UC Watershed and Waterways Plan 2017-2025

Katie Nimmo
Sustainability Projects Facilitator
Sustainability Office
University of Canterbury
April 2017

Table of Contents

Contributors
Dr. Frances Charters
Dr. Tom Cochrane (Civil and Natural Resources Engineering)
Darryl Cone (Supervisor, UC Grounds)
Nigel Harris (Senior Projects Manager, AVC Maori)
Prof. Jon Harding (School of Biological Sciences)
Prof. Angus McIntosh (School of Biological Sciences)
Prof. Jenny Webster-Brown (Director, Waterways Centre for Freshwater Management).

Cover photo: Rain gardens north of the Ernest Rutherford Building**.**

Background

Description of Waterways on University of Canterbury property

Three waterways flow through the University of Canterbury at Ilam; Kā Waimaero/Ilam stream and Waiutuutu/Okeover stream flow into the Ōtākaro/Avon river (Figure 1). Together, they represent a sub-catchment (part of the whole watershed) within the suburbs of Christchurch and are distinctive landscape features of the University campus.

Te Reo Māori for UC waterways were confirmed by the Ngāi Tahu Research Centre in 2015 and 2016. Note that distinct sections of the waterway known commonly and as a whole as the Avon stream or river has different names in Teo Reo Māori. For example, the Avon stream to the west of Waimari road is known as Ōrakipoa. From Waimari road to Clyde road it is known as Haereroa, and from Clyde road in an easterly direction, it is known as Ōtākaro.

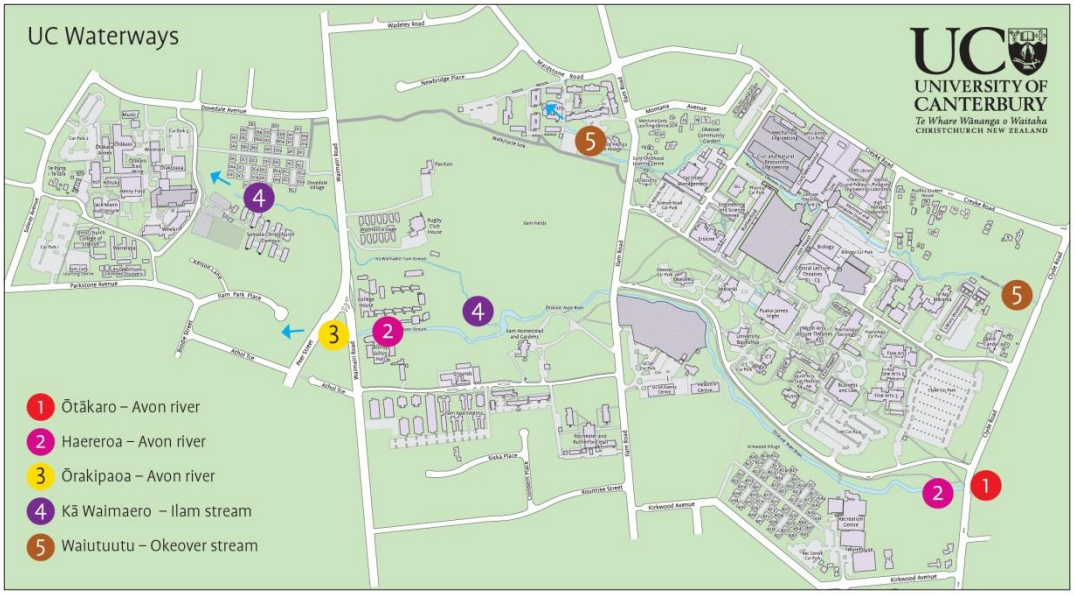

Figure 1 Waterways flowering through University of Canterbury property

UC Waterways and Mana Whenua, Te Ngāi Tūāhuriri

Te Ngāi Tūāhuriri have Mana Whenua over University of Canterbury (UC) waterways. Te Ngāi Tūāhuriri is one of the primary hapū of Ngāi Tahu whose tribal boundaries (takiwā) centre on Tuahiwi. Tūāhuriri is our ancestor, from whom we all descend and we take our name from him. The following is a traditional Ngāi Tūāhuriri *pepehā,* or tribal statement of identity.

Ko Maungatere te Maunga

Our mountain, Maungatere (Mount Grey) stands above us;

Ko Waimakariri, ko Rakahuri ngā Awa

Our rivers – the Waimakariri and Rakahuri (the Ashley) – flow below;

Ko Tūahuriri te Tangata

Tūāhuriri is our ancestor.

Te Ngāi Tūāhuriri marae

The Ōtākaro-Avon River and the cultural area of Christchurch has particular historical significance to Ngāi Tūāhuriri and Ngāi Tahu for navigation and mahinga kai. Mahinga kai refers to places where natural resources are produced and procured. Along with whakapapa (genealogy), mahinga kai is the main axle upon which Ngāi Tahu identity with the natural environment revolves.[1] The Christchurch area was utilised extensively as mahinga kai by Ngāi Tahu from the 1600s, and the Ōtākaro-Avon river was a highly regarded mahinga kai in the Ōtautahi/Christchurch area of food-rich wetlands. Tuna (eel), kanakana (lamprey), tuere (hagfish) and pātiki (flounder) and many other species were caught in the streams, and wai kōura (*Paranephrops planifrons*, a fresh-water species of crayfish) and waikakahi (*Hyridella menziesi*, a fresh-water bivalve mollusc) were collected from riverbanks. Wairarapa was the middle part of the Ōtākaro-Avon river, where Ilam stands today.[2] Wairarapa was used as a temporary home by Ngāi Tahu during harvesting periods.

