater treatment wetland – indicative location and size

## 9.11 Contaminant reduction measures

The council considers that with the current state of knowledge the following are best practicable contaminant load reduction options for the SMP:

- Treatment of stormwater from new development (mostly through Table 7: Minimum standards for stormwater detention and treatment minimum standards for small site development) under Section 10.1 Objectives 1.1 & 1.2.
- One stormwater treatment wetland for the Bromley industrial area.
- Potential to treat a second commercial sub-catchment subject to the Council receiving, considering and approving a report on "benefits and costs of stormwater treatment city-wide" before release of additional LTP funding for treatment facilities.
- Remediating eroding hillside stormwater outfalls, Section 10.1 Objective 1.5.
- Erosion and sediment control on development and construction sites, Section 10.1 Objectives 1.3, 1.4, 1.6.
- Investigating the feasibility and legality of zinc control measures for building cladding, Section 10.1 Objectives 2.2 to 2.5.
- Auditing high-risk industrial sites and working with occupiers to remediate contaminated stormwater discharges, Section 10.1 Objective 4.2
- Working with community groups and the public to educate the community about the effects of and mitigation of stormwater contaminants, Section 10.1 Objective 5.1
- Managing flooding by ensuring that stormwater from all new development sites or re-development sites will be attenuated to a minimum standard, Section 10.1 Objective 6.1

Further work will be required to identify BPOs for mitigating copper and zinc discharges from buildings, copper discharges from vehicles and sediment discharges from sources other than development sites. Implementation of such BPOs is more likely to be implemented through the Surface Water Implementation Plan referred to in section 2.1.

The Council is commissioning research into the effectiveness of contaminant reduction options and the toxicity of short duration bursts of dissolved metals in waterways during stormwater runoff. Some answers to these questions may be available within 2 – 3 years.

## 9.12 Effects of stormwater on groundwater

Groundwater in plains areas of this catchment is shallow. While there are believed to be numerous private soak pits for roof runoff disposal there are no civic scale infiltration facilities and nor are these likely, because of the limited available depth to groundwater.

Some infiltration of "storm water" occurs where there is modified bare ground such as parking and storage yards on industrial sites. The volume of infiltration is relatively minor, and most contamination can be expected to be trapped in the soil.

The effects of stormwater on groundwater are thought to be minor,  and any consequences are also minor as this groundwater is not needed for drinking and moving eastwards into the ocean. Groundwater is not considered further in this SMP.

Rain water soakage into the ground from greenspace is not defined as stormwater by the discharge consent.

## 9.13 Changes to springs and base-flow

Schedule 2(l) to the CSNDC (CRC231955) requires consideration of the diversion and discharge of stormwater on baseflow and springs.

There are three recorded springs in this catchment – marked as green triangles in Figure 3 to **Error! Reference source not found.** and Figure 17: Proposed stormwater treatment wetland – indicative location and size.   Two indicated springs near Cashel Street / Linwood Avenue are unknown and may no longer be active.  One spring near the shore at the intersection of Main and Beachville Roads will not be affected by activities carried out under the SMP.

# 10 The Plan - Objectives

These objectives address the issues arising from Sections 3 and 5 through 11.

## 10.1 Goals and Objectives

Goal 1. Control sediment discharges

Our Objectives are:

1.1 *Ensure the quality of stormwater from all new development sites or re-development sites is treated to best practice (with section 9.10.3 being the minimum standard);*

1.2 *100% of stormwater treatment facilities contributing to CSNDC condition 19, Table 2, are constructed and conform to WWDG standards;*

1.3 *Sediment from 95% of consented construction activities on the flat is treated to best practice by 2025;*

1.4 *Sediment from 90% consented construction activities on the Port Hills is treated to best practice by 2025;*

1.5 *Remediate at least one hillside stormwater outfall per year where the discharge is causing erosion and sediment discharge.*

1.6 *Investigate the feasibility of techniques for remediating adverse effects of sediment discharges on receiving environments by 2022 (Schedule 3g of CSNDC);*

1.7 *Analyse options for carrying out street sweeping, sump cleaning, and diversion to wastewater trials in 2020/21 (Schedule 4b & d of CSNDC).*

*There should be a table number and title*

Table 8: Action Plan for Urban Sediment

| Objective | Action | Mechanism | Action Components | Timing |
|---|---|---|---|---|
| **Sediment (urban)** | | | | |
| 1.1<br>New developments | Plan and oversee installation of detention basins, wetlands & swales | District Plan (Development contributions) and Long Term Plan | Normal planning processes. | Ongoing |
| 1.2<br>New treatment facilities | Ensure new facilities are built to best practice | Designs should conform to the Infrastructure Design Standard and allow CSNDC Attribute Target Levels to be met | Normal Council planning, design and procurement process. | Ongoing |

| Table 8: Action Plan for Urban Sediment | | | | |
|---|---|---|---|---|
| **Objective** | **Action** | **Mechanism** | **Action Components** | **Timing** |
| 1.3 & 1.4<br>Construction & excavation sites | On-site sediment and erosion control effected through Erosion and Sediment Control Plans | Council enforcement powers under the Building Act 2004. | Train Building Inspectors.<br>Implement an enforcement process.<br>Contractor(s) on standby for cleanup when breaches occur. | ESC now part of resource consents for earthworks and building.<br>Inspections carried out throughout the construction |
| 1.5<br>Reduce sediment discharges from hillsides | Remediate at least one hillside stormwater outfall per year. | Carry stormwater to the valley floor or distribute on the hillside | Survey outfalls, review outfall designs, design new outfall, install | Starting 2023 |
| 1.6<br>Investigate sediment removal from waterways | Feasibility studies | A study conducted under CSNDC Schedule 3(g) | Review similar activities, consider consenting issues, carry out costings. | To be completed 2022 |
| 1.7<br>Road runoff contains sediment | Investigate & develop methods to treat runoff from arterial roads, | Increase frequency of street sweeping, rain gardens | 1. Street sweeping trials.<br>2. Construct rain gardens where feasible. | Commencing 2021 |

<u>*Recommended for consideration through the Surface Water Implementation Plan*</u>

*1.8* *Plant severely eroding natural areas of the Port Hills (600 Ha identified by the Trangmar 2003 definition) from Heathcote Valley to Hoon Hay Valley;*

*1.9* *Best practice sediment controls are implemented on Port Hills roads and tracks by 2025;*

*1.10* *Road sediment is reduced by a best practicable option determined by the results of street sweeping, sump cleaning and alternative treatment trials (Schedule 4c, f, g & h.).*

<u>Goal 2. Control zinc contaminants</u>

*Our Objectives are:*

*2.1* [repeats Objective 1.2] *All the facilities required to meet contaminant load reduction standards (Table 2 in the consent conditions) are constructed.*