In 2013, a Sustainability Office summer scholarship project looked at the feasibility of producing food in a way that strengthens mana whenua as kaitiaki at the University of Canterbury.[3] It examined the potential for mahinga kai to develop in Waiutuutu/Okeover stream. The feasibility of traditional mahinga kai in the Waiutuutu Stream was not supported, but the study did identify that there is an opportunity to assess the role of mahinga kai as 'biological engineers' to effectively remove metals from the waterway and along riparian zones.

The impact of urban development

Up until the 1990s, drainage by European settlers of what was predominantly wetland and the increasing development of Christchurch had degraded waterways in the city. With increasing urban development and creation of impermeable surfaces such as roads and houses, many of the natural, high water-quality groundwater springs dried up. Meanwhile stream flows became supplemented by

[1] Te Rūnanga o Ngāi Tahu (2004).
[2] Tau T.M. Goodall, A., Palmer, D., Tau, R. (1990).
[3] Kainamu, A (2013)

artificial inputs, for example, car park runoff and building discharges, which have inherently poorer water quality.

Grassy lawns and exotic deciduous trees dominated the UC campus when it was developed in the 1960s. Maintenance practices thereafter of mowing lawn to the edges of stream banks and clearing aquatic vegetation from the streambeds resulted in extensive in-stream siltation. The combined effect of all the above factors was a loss of aquatic and riparian habitat, a decline in plant and animal species diversity, and an overall loss of intrinsic natural character. [4]

Changes in management practices

During the early 1990s, approaches to stream management changed throughout Christchurch, led by the Christchurch City Council. Focus moved away from managing streams solely as drainage channels towards maintaining their ecological character (i.e. the plant, fish, invertebrate and bird species they support) and their aesthetic value to the public.

In 1996 an informal partnership between the Christchurch City Council and Kakariki (the University of Canterbury student environment group) was formed to initiate the "Green Corridor Project". The project aimed to revegetate the banks of the Avon River to provide a habitat corridor between Ilam Gardens and Riccarton Bush. With the support of City Council restoration planners and University grounds staff, the first of a number of plantings involving student volunteers was conducted in August 1997.

Over the next few years, interest in this planting and stream rehabilitation grew, supported by staff in Facilities Management and the School of Biological Sciences. From 1997 to 2005, City Council and University staff implemented a programme of major waterways rehabilitation and restoration, focussing on Waiutuutu/Okeover stream. [5] The process was supported by the then UC Waterways Group[6] which provided input into the scientific basis of the restoration, monitored the response of aquatic communities to change, and integrated waterways into teaching and course work.

In 2006, a Draft Waterways Plan was developed by the UC Waterways Group, which outlined a coherent vision for UC Waterways which was sympathetic to many of the key themes expressed in the proposed UC Campus Landscape Master Plan;

> *"A series of self-sustaining ecosystems, which have a natural physical character and function. These ecosystems will support communities of plants and animals dominated by indigenous species appropriate to a lowland South Island stream tributary. These waterways will be an integral part of the University's programme of research and teaching, and will contribute to an urban campus environment that can sustain wildlife and is enjoyed and valued by people."*[7]

[4] UC Waterways Group (2006)
[5] For more information about interventions completed on Waiutuutu/Okeover stream, please see "*UC Waterways: Issues and Options" (2016).* This document was developed by the UC Waterscape Action Group with the intention to inform the wider landscape plan.
[6] The UC Waterways Group in 2006 consisted of staff from Biological Sciences, Geography, Natural Resources Engineering, UC general staff, and students.
[7] UC Waterways Group (2006).

The plan also identified key strategic imperatives and short and long term targets for rehabilitating all three streams on campus. Whilst this vision and draft plan was not formally accepted by UC management or Council and progress against it was not monitored, some targets were achieved, including shifting away from the physical remediation of waterways to community engagement and awareness-raising.[8]

In 2007 UC hosted an 'Urban Waterways' forum with the aim to share recent research, management practices and seek greater interaction amongst researchers and waterways management practitioners. Between 2009 and 2010 UC worked in partnership with Environment Canterbury on a community education and engagement programme, which was a pilot for a larger 'Urban Water Health Programme'. The pilot consisted of a phone interviews with households, face to face interviews with community members, focus groups, and facilitated meetings with the intention to collect data for a targeted social marketing campaign for the whole watershed/catchment. The desired outcome for this project was a self-managing community group committed to working on improving the health of Waiutuutu/Okeover stream. This was not achieved, suggesting that ongoing support and coordination is required to sustain community awareness and behaviour change.