2.2 *As part of an education programme to stop contaminants at source, before the end of 2023, develop an information package describing the harmful nature of zinc and the contribution of bare metal roofs to annual zinc loads to waterways. The information will be circulated to all commercial building owners and relevant building professionals, with suggestions to consider painting roofs, installing stormwater filters or rain gardens.*

2.3 *By 2022 the Council will have investigated zinc mitigation measures and carried out cost/benefit analyses toward identifying their effectiveness as best practicable options.*

2.4 *By 2025 the Council has consulted with key stakeholders and identified a long term zinc strategy consistent with current technologies.*

2.5 *The Council collaborates with local and regional government in joint submissions to central government seeking national measures and industry standards to reduce the discharge of building and vehicle contaminants.*

Table 9: Action Plan for Zinc

| Objective | Action | Mechanism | Action Components | Timing |
|---|---|---|---|---|
| **Zinc** | | | | |
| 2.1<br>Same as 1.1 | | | | |
| 2.2<br>Information package on harmful effects of zinc | Develop an information package and circulate to developers, designers, specifiers | Education, persuasion | Collate relevant information; develop & print a pamphlet; identify influencers; circulate. | 2023 |
| 2.3<br>Zinc mitigation BPOs | Investigation and analysis | Information gathering and desktop analysis | Information gathering and cost/benefit analysis. | 2023-24 |
| 2.4<br>Consult re long term zinc strategy | Investigate, inform and consult on a long term zinc strategy | Research, obtain information from industry, prepare and disseminate information, form relation-ships with interest groups, consult. | Investigate environmental harm and costs/benefits of alternative materials.<br>Consult widely. | 2023-25 |

| Table 9: Action Plan for Zinc | | | | |
|---|---|---|---|---|
| **Objective** | **Action** | **Mechanism** | **Action Components** | **Timing** |
| 2.5 Seek to national measures implemented to mitigate zinc | Submissions to central government seeking national measures and industry standards to reduce the discharge of building and vehicle contaminants. | Collaboration, persuasion, finding common ground. | Developing relationships, finding common ground, consensus-building | Under way 2021 |

*Recommended for consideration through the Surface Water Implementation Plan*

*2.6 By 2025 a civic-scale facility (or array of devices) will be installed in at least one urban sub-catchment to treat runoff from busy roads. By 2029 similar facilities/devices will be installed in at least three urban sub-catchments.*

*2.7 The Council adopts a zinc limitation strategy based on identified best practicable options.*

*2.8 The Council engages in research into and trials means of trapping roof-sourced zinc on site.*

Goal 3. Control copper contaminants

*Our Objectives are:*

*3.1 The Council seeks to consult with the government, through the Ministry for the Environment, about legislation to limit the copper content in vehicle brake pads.*

*3.2 The Council does not permit stormwater discharges into the network from unprotected copper cladding, spouting or downpipes.*

*3.3 As part of an education programme to stop contaminants at source, before the end of 2023, develop an information package describing the harmful nature of copper and the contribution of copper cladding to annual copper loads to waterways. The information will be circulated to relevant building professionals, with suggested alternatives.*

*3.4 The Council will investigate the feasibility of a District Plan rule to discourage the use of copper claddings.*

| Table 10: Action Plan for Copper | | | | |
|---|---|---|---|---|
| **Objective** | **Action** | **Mechanism** | **Action Components** | **Timing** |
| **Copper** | | | | |
| 3.1<br>Vehicle brake pads | Request legislation requiring low/no copper in brake pads. | Combined regional and local authority approach to government re legislation to apply nation-wide. | Liaison between local and regional councils.<br>Representation to government via NZTA, MfE. | Unknown |
| 3.2 & 3.3<br>Architectural copper (roofs, spouting, downpipes) | Prohibit the use of unprotected architectural copper.<br>Seek to limit or eliminated the use of architectural copper. | NZ-wide legislation; possible District Plan rule; otherwise investigate Regional Rule. | Liaise with government through MfE.<br>Investigate and consult. | Unknown |
| 3.4<br>District Plan rule to discourage copper claddings | Seek planning and regulatory mechanisms that could limit applications involving copper cladding. | Legal avenues. Possible District Plan rule. | Obtain legal advice and planning advice if relevant. | Unknown |

Goal 4.  Control industrial site contaminants

*Our Objectives are:*

*4.1 A database of industrial sites considered to be medium or high risk is compiled, based on the best available information, by 2025.*

*4.2 High risk industrial sites are audited by the approved procedure under the CSNDC.*

| Table 11: Action Plan for Industrial Sites | | | | |
|---|---|---|---|---|
| **Objective** | **Action** | **Mechanism** | **Action Components** | **Timing** |
| 4.1<br>Limited infor-mation about industrial sites. | Gather data to improve database of industrial site information. | Desktop analysis, questionnaires, Chamber of Commerce. | Desktop analysis, mail-outs, questionnaires, industry liaison. | Starting 2021 |
| 4.2<br>Industries unaware of effects of discharges to stormwater | Develop awareness among all industries of the harmful effects of contaminated discharges. | Educate via mail-outs.  Educate during site audits. | Inspect sites in risk order.<br>Communicate results and expectations. | Starting 2021 |
| 4.2<br>Some industries failing to control harmful substances | Ensure that harmful substances are contained, tracked, and disposed of safely. | Audit sites and follow up with education and enforcement. | Protocols for site controls developed jointly by Council, ECan and industry.<br>Site audits. | Phase in over c 5 years |
| 4.2<br>Non-compliant discharges | Trace and eliminate discharges. | Audit sites and follow up with education and enforcement. | Communicate the issue to industry & visit industries.<br>Generate improvement plan.<br>Engage and obtain compliance. | Phase in over c 5 years |

Goal 5. Engagement and education

*Our Objectives are:*

5.1 *By 2025 the Council will be working with community groups to engage with the public to educate participants about current stormwater practice and enable the public to take action to stop contaminants at source.*

5.2 *By 2025 the Council will be engaging regularly with the Ministry for the Environment to collaborate on contaminant reduction initiatives.*