Investigations conducted by Natural Resource Engineering researcher staff in 2006 and 2009 identified that zinc, copper and lead concentrations from stormflow in Waiutuutu/Okeover stream exceeded relevant guidelines for the protection of 90% of aquatic species by 18-, 9- and 5-fold, respectively, suggesting substantial ecotoxicity potential. Sporadic copper (Cu) inputs from roof runoff exceeded these levels up to 3,200-fold at >4,000 μg L^{-1} while Cu in baseflow from air-conditioning inputs exceeded them 5.4-fold. In addition there was an 11-fold greater annual Cu load to the stream from air-conditioning discharge compared to stormwater runoff. [9] In response to these findings, UC Engineering Services instituted a policy of replacing copper components in existing heating systems with PPR or steel as any opportunity arose, plus stating explicitly in design specifications for new buildings that copper should be avoided wherever possible. It is estimated that 80% of copper componentry in heating systems could be replaced by 2030.[10]

Between 2011-2017, no major modifications or interventions were implemented on any of the waterways on campus. All relevant resources internal to UC were diverted to respond and recover from the 6.3 magnitude earthquake in February 2011, which wreaked significant damage across the whole of Christchurch and disrupted campus operations for some time. Once UC entered the recovery phase, it became clear that a long term, campus-wide remediation programme was necessary, and that stream rehabilitation was best planned once a campus master plan and a landscape plan had been developed. In April 2015, a Senior Health and Safety Consultant was tasked with addressing contamination events associated with construction and routine maintenance activities on campus.

[8] Ibid.

[9] O'Sullivan, A., Wicke, D., & Cochrane, T. (2012)

[10] Pers Comm, Steve Palmer, Mechanical Services Supervisor, Engineering Services. University of Canterbury.

UC Waterways as a Living Laboratory - Research and Teaching

Waterways on UC land have been highly valued as a 'Living Laboratory' since 1999. Research topics have explored stream ecology, restoration ecology, water chemistry, storm water contaminants, GIS applications, hydrology and cultural identifiers.

UC waterways have been used as sites or topics for student labs, undergraduate and post-graduate projects, summer scholarships, and theses in Biological Sciences and Natural Resources Engineering (Civil Engineering) departments. For more detail, see Appendix F.

Most research has been conducted on Waiutuutu/Okeover stream, and there is scope to expand research programmes to Ōtākaro/Avon river and Kā Waimaero/Ilam stream.

Monitoring

UC waterways have been (partially) monitored on a variable basis by three different academic groups.

Academic Discipline	**Data**
School of Biological Sciences/Freshwater Ecology Research Group	Annual freshwater biodiversity monitoring in Waiutuutu/Okeover stream since 2000.[11]
Waterways Centre for Fresh Water Management	Springs flow and quality in the Kā Waimaero/Ilam Stream watershed/catchment.
Natural Resource Engineering	Ad-hoc monitoring through sporadic student-based projects, investigating water quality and contaminant loading on Waiutuutu/Okeover Stream. These data sets can be regarded as reliably indicative of water quality and contaminant loading for this waterway. In 2014, a student project investigated the feasibility of continuous water quality monitoring of Waiutuutu/Okeover. Key findings from this project are outlined below.

Analysis of sediment in Waiutuutu/Okeover has been undertaken once by Hills Laboratory in 2015. No long term longitudinal data collected by UC provides long term information about water quality of Ōtākaro/Avon river and Kā Waimaero/Ilam stream. The Christchurch City Council does monitor the water quality of Ōtākaro/Avon river, but sites on UC property are not used.[12]

A comprehensive, integrated, and efficient monitoring framework across all three waterways is required. The framework should include cultural content, as advised by Te Ngāi Tūāhuriri. A good starting point could be to consider if existing monitoring data could be integrated into a framework similar to that used for *State of the Takiwa* reports.[13] Data collected through such a framework includes;

1. Takiwā General Site Assessment
2. CHI Cultural Health Waterway Assessment

[11] http://www.biol.canterbury.ac.nz/ferg/urban.Okeover.shtml (Dataset to be updated)
[12] CCC (2016)
[13] Mahaanui Kurataiao Ltd (2012). Pg 8.

3. Stream Health Monitoring Assessment (SHMAK)
4. Indigenous Vegetation and Bird Surveys
5. Fish Surveys
6. *E. coli* testing
7. *E. coli* antibiotic resistance

Kainamu's (2013) conclusion that there is an opportunity to assess the role of mahinga kai as 'biological engineers' to effectively remove metals from UC waterways and along riparian zones could also be taken into consideration when developing a monitoring and research framework.[14]

Such a framework will require adequate resourcing, and may provide an opportunity to extend the responsibility of collecting and analysing additional data sets to a wider range of academic disciplines. This is likely to take a number of years to implement and the introduction of new data sets should be prioritised according to resources available. Not all categories of data may need to be surveyed every year.

A robust monitoring framework can be used to prioritise and track the effectiveness of any interventions implemented by UC, plus identify any problems that may originate off, or on campus. The same data could be used to

- Inform an annual 'state of waterways' report.
- communicate effectively with stakeholders in the wider watershed/catchment (e.g. local residents)
- respond to the Otākaro/Avon Storm Water Management Plan and any other relevant plans.
- inform funding applications.
- Inform further *'State of Takiwa'* reports, which could in turn contribute to and strengthen the existing relationship(s) between UC and Mana Whenua.

Current Context

Ecological health of UC streams

Waiutuutu/Okeover

Waiutuutu/Okeover Stream receives more than 40 air-conditioning and stormwater discharges. The biological health of the stream has been monitored annually since 2000 by staff and students of Biological Sciences. The MCI, (or Macroinvertebrate Community Index) indicates that the ecological health of this stream overall is poor with less than 14 species of stream invertebrates.