Table 12: Action Plan for Engagement and Education

| Objective | Action | Mechanism | Action Components | Timing |
|---|---|---|---|---|
| 5.1<br>Valuing Water Resources | Education and engagement to empower community groups<br>Each new generation values waterways. | Joint partnership programme to effectively co-ordinate existing education and engagement of community groups. | Partner delivery (Council, ECan, Ngāi Tahu, CWMS) with stream care and other community groups. | Community Water Partnership programme |
| 5.1<br>Communication strategy | Develop a long term communication strategy. | Strategy development | Understand community thinking about waterways.<br>Agree message and means of communicating. | After 2021 LTP |
| 5.1<br>Promote community action | Encourage supportive community groups | More direct support for active groups. Provide information and involve in planning. | Assist groups to develop Objectives and action plans. Share Council planning. Fund and track funding. Monitor results. | After 2021 LTP |
| 5.2<br>Council and MfE engaged re heavy metals reduction. | Council to seek regular contact with relevant MfE planning team(s). | The anticipated mechanism is regulation or national education campaign. | Council to contact MfE, starting at executive level, progressing to staff level contacts. | Ongoing |

Goal 6. Manage flooding

*Our Objectives are:*

*6.1 The quantity of stormwater from all new development sites or re-development sites will be attenuated to at least the minimum standard of section 9.10.3.*

*6.2 Protection for houses will continue to be achieved through full mitigation of water quantity effects during development and controls on new floor levels.*

Table 13: Action Plan for Flooding

| Objective | Action | Mechanism | Action Components | Timing |
|---|---|---|---|---|
| 6.1 Control extra stormwater runoff from new development | Limit the increase in peak stormwater runoff. | Stormwater from new subdivisions is controlled through basins. Stormwater from larger individual sites attenuated on site. | Normal planning processes | Ongoing |
| 6.2 Minimise flooding caused by city growth & change | Monitor changes to impervious areas and stormwater network capacity and compensate if necessary. | Regular computer-based flood modelling. | Keep models up-to-date as the city changes. Compare models with flood events. Plan for flood mitigation as necessary. | Ongoing |

## 10.2 Flood Management Plan

### 10.2.1 Recommended Flood Risk Management Option

Flood protection needs continue to be investigated by the Council to:

- Improve understanding of the effects of heavy rain on the network,
- determine what flooding effects if any have arisen from the 2010/11 earthquakes,
- gain an understanding of the vulnerability of coastal areas to sea level rise.

Waterway and ground level changes caused by uplift and settlement have caused low-lying houses to be more susceptible to flooding. The Council's intention has been to return the risk of flooding to a level not exceeding what existed prior to 2010.

Results from the whole-catchment hydraulic model (a 2-D floodplain model) when available will enable the Council to assess the vulnerability of buildings in areas remote from the river.

### 10.2.2 Key Flood Level Locations

Schedule 2(s), Condition 7, requires the "identification of key locations in addition to those shown in Schedule 10 where modelled assessments of water levels and/or volumes shall be made for the critical 2% AEP event and any other relevant return interval." Two key locations are proposed in Table 14:

Table 14: Key flood level and volume locations.

| Waterway | Key Flood Level/Volume Location | Reason for selection |
|---|---|---|
| City Outfall Drain | Hargood Street | A potential problem location |
| Sumner Stream | Nayland St (provisional) for monitoring only | Model and monitor ponding levels in the lower "basin" as potentially affected by development. |

Key locations may be amended when the floodplain model is delivered. This may be requested as a minor change to the SMP under Condition 10.

## 11 Conclusion

The purpose of the CSNDC is to drive planning and actions that will progressively improve the quality of stormwater discharges.

Actions the Council can take through the SMP must be accompanied by other actions if the Council's Community Outcome (Healthy Environment) and the Mahaanui Iwi Management Plan objectives are to be realised. Further actions, by the Council and others, include:

- Raise awareness and educate citizens on how to stop contaminants at source from entering stormwater.
- Eliminate or reduce contaminants at source (e.g. by substituting for contaminating building materials).
- Remove contaminants from stormwater before they enter natural waterways.
- Restore waterway corridors to a natural state.
- Restore and plant riparian margins.
- Improve instream habitat by sediment removal, riparian tree planting (for temperature control, bank stability and shelter).
- Improve biodiversity to improve food sources for instream life.
- Performance monitoring of treatment facilities.

Progressive improvement can occur through further activities in Table 15:

Table 15: Areas for improvement outside of the stormwater management plan

| Activity | Motivation for the Activity |
|---|---|
| The Council regulating and acting under regulations to stop the discharge of contaminants. | As required by conditions of CRC231955 (CSNDC) |
| The Council investigating new means of controlling contaminants at source (e.g by materials substitution or innovative means of treatment). | As required by conditions of CRC231955 (CSNDC) |
| The Council and others implementing new or improved contaminant mitigation practices. | Through the proposed Surface Water Implementation Plan (referred to in section 2.1) |
| The Council and others making progressive environmental improvements such as restoring waterways and their corridors to a natural state. | Community Outcome (Healthy Environment) |
| Citizen-based awareness and advocacy for clean water and improved biodiversity. | Kaitiakatanga |
| Advocacy by Ngāi Tahu for the mana of water and waterways. | Kaitiakatanga. Kawanatanga. Mahaanui Iwi Management Plan |

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# Appendix A Schedule 2 responses

Table 16: Schedule 2 matters to be included in SMPs: CRC231955 Condition 7

| Matters for inclusion in SMPs | Where addressed in the SMP |
|---|---|
| a. Specific guidelines for implementation of stormwater management to achieve the purpose of SMPs; | The SMP is the guideline |
| b. A definition of the extent of the stormwater infrastructure, that forms the stormwater network within the SMP area for the purposes of this consent; | 3.3 |
| c. A contaminant load reduction target(s) for each catchment within that SMP area and a description of the process and considerations used in setting the contaminant load reduction target(s) required by Condition 6(b) using the best reasonably practicable model or method and input data; | 9.5.1 and 9.5.2 |
| d. A description of statutory and non-statutory planning mechanisms being used by the Consent Holder to achieve compliance with the conditions of this consent including the requirement to improve discharge water quality. These mechanisms shall include:<br>i. Relevant objectives, policies, standards and rules in the Christchurch District Plan;<br>ii. Relevant bylaws; and<br>iii. Relevant strategies, codes, standards and guidelines; | 1.3 through 1.9 |
| e. Mitigation methods to achieve compliance with the conditions of this resource consent including the requirement to improve discharge water quality under Condition 23, and to meet the contaminant load reduction targets for each catchment as determined through the SMPs and the standards for the whole of Christchurch set in Condition 19. These methods shall include:<br>i. Stormwater mitigation facilities and devices;<br>ii. Erosion and sediment control guidelines; | 9.8 |

| | |
|---|---|
| iii. Education and awareness initiatives on source control systems and site management programmes;<br><br>iv. Support for third party initiatives on source control reduction methods;<br><br>v. Prioritising stormwater treatment in catchments: that discharge in proximity to areas of high ecological or cultural value, such as habitat for threatened species or Areas of Significant Natural Value under the Regional Coastal Environment Plan (Canterbury Regional Council, 2012); and areas with high contaminant loads; | |
| f. Locations and identification of Christchurch City Council water quality and water quantity mitigation facilities and devices; including a description and justification for separation distances between mitigation facilities or devices and any contaminated land; | 9.11.1 |
| g. Identification of areas planned for future development and a description of the Consent Holder's consideration to retrofit water quality and quantity mitigation for existing catchments through these developments where reasonably practicable; | Very limited areas planned for future development as per Sections 6.2.1 and 9.11 |
| h. Identification of areas subject to known flood hazards; | 8.4 to 8.14 |
| i. A description of how environmental monitoring and assessment of tangata whenua values have been used to develop water quality mitigation methods and practices; | 9.6.3 |
| j. Results from and interpretation of water quantity and quality modelling, including identification of sub-catchments with high levels of contaminants; | 9.1, 9.2, 9.5.1 |
| k. Mapping of existing information from Canterbury Regional Council and the Consent Holder showing locations where discrete spring vents occur; | Figures 3 to 6 and 19 |
| l. Consideration of any effects of the diversion and discharge of stormwater on base-flow in waterways and springs and details of monitoring that will be undertaken of any waterways and springs that could | 9.13 |

| | |
|---|---|
| be affected by stormwater management changes anticipated within the life of the SMP; | |
| m. A cultural impact assessment; | 4.3 |
| n. A summary of outcomes resulting from any collaboration with Papatipu Rūnanga on SMP development; | MKT advised that the cultural impact assessment was sufficient. |
| o. An assessment of the effectiveness of water quality or quantity mitigation methods established under previous SMPs and identification of any changes in methods or designs resulting from the assessment; | 9.6.3 |
| p. Assessment and description of any additional or new modelling, monitoring and mitigation methods being implemented by the Consent Holder; | No new modelling or monitoring and mitigation methods. |
| q. A summary of feedback obtained in accordance with Condition 8 and if / how that feedback has been incorporated into the SMP; | 9.7 |
| r. If the Consent Holder intends to use land not owned or managed by the Consent Holder for stormwater management, a description of the specific consultation undertaken with the affected land owner; | Not applicable; no non-Council land to be used for storm-water management. |
| s. Identification of key monitoring locations in addition to those identified in Schedule 10 where modelled assessments of water levels and/or volumes shall be made. For all monitoring locations, water level reductions or tolerances for increases shall be set for the critical 2% and 10% AEP events in accordance with the objective and ATLs in Schedule 10 and shall be reported with the model update results required under Condition 55; | 10.2.2 |
| t. Procedures, to be developed in consultation with Christchurch International Airport Limited, for the management of the risk of bird strike for any facility owned or managed by the Christchurch City Council within 3 kilometres of the airport; | Does not apply because no proposed basins are within 3 km (or within 13 km - CIAL preference) of a runway threshold. |
| u. A description of any relevant options assessments undertaken to identify the drivers behind mitigation measures selected; and | 9.2 |

| | |
|---|---|
| v. An assessment of the potential change to the overall water balance for the SMP area arising from the change in pervious area and the stormwater management systems proposed. | 9.11, 9.13 |

# Appendix B Attribute Target Levels, Schedules 7 to 10

Waterways, Coastal and Groundwater Receiving Environment Attribute Target Levels in Schedules 7 to 10 from Condition 23, Consent CRC231955.

## Schedule 7: Receiving Environment Objectives and Attribute Target Levels for Waterways

*The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels.*
*TBC-A = To Be Confirmed once a full year of monitoring allows hardness modified values to be calculated, in accordance with Condition 52.*
*TBC-B = To Be Confirmed following engagement with Papatipu Rūnanga, through an update to the EMP, in accordance with Condition 54.*

| Objective | Attribute | Attribute Target Level | Basis for Target |
|---|---|---|---|
| Adverse effects on ecological values do not occur due to stormwater inputs | QMCI | Lower limit QMCI scores:<br>• Spring-fed – plains – urban waterways: 3.5<br>• Spring-fed – plains waterways: 5<br>• Banks Peninsula waterways: 5 | QMCI is an indicator of aquatic ecological health, with higher numbers indicative of better quality habitats, due to a higher abundance of more sensitive species. QMCI scores are taken from the guidelines in Table 1a of the LWRP (Canterbury Regional Council, 2018). This metric is designed for wade able sites and should therefore be used with caution for non-wade able sites. These targets can be achieved through reducing contaminant loads and waterway restoration. |
| Adverse effects on water clarity and aquatic biota do not occur due to sediment inputs | Fine sediment (<2 mm diameter) percent cover of stream bed<br><br>TSS concentrations in surface water | Upper limit fine sediment percent cover of stream bed:<br>• Spring-fed – plains – urban waterways: 30%<br>• Spring-fed – plains waterways: 20%<br>• Banks Peninsula waterways: 20%<br><br>Upper limit concentration of TSS in surface water: 25 mg/L<br><br>No statistically significant increase in TSS concentrations in surface water | Sediment (particularly from construction) can decrease the clarity of the water, and can negatively affect the 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. The sediment cover Target Levels are taken from the standards for the original Styx and South-West Stormwater Management Plan consents, and are based on Table 1a of the LWRP (Canterbury Regional Council, 2018). These targets should be used with caution at sites that likely naturally have soft-bottom channels. These targets can be achieved through reducing contaminant loads (particularly using erosion and sediment control) and instream sediment removal. |

| | | | |
|---|---|---|---|
| Adverse effects on aquatic biota do not occur due to copper, lead and zinc inputs in surface water | Zinc, copper and lead concentrations in surface water | Upper limit concentration of dissolved zinc:<br>• Ōtākaro/ Avon River catchment: 0.0297 mg/L<br>• Ōpāwaho/ Heathcote River catchment: 0.04526 mg/L<br>• Cashmere Stream: 0.00724 mg/L<br>• Huritīni / Halswell River catchment: 0.01919 mg/L<br>• Pūharakekenui/ Styx River catchment: 0.01214 mg/L<br>• Ōtūkaikino River catchment: 0.00868 mg/L<br>• Linwood Canal: 0.146 mg/L<br>• Banks Peninsula catchments: TBC-A | These metals can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behavior. The Council has developed these hardness modified trigger values in accordance with the methodology in the 'Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand' (ANZG, 2018) guidelines, and the species protection level relevant to each waterway in the LWRP (Canterbury Regional Council, 2017). This calculation document can be provided on request.<br>These targets can be achieved primarily through reducing contaminant loads. |
| | | Upper limit concentration of dissolved copper:<br>• Ōtākaro/ Avon River catchment: 0.00356 mg/L<br>• Ōpāwaho/ Heathcote River catchment: 0.00543 mg/L<br>• Cashmere Stream: 0.00302 mg/L<br>• Huritīni / Halswell River catchment: 0.00336 mg/L<br>• Pūharakekenui/ Styx River catchment: 0.00212 mg/L<br>• Ōtūkaikino River catchment: 0.00152 mg/L<br>• Linwood Canal: 0.0175 mg/L<br>• Banks Peninsula catchments: TBC-A | |