The upper, ephemeral reach of Waiutuutu/Okeover (west from Ilam road) is ecologically dead, due partly to storm water quality issues and prolonged dry periods. For a good part of the year, the only natural, constant flow in Waiutuutu/Okeover are small springs slightly east of Engineering Road and below the RSIC building. Fresh water is otherwise pumped into the stream from building cooling systems on campus. With respect to the 'Headwaters' section of Waiutuutu/Okeover (the part of the river which was the focus of significant intervention from 1998-2000), it has become obvious that riparian planting and re-battering stream-sides are inadequate for achieving improved health for in-

[14] Kainamu, A (2013)

stream freshwater communities. [15,16] Water quality, contaminant loading, and water quantity issues must be addressed as well.

Between 24 July and 30 September 2014, a student project investigated a methodology to continuously monitor the temperature, pH, conductivity, turbidity, and water level in Waiutuutu/Okeover stream. Grab samples were also used to measure heavy metals and total suspended solids concentrations. Two sites were selected – downstream of the bridge outside the E9 lecture theatre, and downstream of the bridge adjacent to the Electrical Engineering Building. Preliminary data showed that the stream experiences a significant drop in specific conductivity and temperature and a large rise in turbidity in response to storm events. The data also showed a diurnal pattern in water levels caused by air-conditioning discharges to the stream. Heavy metals concentrations showed that aluminium, chromium, copper, and zinc exceed the 90 per cent trigger values for ecosystem protection at most baseflows and all stormflows. Nickel and lead only exceeded the trigger values during stormflows. Air-conditioning discharges and the re-suspension of bed sediment are suspected to cause the high concentrations of heavy metals at baseflow conditions. Total aluminium, zinc and lead concentrations demonstrated linear behaviour with TSS, temperature and specific conductivity.[17]

Another significant, ongoing issue for Waiutuutu/Okeover stream is the need to empty a series of sediment traps located along the stream from Ilam road down to the Engineering Pool, then manage the whole waterway in the long term so they do not need cleaning out at a high frequency. [18] These silt traps have been effective in reducing sedimentation in the Riffles and Meanders sections below Engineering Pool.

Ōtākaro/Avon River and Kā Waimaero/Ilam stream

The water quality, quantity and the biological health of the Ōtākaro/Avon river and Kā Waimaero/Ilam stream has not been researched or monitored anywhere to the same degree as Waiutuutu/Okeover stream. Little data exists which can be used to reliably determine which the health of either streams over time.

The profile of the Kā Waimaero/Ilam stream changed significantly in 2016 since a weir at the confluence of the Ōtākaro/Avon river and Kā Waimaero/Ilam stream was decommissioned, and water ceased to be pumped from the weir up to a location opposite College House. In addition, lowland streams across Christchurch were affected in 2016 by low groundwater levels partly due to the long term effect of earthquakes, dry weather failing to recharge aquifers, and abstraction for Christchurch's water supply. The volume of water in the Kā Waimaero/Ilam stream has subsequently significantly reduced. The remaining flow is narrowing and deepening into a natural channel, leaving a wide, muddy flood plain which has significant potential for planting out and regeneration.

[15] Between Ilam road and Engineering Road

[16] Populations of Canterbury mudfish (Waikākā) and fresh water crayfish (Waikōura) re-introduced to Waiutuutu/Okeover in 2002 and 2003 did not survive, and this can probably be attributed to predation and toxic 'first flushes' of storm water into the stream. Pers. Comm. (2016) Prof, Harding, Jon., University of Canterbury. School of Biological Sciences

[17] Brown., A. M., Scouller., J.M. (2014)

[18] An application to Environment Canterbury 'Immediate Steps Biodiversity Funding' for funds to remove sediment from Engineering Pool was submitted in February 2017.

For more information about a range of different options for remediating all three streams, please see "UC Waterways: Issues and Options" (2015).[19] This document was developed with the intention to inform the wider landscape plan.

Planning and policy settings

The Ōtākaro-Avon River has a landscape overlay scheduled in the Christchurch District Plan as a significant feature (SF) (planning map: 30, SF8.3). Refer to District Planning Map which shows the extent of SF8.3 in the grounds of the University of Canterbury, Ilam.

- Chapter 9 Heritage , Section 9.2.9.2.3 Schedule of Significant features
- Otākaro / Avon River Open Space water and margins

Policy relevant to treatment of significant features is set out in section 9.2.2.8 Policy – 'Recognising and maintaining the qualities of significant features', and this should be complied with when work is being undertaken within the significant feature area identified in the District Plan.[20]

Strategic context

The wider strategic context within which UC must care for its waterways is significantly different compared to when the first UC Waterways Plan was drafted in 2006. Several important regional and territorial local authority strategies are applied operationally at a discrete, watershed/catchment - specific scale, and clearly articulate a holistic framework of key values that need to be considered when managing waterways in Canterbury. A proactive approach to planning and management of UC waterways will help to anticipate and respond to these. The University of Canterbury should be an exemplar in demonstrating an 'on the ground' commitment to restoring the health of three high profile, lowland Canterbury streams.