| Objective | Attribute | Attribute Target Level | Basis for Target |
|---|---|---|---|
| | | Upper limit concentration of dissolved lead:<br>• Ōtākaro/ Avon River catchment: 0.01554 mg/L<br>• Ōpāwaho/ Heathcote River catchment: 0.02916 mg/L<br>• Cashmere Stream: 0.00521 mg/L<br>• Huritīni / Halswell River catchment: 0.01257 mg/L<br>• Pūharakekenui/ Styx River catchment: 0.00634 mg/L<br>• Ōtūkaikino River catchment: 0.00384 mg/L<br>• Linwood Canal: 0.167 mg/L<br>• Banks Peninsula catchments: TBC-A<br><br>No statistically significant increase in copper, lead and zinc concentrations | |
| Excessive growth of macrophytes and filamentous algae does not occur due to nutrient inputs | Total macrophyte and filamentous algae (>20 mm length) cover of stream bed | Upper limit total macrophyte cover of the stream bed:<br>Spring-fed – plains – urban waterways: 60%<br>Spring-fed – plains waterways: 50%<br>Banks Peninsula waterways: 30%<br><br>Upper limit filamentous algae cover of the stream bed: | Macrophyte and algae cover are indicators of the quality of aquatic habitat. Targets are taken from Table 1a of the LWRP (Canterbury Regional Council, 2018). Improvement towards these targets can be achieved by reduction in nutrient concentrations and riparian planting to shade the waterways. |

| Objective | Attribute | Attribute Target Level | Basis for Target |
|---|---|---|---|
| | | Spring-fed – plains – urban waterways: 30%<br>Spring-fed – plains waterways: 30%<br>Banks Peninsula waterways: 20% | |
| Adverse effects on aquatic biota do not occur due to zinc, copper, lead and PAHs in instream sediment | Zinc, copper, lead and PAHs concentrations in instream sediment | Upper limit concentration of total recoverable metals for all classifications:<br>Copper = 65 mg/kg dry weight<br>Lead = 50 mg/kg dry weight<br>Zinc = 200 mg/kg dry weight<br>Total PAHs = 10 mg/kg dry weight<br><br>No statistically significant increase in copper, lead, zinc and Total PAHs | Meta Metals can bind to sediment and remain in waterways, potentially negatively affecting biota. These trigger values are based on the ANZG guidelines (ANZG, 2018). These targets can be achieved through reducing contaminant loads and instream sediment removal. |
| Adverse effects on Mana Whenua values do not occur due to stormwater inputs | Waterway Cultural Health Index and State of Takiwā scores | Lower limit averaged Waterway Cultural Health Index and State of Takiwā scores for all classifications:<br>Spring-fed – plains – urban waterways: TBC-B<br>Spring-fed – plains waterways: TBC-B Banks Peninsula waterways: TBC-B | The Waterway Cultural Health Index assesses cultural values and indicators of environmental health, such as mahinga kai (food gathering). These indices are on a scale of 1 - 5, with higher scores indicative of greater cultural values. No guidelines are available currently for the different types of waterways, so these targets will be developed specifically for this consent, with higher targets for waterways with higher values. These targets can be achieved through reducing contaminant loads and habitat restoration. |

## Schedule 8: Receiving Environment Objectives and Attribute Target Levels for Coastal Waters

*The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels.*
*TBC-B = To Be Confirmed following consultation with Papatipu Rūnanga, through an update to the EMP, in accordance with Condition 54.*

| Objective | Attribute | Attribute Target Level | Basis for Target |
|---|---|---|---|
| Adverse effects on water clarity and aquatic biota do not occur due to sediment inputs | TSS concentrations in surface water | No statistically significant increase in TSS concentrations | Elevated levels of TSS in the water column decrease the clarity of the water and can adversely affect aquatic plants, invertebrates and fish. For example, sediment can affect photosynthesis of plants and therefore primary productivity, interfere with feeding through the smothering of food supply, and can clog suitable habitat for species. There is no guideline available for this parameter, so no change in concentrations is proposed to be conservative. The target will be achieved by reducing contaminant loads (particularly using erosion and sediment control measures). |
| Adverse effects on aquatic biota do not occur due to copper, lead and zinc inputs in surface water | Copper, lead and zinc concentrations in surface water | Maximum dissolved metal concentrations for all classes (with the exception of the Operational Area of the Port of Lyttelton):<br>Copper: 0.0013 mg/L<br>Lead: 0.0044 mg/L<br>Zinc: 0.015 mg/L<br><br>No statistically significant increase in copper, lead and zinc concentrations | Metals, in particular, copper, lead and zinc, can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behavior (Harding, 2005). These targets are taken from the ANZG (2018) guidelines for the protection of 95% of species. The Operational Area of the Port of Lyttelton is affected by direct discharges from boats that will make monitoring of the effects of stormwater difficult, therefore the targets are not applicable to this area. These targets will be achieved by reducing contaminant loads. |
| Adverse effects on Mana Whenua values do not occur due to stormwater inputs | Marine Cultural Health Index and State of Takiwā scores | Minimum averaged Marine Cultural Heath Index and State of Takiwā scores for all classes: TBC-B | The Marine Cultural Health Index and State of Takiwā scores assesses cultural values and indicators of environmental health, such as mahinga kai (food gathering). These indices are on a scale of 1 - 5, with higher scores indicative of greater cultural values. No guidelines are available currently for coastal areas, so this target will be developed specifically for this consent. These targets can be achieved through reducing contaminant loads. |