Relevant legislation, strategies and policies include;

1. Ngāi Tahu Claims Settlement Act (1998)
2. Mahaanui Iwi Management Plan (2013)
3. Environment Canterbury: Canterbury Water Management Strategy (2009)[21]
4. Environment Canterbury: Canterbury Land & Water Regional Plan (2016)[22]
5. Christchurch West Melton Zone Committee: Zone Implementation Plan (2013)[23]
6. Christchurch City Council Surface Water Strategy (2009)[24]
7. Christchurch City Council: Ōtākaro/Avon Catchment Vision and Values (2016).[25]

For more information about the above Acts, Strategies, or Plans please see **Appendix E**.

[19] UC Waterscape Action Group (2015)
[20] University of Canterbury (2017)
[21] Environment Canterbury (2010)
[22] Environment Canterbury (2016)
[23] Environment Canterbury/Christchurch West Melton Committee (2013) .
[24] Christchurch City Council (2009)
[25] Christchurch City Council (2016)

Well-being and community expectations in an urban setting

Green, blue, and open spaces are vital for a sense of well-being or hauora for urban communities.[26] Significant investment has been made by the Crown and the Christchurch City Council into Te Papa Ōtākaro-Avon river precinct in the central city ($96m). There is also substantial, unprecedented community aspirations for the 'red zone' around the Ōtākaro-Avon river, which has included proposals for multiple contact-water recreation activities or facilities. These plans and projects could result in higher expectations of water quality from communities downstream of UC.

Waterways on UC land provide a valuable community asset by offering a safe, pleasant environment for commuters and local residents. Two major cycle routes (the Unicycle route, and Nor-West Arc) follow the Ōtākaro/Avon stream, and Waiutuutu/Okeover streams. The walking track along Okeover stream in particular is heavily used and much enjoyed by the local residents. UC waterways are also a feature of the proposed Greater Christchurch Perimeter Trail, which has the potential to offer significant opportunities for green recreation throughout the whole of Christchurch.[27]

UC Master Plan

The UC Campus Master plan (approved in early 2017) and Landscape plan (to be approved mid-2017) signal a significant shift for the management of UC's waterways, framing them as a key feature of campus which must be treasured, celebrated and cared for.

The Campus Master Plan outlines a planning vision, cultural narrative, and high level design principles to guide the development of the University's built infrastructure over the next 20-30 years. A staged approach is proposed.

A Cultural Narrative developed by Ngāi Tūāhuriri has been incorporated into the Campus Master Plan, providing further interpretation to assist with its integration into specific projects, which should include waterways remediation. This ensures that the values and aspirations of Mana Whenua are visible, accessible and are rendered in culturally appropriate ways in any future campus development.

Mana motuhake	The status of iwi and hapū as Mana Whenua is recognised and respected.
Whakapapa	Māori names are celebrated.
Tohu	Mana Whenua significant sites and cultural landmarks are acknowledged.
Taiao	The natural environment is protected, restored and / or enhanced.
Mahi Toi	Iwi/hapū narratives are captured and expressed creatively and appropriately.
Ahi Kā	Iwi/hapū have a living and enduring presence and are secure and valued within their role.

Ten high level design principles for the Campus Master Plan were developed through user group consultations, interviews, analysis, research and envisioning workshops. These design principles

[26] CCC (2010)
[27] https://christchurch360trail.org.nz/

guide fundamental recommendations for the structure of the campus, plus the nature and design of all key projects and initiatives. Design principles most relevant to UC waterways include;[28]

Streams and landscape	Celebrate the natural landscape assets and open spaces of the campus as fundamental campus identity and settings for campus life
Environmental responsibility	Kaitiakitanga – build for the future, creating a sustainable environment that is efficient, safe and healthy.
Expression of culture	Recognition of Mana Whenua and the welcoming of other peoples and cultures that make up the University community, creating an inclusive environment.

The UC Campus Master Plan is staged and waterways remediation is included in these stages.[29]

Stage 1 By Jubilee Anniversary in 2023	Implementation of the streams remediation strategy
Stage 2 Post Jubilee Anniversary 2023+	New pedestrian bridges over the streams
Stage 3 Future Expansion	Completion of streams remediation strategy

UC Landscape Plan

"Healthy Habitats" is the theme which encompasses UC waterways. This theme states all landscape between buildings in the campus core is functional and expressed artistically, to invite continuing learning conversations and promote education on display, with a focus on

- Tohungatanga/expertise, knowledge – functional, attractive 'living laboratory landscape' for the movement and treatment of water
- Kaitiakitanga/stewardship of environment – healthy waterways, habitat and mahinga kai
- Manaakitanga/looking after community – edible landscape and mahinga kai visible within (or from) campus heart.
- Mahinga kai/knowledge and values associated with gathering resources.

The University of Canterbury is articulated clearly in the UC Landscape Master Plan as a learning landscape. These themes underpin the plan, and provide principles for future projects to be designed and evaluated against.

Purpose of UC Waterways Plan

This UC Waterways Plan is a mechanism by which principles, outcomes and interventions outlined in the Campus Master Plan and Landscape Master Plan relevant to UC Waterways can be delivered.