## Schedule 9: Receiving Environment Objectives and Attribute Target Levels for Groundwater and Springs

*The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels*

| Objective | Attribute | Attribute Target Level | Basis for Target |
|---|---|---|---|
| Protect drinking water quality | Copper, lead, zinc and *Escherichia coli* concentrations in drinking water | Concentration to not exceed:<br>Dissolved Copper: 0.5 mg/L<br>Dissolved Lead: 0.0025 mg/L<br>Dissolved Zinc:0.375 mg/L<br><br>No statistically significant increase in the concentration of *Escherichia coli* at drinking water supply wells | The most important use of Christchurch groundwater is the supply of the urban reticulated drinking water supply. Contaminants in stormwater that infiltrate into the ground could impact on the quality of water supply wells and/or springs. The compliance criteria for a potable and wholesome water supply are specified in the Drinking Water Standards for New Zealand 2005 (Revised 2008). Metals and *E.coli* were chosen for these targets, as these are contaminants present in stormwater. The target values for copper and lead are a quarter of the Maximum Acceptable Value (MAV) or Guideline Value (GV) taken from the Drinking Water Standards for New Zealand 2005 (revised 2008). This is to ensure investigations occur before the water quality limits in the LWRP are exceeded, which are that concentrations are not to exceed 50% of the MAV. An equivalent criteria has also been applied to the zinc target, which is not included in the LWRP water quality limits, but has a guideline in the drinking water standards. |
| Avoid widespread adverse effects on shallow groundwater quality | Electrical conductivity in groundwater | No statistically significant increase in electrical conductivity | Contaminants in stormwater that infiltrate into the ground could impact on groundwater quality. Long term groundwater quality at monitoring wells is undertaken by Canterbury Regional Council. Those monitoring points that occur within the urban area could be impacted by Council stormwater management activities. Electrical conductivity is to be used as an indicator for identifying any general changes in groundwater quality related to recharge. |

## Schedule 10: Receiving Environment Attribute Target Levels for Water Quantity

**MODELLED CATCHMENTS**

Objective for the management of stormwater quantity:

To mitigate the risk of inundation, damage to downstream property or infrastructure or human safety through management of stormwater run-off volumes and peak flows. The extent of mitigation shall be assessed against the achievement of attribute target level(s) for each receiving environment.

Attribute Target Level: Modelled flood levels for the relevant AEP for the assessment year critical duration event shall not increase more than the Maximum Increase listed below when compared to the same modelled AEP for the baseline year impervious scenario critical duration, as determined using Council flood models. The baseline year scenario and assessment year scenario shall be identical except for changes to the impervious area, mitigation measures and the inclusion of any new network(s) that has arisen
between the dates of the two scenarios and within the city limits. All non-variant scenario parameters shall be as at the assessment year scenario. The critical duration shall be assessed at the monitoring location of the attribute target level. Non-variant scenario parameters include, but are not limited to, channel cross-sections, roughness and floodplain shape. Prior to undertaking the assessment, the appropriateness of the non-variant scenario parameters shall be assessed and updated if necessary.

**WATER LEVEL REDUCTIONS OR TOLERANCES FOR INCREASES**

| Receiving Environment | Monitoring Location | Baseline Year | Annual Exceedance Probability | Maximum Increase (mm) |
|---|---|---|---|---|
| Ōtākaro/ Avon River | Gloucester Street Bridge | 2014 | 2% | 50 |
| Pūharakekenui/ Styx River | Harbour Road Bridge | 2012 | 2% | 100 |
| Ōpāwaho/ Heathcote River | Ferniehurst Street | 1991 | 2% | 30 |
| Huritīni/ Halswell River | Minsons Drain confluence* | 2016 | 2% | 0 |

**NON-MODELLED CATCHMENTS**

| Receiving Environment | Attribute Target Level | Basis for Target | Notes |
|---|---|---|---|
| Ōtūkaikino River | Discharges from all new greenfield development into the Christchurch City Council network are mitigated using the "Partial Detention" strategy outlined in the Pūharakekenui/ Styx SMP until such time as a monitoring location can be set during review of the SMP | As measured through the Council discharge authorisation compliance process for Resource and Building Consents until such time as an Baseline Year can be set during review of the SMP | See Note 1 below. |

Council has just begun monitoring the Ōtūkaikino at Dickeys Road Bridge. Council does not currently model flooding in the Ōtūkaikino River.
Flooding occurs primarily due to backwater effects in the Waimakariri River. Therefore, a best practice approach to mitigation of development will be implemented until such time as maximum Increase can be set during review of the SMP.

# Appendix C Basins and Swales

Council owned basins and swales in the Ihutai-Estuary and Coastal catchment

| Basin ID | Name | Purpose | Address | Constructed | Area ($m^2$) | Easting | Northing | Maintenance months |
|---|---|---|---|---|---|---|---|---|
| 130 | Lamorna Basin | Pond | Lamorna Road & Bottle Lake Drive | 2003 | 2540 | 1,576,300 | 5,186,040 | Monthly |
| 135 | Sandpiper Swale | Infiltration swale | Aston Drive | 2004 | 670 | 1,577,120 | 5,186,180 | |
| 136 | Eastwood Swale | Infiltration swale | Sandpiper Place & Aston Drive | 2004 | 600 | 1,577,110 | 5,186,290 | |
| 368 | no name | Infiltration basin | Torrey Pines | 2008 | 405 | 1,576,970 | 5,186,100 | March, September |
| 369 | no name | Infiltration basin | The Belfry | 2008 | 2270 | 1,576,840 | 5,186,280 | March, September |

Basins and ponds are maintained under the Stormwater and Waterways Maintenance Contract with City Care Limited.

Swales are maintained by mowing under a Parks, Transport or Stormwater maintenance contract.

The specification for routine stormwater basin maintenance is copied below:

Table 17: Stormwater basin routine works specification

| 16 | Stormwater Basin Routine Works |
|---|---|
| **Asset** (General Specifications, paragraphs 2.5 and 3.1) | Stormwater Basins |
| **Required activities** (General Specifications, paragraph 5.5.8) | - The Contractor shall:<br>o inspect and clear all control structures associated with the basin (inlets, outlets, headwalls, weirs, energy dissipaters, and grilles), and ensure they are in working order;<br>o maintain vegetated areas in a tidy state if not included under Councils parks maintenance;<br>o remove vegetation and rubbish/debris from invert and margins, ensuring easy conveyance of water;<br>o keep low flow channel clear of weeds, grass, silt and debris;<br>o control pest plants (including saplings and suckers), unless otherwise specified by the Engineer, in accordance with section 2 of the Specifications Supplementary Information 'Pest Plant Species';<br>o clear ponds of all debris to high water line;<br>o check for blockages or reinstate base soakage where sumps are continually full and the surrounding ground is sodden;<br>o dispose of green waste, rubbish and debris collected during performance of the Stormwater Basin Routine Works off-site within 24 hours; and<br>o ensure debris stockpiled for collection does not damage private property or inhibit public access.<br>- There are various maintenance tasks required against specific Assets within a stormwater basin, which are set out in the Routine Works Frequency Schedule. The Contractor shall perform those maintenance tasks under a separate Routine Works Work Order for the applicable Asset and report to the Engineer any omissions and/or activities not required.<br>- Stormwater Basins are often located within drainage, or roadside, reserves where Separate Contractors maintain the turf and gardens. Unless specified in the Routine Works Frequency Schedule, the Contractor shall only maintain the structures associated with the stormwater basin, the areas of water conveyance and their margins (including the boundary line between the Contractor's works and the Separate Contractor's works), as set out in paragraph 5.3 of the General Specifications. |
| **Required outcomes** (General Specifications, paragraph 5.5.8) | - Basins and associated Assets within the basins are operating as required.<br>- Vegetated areas cut and debris removed and offsite |
| **Additional Contractor's Plan requirements** (General Specifications, paragraph 4.8) | - The Contractor shall provide a method statement in the Contractor's Plan. The method statement shall include Standard Operating Procedures. |
| **Additional Maintenance Works Data requirements** | - Record the volume and type of material removed.<br>- Progress photos |

# Appendix D Contaminant Load Model Results

Results from the contaminant load model are reported in Tables 13, 14 and 15 below. Information in the tables is taken from tables in the model report (DHI, 2021) with some reformatting.

Urban and rural copper and zinc loads are presented as totals and per hectare . In some cases rural copper loads exceed urban copper loads per hectare. This reflects that there is a copper content in soils, and that significant amounts of sediment may be discharged from some rural catchments. Model results should be viewed cautiously, as they have not been confirmed by measurements.

Table 18: MEDUSA model annual TSS (particulate) loads.

| Sub-catchment | Area ($km^2$) | % urban | Modelled TSS load (kg/yr) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Total** | **Total TSS/Ha** | **Roofs** | **Roads** | **Paved** | **Rural** | **Urban TSS/Ha** | **Rural TSS/Ha** |
| Augusta St | 0.726 | 71.8 | 4096.31 | 0.56 | 227.67 | 2707.33 | 321.33 | 839.98 | 6246.9 | 1157.0 |
| Beachville | 0.155 | 90.4 | 1020.55 | 0.66 | 64.33 | 900.33 | 55.67 | 0.21 | 7281.8 | 1.4 |
| Bromley | 1.263 | 86.7 | 9083.52 | 0.72 | 1261.67 | 3764 | 4055 | 2.85 | 8292.7 | 2.3 |
| Burwood Forest / Brooklands | 10.179 | 0.6 | 2991.15 | 0.03 | < 0.01 | < 0.01 | < 0.01 | 2991.15 | | 293.9 |
| Charlesworth | 0.17 | 1.8 | 2.84 | 0.00 | < 0.01 | < 0.01 | < 0.01 | 2.84 | | 16.7 |
| Godley Head | 1.833 | 0 | 43051.57 | 2.35 | < 0.01 | < 0.01 | < 0.01 | 43051.57 | | 23486.9 |
| Estuary | 1.675 | 33.8 | 4838.65 | 0.29 | 223 | 4146.33 | 456 | 13.31 | 8523.1 | 7.9 |
| Linwood Canal | 4.608 | 80.9 | 38545.3 | 0.84 | 2709 | 30924 | 4897.33 | 14.97 | 10335.7 | 3.2 |
| Linwood Paddocks | 0.883 | 0 | 15.01 | 0.00 | < 0.01 | < 0.01 | < 0.01 | 15.01 | | 17.0 |
| Mcclurg | 0.138 | 8.9 | 2009.65 | 1.46 | < 0.01 | < 0.01 | < 0.01 | 2009.65 | | 14562.7 |
| McCormacks Bay | 1.607 | 36.9 | 18168.55 | 1.13 | 304.33 | 5099.33 | 512.67 | 12252.21 | 9977.2 | 7624.3 |
| Moncks Bay | 0.562 | 62.1 | 3622.42 | 0.64 | 118.67 | 3405.67 | 95 | 3.09 | 10370.5 | 5.5 |
| Mt Pleasant | 0.853 | 86.3 | 4841.7 | 0.57 | 257 | 4416 | 167 | 1.7 | 6574.8 | 2.0 |
| Parklands | 4.68 | 78 | 30121.12 | 0.64 | 1932.33 | 26291.67 | 1593 | 304.12 | 8168.1 | 65.0 |
| Richmond Hill | 1.137 | 36 | 12869.93 | 1.13 | 153.33 | 3308.67 | 206 | 9201.93 | 8961.2 | 8093.2 |
| Rifle Range | 2.651 | 13.2 | 68530.04 | 2.59 | 181.67 | 3613 | 194 | 64541.37 | 11398.4 | 24346.0 |
| Scarborough | 0.604 | 61.9 | 1653.67 | 0.27 | 114.33 | 1390.67 | 145.33 | 3.34 | 4414.1 | 5.5 |
| Southshore | 1.979 | 52.6 | 7181.63 | 0.36 | 436.33 | 6290.67 | 177 | 277.63 | 6632.4 | 140.3 |
| St Andrews Hill | 0.454 | 97.4 | 4159.17 | 0.92 | 150.33 | 3898.33 | 110.33 | 0.17 | 9405.3 | 0.4 |
| Sumner | 4.772 | 23.8 | 122316.4 | 2.56 | 545.67 | 14854.33 | 655.67 | 106260.8 | 14136.8 | 22267.6 |
| Taylors Mistake | 1.427 | 2.6 | 32257.33 | 2.26 | 6.67 | 487.3 | 7 | 31756.36 | 13502.5 | 22253.9 |
| Tidal View | 0.093 | 94.2 | 1176 | 1.26 | 88.67 | 796 | 291.3 | 0.09 | 13423.4 | 1.0 |

Table 19: MEDUSA model annual copper loads.