The 2006 Draft UC Waterways plan was reviewed and updated by the current UC Waterscape Action Group, with the aim to align it with current campus master and landscape planning processes. The

[28] http://www.canterbury.ac.nz/capitalworks/planning/design-principles.shtml
[29] http://www.canterbury.ac.nz/capitalworks/planning/stage1.shtml

UC Waterscape Action Group has re-confirmed and supported its vision which was originally developed by the original UC Waterways Group. Key strategic pathways in the 2006 plan have also been retained, with some given more emphasis in the short term than others. Within each of the strategic pathways, sets of activities have been developed to implement the Waterways plan.

UC Waterscape Group

The UC Waterscape Group was reconvened late 2015, with the intention to inform and influence the campus master and landscape plans. Current members include;

- Dr. Frances Charters
- Dr. Tom Cochrane (Civil and Natural Resources Engineering)
- Katie Collins (PHD student, School of Biological Sciences)
- Darryl Cone (Supervisor, UC Grounds)
- Nigel Harris (Senior Projects Manager, AVC Maori)
- Prof. Jon Harding (School of Biological Sciences)
- Prof. Angus McIntosh (School of Biological Sciences)
- Katie Nimmo (Sustainability Office)
- Prof. Jenny Webster-Brown (Director, Waterways Centre for Freshwater Management).

See Appendix C: UC Waterscape Action Group; *Terms of Reference* for more information about the scope and role of this group.

Scope of UC Waterways Plan 2017-2025

The primary scope of this plan is the streambed and riparian margin of the:

1. Waiutuutu/Okeover Stream from Waimairi Road, downstream to its confluence with the Ōtākaro/Avon River.
2. Kā Waimaero/Ilam Stream from where it emerges from pipes on the grounds of the Christchurch College of Education, down to the weir at its confluence with the Ōtākaro/Avon River.
3. Ōtākaro/Avon River where it flows through the grounds of the University of Canterbury

Whilst a significant number of waterways interventions are detailed in the draft UC Landscape Plan, these are not specifically itemised in the 2017 UC Waterways Plan because all recommendations remain subject to approval to proceed. This plan provides guidance by which these interventions can be prioritised and executed using a collaborative, multi-stakeholder process which is grounded in nearly twenty years of institutional knowledge about UC waterways, at the same time giving effect to the key principles outlined in the UC Campus Master Plan and Landscape Plans.

The UC Waterways Plan does have a wider scope than the UC Landscape Plan, which focusses primarily on the built environment and sustainable resource management interventions. The UC Waterways Plan explores in greater depth how UC waterways can be articulated as Living Laboratory by outlining more detailed research/monitoring and teaching/learning programmes. And in the long term, it looks past UC property boundaries and encourages engagement with the local community on watershed/catchment-wide issues.

Activities identified for the years 2017 and 2018 are mostly about addressing how UC waterways are managed by UC, integrating high priority issues from the UC landscape and master plans. Activities identified for 2018/2019 focus on consolidating UC waterways' role as a Living Laboratory. From 2019 onwards, watershed/catchment-wide community engagement strategies are emphasised. Note however that this time line of activities is by no means a fixed, linear process. Interventions across all strategic pathways will ideally take place as opportunities arise and as the Campus Master and Landscape Plans are implemented. This plan will be reviewed on a yearly basis for the next six years in July to track progress against priority tasks identified.

High Level Risks Associated with UC Waterways

Below is a summary of high level risks associated with UC waterways and ongoing management of them. Risks associated with specific strategic pathways are listed separately under each pathway.

Risk	**Impact**
Flooding	Significant rainfall event overwhelming drainage and/or having a negative impact on existing in-stream-biota.
Unpreparedness for the effects of climate change - e.g. flooding, temperature rises, or draught. [30]	Increased instances of flooding Drought effects on waterways Reduced positive experience of campus grounds. In stream ecological values further reduced. Potential public health issues (e.g. mosquitos)
Reduced positive experience of campus if waterways not adequately restored.	Negative reputational effect for UC from students and staff
Negative impact on water quality of headwaters or tributaries for the Ōtākaro - Avon river, with an ongoing loss of existing instream biodiversity.	Negative reputational effect for UC in wider Christchurch community, particularly within the Ōtākaro-Avon catchment, by being held partly responsible for ongoing impacts on the stream (e.g. sediment from building works). UC seen as failing to support the Christchurch West Melton Zone Implementation Plan or extensive remediation activities lower in the catchment.

[30] This is already noted in an existing risk registers (Engineering Services).

Strategic Pathway 1: Governance, leadership and management

We need to establish institutional processes and resources that will allow the objectives of the waterways restoration project to be met.

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Mana motuhake, Taiao, Ahi Kā, Kaitiakitanga, Streams and Landscape	Healthy Habitats, Kaitiakitanga

Long Term Strategic Goal (December 31, 2025) The University and the UC Waterscape Action Group will be recognised as a leader in the restoration of urban waterways.