| Sub-catchment | Area (km²) | % urban | Modelled Copper load (kg/yr) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Total Cu/Ha | Roofs | Roads | Paved | Rural | Urban Cu/Ha | Rural Cu/Ha |
| Augusta St | 0.726 | 71.8 | 2.01 | 0.0003 | 0.47 | 1.37 | 0.17 | 0.01 | 0.0004 | 0.0010 |
| Beachville | 0.155 | 90.4 | 0.57 | 0.0004 | 0.17 | 0.4 | < 0.01 | < 0.01 | 0.0004 | 0.0038 |
| Bromley | 1.263 | 86.7 | 4.6 | 0.0004 | 0.93 | 1.8 | 1.87 | < 0.01 | 0.0004 | 0.0027 |
| Burwood Forest / Brooklands | 10.179 | 0.6 | 0.03 | 0.0000 | < 0.01 | < 0.01 | < 0.01 | 0.03 | 0.0000 | 0.0000 |
| Charlesworth | 0.17 | 1.8 | < 0.01 | 0.0000 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | | |
| Godley Head | 1.833 | 0 | 0.99 | 0.0001 | < 0.01 | < 0.01 | < 0.01 | 0.99 | | 0.0001 |
| Estuary | 1.675 | 33.8 | 2.8 | 0.0002 | 0.37 | 2.23 | 0.2 | < 0.01 | 0.0005 | 0.0003 |
| Linwood Canal | 4.608 | 80.9 | 21.6 | 0.0005 | 4.73 | 14.63 | 2.23 | < 0.01 | 0.0006 | 0.0025 |
| Linwood Paddocks | 0.883 | 0 | < 0.01 | 0.0000 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | | |
| Mcclurg | 0.138 | 8.9 | 0.05 | 0.0000 | < 0.01 | < 0.01 | < 0.01 | 0.05 | 0.0004 | 0.0000 |
| McCormacks Bay | 1.607 | 36.9 | 3.9 | 0.0002 | 0.57 | 2.93 | 0.2 | 0.2 | 0.0007 | 0.0004 |
| Moncks Bay | 0.562 | 62.1 | 1.83 | 0.0003 | 0.3 | 1.53 | < 0.01 | < 0.01 | 0.0005 | 0.0009 |
| Mt Pleasant | 0.853 | 86.3 | 2.77 | 0.0003 | 0.67 | 2 | 0.1 | < 0.01 | 0.0004 | 0.0024 |
| Parklands | 4.68 | 78 | 19.07 | 0.0004 | 4.73 | 13.57 | 0.77 | < 0.01 | 0.0005 | 0.0019 |
| Richmond Hill | 1.137 | 36 | 2.22 | 0.0002 | 0.3 | 1.6 | 0.1 | 0.22 | 0.0005 | 0.0003 |
| Rifle Range | 2.651 | 13.2 | 4.03 | 0.0002 | 0.4 | 2 | 0.1 | 1.53 | 0.0012 | 0.0002 |
| Scarborough | 0.604 | 61.9 | 1.03 | 0.0002 | 0.23 | 0.7 | 0.1 | < 0.01 | 0.0003 | 0.0004 |
| Southshore | 1.979 | 52.6 | 4.3 | 0.0002 | 1.2 | 3 | 0.1 | < 0.01 | 0.0004 | 0.0005 |
| St Andrews Hill | 0.454 | 97.4 | 2.23 | 0.0005 | 0.37 | 1.8 | 0.07 | < 0.01 | 0.0005 | 0.0189 |
| Sumner | 4.772 | 23.8 | 11.46 | 0.0002 | 1.2 | 7.57 | 0.3 | 2.39 | 0.0010 | 0.0003 |
| Taylors Mistake | 1.427 | 2.6 | 0.2 | 0.0000 | 0 | 0.2 | 0 | 0.75 | 0.0005 | 0.0000 |
| Tidal View | 0.093 | 94.2 | 0.57 | 0.0006 | 0.1 | 0.37 | 0.1 | <.0001 | 0.0007 | 0.0106 |

Table 20: MEDUSA model annual zinc loads.

| Sub-catchment | Area ($km^2$) | % urban | Zinc load (kg/yr) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Total Zn/Ha | Roofs | Roads | Paved | Rural | Urban Zn/Ha | Rural Zn/Ha |
| Augusta St | 0.726 | 71.8 | 42 | 0.006 | 27.77 | 12.97 | 1.23 | 0.04 | 0.0080 | 0.0000 |
| Beachville | 0.155 | 90.4 | 10.13 | 0.007 | 7.73 | 2.2 | 0.2 | < 0.01 | 0.0072 | 0.0000 |
| Bromley | 1.263 | 86.7 | 185.8 | 0.015 | 160.13 | 10.47 | 15.2 | < 0.01 | 0.0170 | 0.0000 |
| Burwood Forest / Brooklands | 10.179 | 0.6 | 0.08 | 0.000 | < 0.01 | < 0.01 | < 0.01 | 0.08 | 0.0000 | 0.0000 |
| Charlesworth | 0.17 | 1.8 | < 0.01 | 0.000 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | | |
| Godley Head | 1.833 | 0 | 2.89 | 0.000 | < 0.01 | < 0.01 | < 0.01 | 2.89 | 0.0000 | 0.0002 |
| Estuary | 1.675 | 33.8 | 50.27 | 0.003 | 27.6 | 20.97 | 1.7 | < 0.01 | 0.0089 | 0.0000 |
| Linwood Canal | 4.608 | 80.9 | 500.87 | 0.011 | 333.3 | 149.2 | 18.37 | < 0.01 | 0.0134 | 0.0000 |
| Linwood Paddocks | 0.883 | 0 | < 0.01 | 0.000 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | | |
| Mcclurg | 0.138 | 8.9 | 0.14 | 0.000 | < 0.01 | < 0.01 | < 0.01 | 0.14 | 0.0000 | 0.0001 |
| McCormacks Bay | 1.607 | 36.9 | 63.72 | 0.004 | 37.3 | 23.83 | 1.9 | 0.68 | 0.0106 | 0.0001 |
| Moncks Bay | 0.562 | 62.1 | 32.93 | 0.006 | 14.33 | 18.23 | 0.37 | < 0.01 | 0.0094 | 0.0000 |
| Mt Pleasant | 0.853 | 86.3 | 43.23 | 0.005 | 30.8 | 11.77 | 0.67 | < 0.01 | 0.0059 | 0.0000 |
| Parklands | 4.68 | 78 | 358.24 | 0.008 | 232.5 | 119.77 | 5.97 | 0.01 | 0.0098 | 0.0000 |
| Richmond Hill | 1.137 | 36 | 33.75 | 0.003 | 18.67 | 13.7 | 0.77 | 0.61 | 0.0081 | 0.0001 |
| Rifle Range | 2.651 | 13.2 | 45.53 | 0.002 | 22 | 18.47 | 0.77 | 4.3 | 0.0118 | 0.0002 |
| Scarborough | 0.604 | 61.9 | 18.7 | 0.003 | 13.9 | 4.23 | 0.57 | < 0.01 | 0.0050 | 0.0000 |
| Southshore | 1.979 | 52.6 | 69.51 | 0.004 | 52 | 16.83 | 0.67 | 0.01 | 0.0067 | 0.0000 |
| St Andrews Hill | 0.454 | 97.4 | 37.13 | 0.008 | 18.07 | 18.67 | 0.4 | < 0.01 | 0.0084 | 0.0000 |
| Sumner | 4.772 | 23.8 | 144.89 | 0.003 | 66.23 | 69.47 | 2.47 | 6.72 | 0.0122 | 0.0002 |
| Taylors Mistake | 1.427 | 2.6 | 2.65 | 0.000 | 0.83 | 0.93 | 0 | 2.17 | 0.0013 | 0.0002 |
| Tidal View | 0.093 | 94.2 | 17.8 | 0.019 | 11.3 | 5.4 | 1.1 | <.0001 | 0.0203 | 0.0000 |