	By When	Who	Status (April 2017)
Influence the development of the campus landscape plan where possible/appropriate until it is approved	Landscape plan to be approved April 2017	UC Waterscape Group	Almost complete
Update and finalise UC Waterways Plan 2017-2025. Submit to Engineering Services and Capital Works managers.	13 April 2017	Sustainability Office and Waterscape Action Group	Almost complete
Clarify/confirm relationships between UC, CCC, and ECAN within context of current proposed imminent projects, including the need for a more formal MOU	End 2017	Sustainability Office/Engineering Services	In progress on an ad hoc, informal basis. Maintenance of silt traps clarified with CCC. Waiutuutu Box drain works may require further conversation with CCC. Application to ECAN Immediate Steps Biodiversity Fund submitted March 2017. Meeting with CCC freshwater ecologist and landscape architect re Kā Waimaero restoration December 2016
Clarify/confirm processes for influencing implementation of landscape master plan (e.g. six-monthly meetings).	May 2017	UC Waterscape Action Group/Managers of Engineering Services and Capital Works	Not started

Secure ongoing resourcing for coordination/support for the UC Waterscape Action Group	May 2017	Sustainability Office	In progress
Annual review of progress against UC Waterways Plan	June/July 2018, ongoing	UC Waterscape Action Group	Not started
Maintain positive working relationships with managers of Engineering Services and Capital Works (six monthly meetings)	January/July (alongside annual review of Waterways Plan). Ongoing until 2025	UC Waterscape Action Group/Managers of Engineering Services and Capital Works	Not started
Influence the implementation of the campus master plan, determining fit-for-purpose storm water management tools on a case by case basis as opportunities arise through the campus master and landscape plans (see Strategic Pathway 3).	Ongoing until 2025	UC Waterscape Action Group	See six monthly meetings.

Risk Factors

1. UC Waterways Plan 2017 not accepted or implemented internally due to higher priorities and competition for resources.
2. Lack of clarity concerning processes for influencing the implementation of the Landscape Plan or Waterways plan
3. CCC and ECAN focus resources on other parts of city-wide catchments (e.g. fire-affected sub catchments on the Opāwaho-Heathcote river).

Strategic Pathway 2: Mana Whenua and the Treaty of Waitangi

We need to ensure that our waterways rehabilitation approaches are in alignment with our responsibilities to, and relationships with, Mana Whenua under the Treaty of Waitangi

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Mana motuhake, Whakapapa, Tohu, Taiao, Mahi Toi, Ahi Kā, Kaitiakitanga, Streams and Landscape	Healthy Habitats, Kaitiakitanga

Long Term Strategic Goal (December 31, 2025) The University and the UC Waterscape Action Group will have achieved a closer working relationship with Te Ngāi Tuahuriri by integrating the UC Master Plan Cultural Narrative, and Matapopore Design principles into waterways planning.

	By When	Who	Status
Integrate cultural narrative and Matapopore Design principles via planting plans and signage, as informed by the Campus Master Plan, Campus Landscape Plan, and advised by Mana Whenua.	2017	Te Ngāi Tuahuriri, Waterscape Action Group, Engineering Services, Capital Works	In progress – Nigel Harris, Māori Research Kaiārahi consulted for general cultural narrative framework for waterways signage (trialled with signs for SEL building swale and rain gardens)
Integrate cultural narrative and Matapopore Design principles into **priority** waterways interventions, as informed by the Campus Master Plan, Campus Landscape Plan, and advised by Mana Whenua	2017-2018	Te Ngāi Tuahuriri, Waterscape Action Group, Engineering Services, Capital Works	Not started
Field trip/stream walk, guided by Te Ngāi Tuahuriri representative	2018	Te Ngāi Tuahuriri, Supported by Sustainability Office	Not started
Integrate cultural narrative and Matapopore Design principles into waterways interventions, as informed by the Campus Master Plan, Campus Landscape Plan, and advised by Mana Whenua	As opportunities arise	Te Ngāi Tuahuriri, Waterscape Action Group,	High level principles identified via UC Campus

		Engineering Services, Capital Works	Master Plan, UC Draft Landscape Plan
Opportunities for teaching and learning grounded in a Mana Whenua perspective using UC waterways as a Living Laboratory are actively sought and identified.	As opportunities arise.	Te Ngāi Tuahuriri, Waterscape Action Group	Not started
Integrate cultural content for monitoring frame work and the annual 'State of Waterways' report. Consider Kainamu's (2013) recommendation that there is an opportunity to assess the role of mahinga kai as 'biological engineers' to effectively remove metals from UC waterways and along riparian zones.	January 2018	Te Ngāi Tuahuriri, Waterscape Action Group	Not started

Risk Factors: Lack of clear internal processes result in a failure to incorporate Mana Whenua values and resource management approaches.

Strategic Pathway 3: Ecological rehabilitation

We need to develop and implement plans to restore ecosystem processes, habitat heterogeneity, and plant and animal communities broadly representative of natural lowland South Island stream tributaries for all reaches of all three campus waterways.

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Taiao, Kaitiakitanga, Streams and Landscape	Healthy Habitats, Kaitiakitanga, Tohungatanga/expertise, Living Laboratory landscape for the movement and treatment of water

Long Term Strategic Goal (December 31, 2025) The University will be recreating a series of self-sustaining ecosystems, which have a natural physical character and function, supporting communities of plants and animals dominated by indigenous species appropriate to a lowland South Island stream tributary.

Activities/Interventions	By When	Who	Status
Identify options for removing sediment in Waiutuutu/Okeover Stream, prioritising Engineering Pool for Immediate Steps funding application	February 2017	Sustainability Office/UC Waterscape Action Group	Complete. Funding application submitted March 2017
Advise on CCC box drain project for Waiutuutu/Okeover Stream, if CCC proceeds with the project.	Mid June 2017 for CCC box drain project	UC Waterscape Action Group, Engineering Services, CCC	On hold (April 2017). Waiting for CCC to supply further information.
Develop rehabilitation plan for the 'ephemerals' reach of Waiutuutu/Okeover Stream north west of box drain, taking into account recommendations from the Campus Landscape Master Plan	Interventions for upper reach (upstream, west of box drain) to be determined by landscape plan and operational budget	UC Waterscape Action Group/Engineering Services	Report for rehabilitation of ephemeral reach completed in December 2008.[31] Opportunity for wetland swale identified through UC Camps Master Plan
Develop broad restoration concepts for Kā Waimaero/Ilam stream and Ōtākaro/Avon stream, taking into account recommendations	June -2017 – January 2018.	UC Waterscape Action Group/Engineering Services	CCC fresh water ecologist and Landscape Architect consulted for concept plan for

[31] Golder Associates (2008)

from the Campus Landscape Master Plan, (particularly the Ilam Gardens management strategy). Include identifying priority reaches for rehabilitation and most effective methods in general for restoration for each reach	1 page for each stream only.		naturalisation of Kā Waimaero/Ilam stream December 2016. Concept plan yet to be received. Otherwise not started.
Planting Kā Waimaero/Ilam Stream. CCC providing a concept plan.	Determined by UC Grounds	UC Grounds liaising with CCC landscapers and fresh water ecologists. UC Waterscape Action Group advise on ad-hoc basis	On hold (April 2017)
Developing detailed rehabilitation plans for reaches on Ōtākaro/Avon River and Kā Waimaero/Ilam streams identified as having most urgent priority, taking into account recommendations from the Campus Landscape Master Plan, (particularly the Ilam Gardens management strategy)	2018 onwards: determined by landscape plan/operational budget	UC Waterscape Action Group	Not started

Risk Factors

1. Lack of time and/or interest by University City Council staff (General and Academic) to contribute to the waterways working group and waterways restoration project.
2. Insufficient internal financial resources available to advance waterways restoration.
3. Lack of knowledge regarding appropriate ecological rehabilitation methods.
1. Negative impact on receiving environment (e.g. reduced water quality, increased sediment in stream bed) due to remediation of campus/new build sites
2. CCC and ECAN focus resources on other parts of city-wide catchments (e.g. fire-affected sub catchments on the Ōpāwaho-Heathcote river).

Strategic Pathway 4: Sustainable resource management and maintenance

We need to manage our campus lands and facilities in an environmentally sustainable manner that supports the restoration of the campus waterways.

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Taiao, Kaitiakitanga, Streams and Landscape	Healthy Habitats, Kaitiakitanga, Tohungatanga/expertise

Long Term Strategic Goal (December 31, 2025) The University will have reduced the environmental impacts to the waterways associated with campus operations and integrated waterways restoration into the campus landscape, plus implementing the relevant elements of the Master Campus Plan, Landscape Plan and UC Waterways plan.

Master and Landscape Plan Activities/Interventions	By when	Who	Status
Identify key issues concerning bridges and culverts. Integrate best practise for building access points, bridges and culverts (both internal and external to build).	2017	UC Waterscape Group, Engineering Services, Capital Works	Some research conducted early 2000s. High level problems identified in UC Landscape plan
Develop initiatives to reduce contaminants at source, before they enter storm water, taking into account the Master and Landscape Plans.	Ongoing	UC Waterscape Group, Engineering Services, Capital Works	Rain garden installed in front of RSIC 2017. Filter installed on service road by RSIC 2017. Raingarden and swale installed by SEL building 2016. Significant number of interventions throughout campus identified through draft UC Campus Landscape Master Plan
Develop broad restoration concepts for Kā Waimaero/Ilam stream and Ōtākaro/Avon stream, taking into account recommendations made by the Campus Landscape Master Plan (particularly the Ilam Gardens management strategy). Include identifying priority reaches for rehabilitation and most effective methods in general for restoration for each reach.	June - December 2017. 1 page for each stream only.	UC Waterscape Action Group and Engineering Services	CCC fresh water ecologist and Landscape Architect consulted for concept plan for naturalisation of Kā Waimaero/Ilam stream December 2016. Concept plan

			not received and otherwise not started.
Watch for any opportunity to remove culvert between Engineering and Von Haast	Ongoing	UC Waterscape Group	Ongoing

Management and Maintenance Activities/Interventions	By when	Who	Status
Continue current regime of clearing storm water sumps, filters and pumps.	Ongoing	Grounds, Engineering Services	Ongoing
Continue to keep a watch for construction-related contamination events in Okeover/Waiutuutu and Ōtākaro/Avon, report to Grant Craig	Ongoing	UC Waterscape Group, Capital Works PMs, Engineering Staff	Ongoing
Integrate water quality issues into UC Design Guidelines (ANZEE). As requested by Rob Oudshoorn, manager of Engineering Services.	April 2017	UC Waterscape Group, Engineering Services, Capital Works	Not started
Identify potential risks to the campus waterways from campus activities, and ways to ameliorate those risks, including from storm-water inputs, waterways pests, silt and leaf litter inputs, and rubbish. 1 page only	June 2017. Once risks confirmed through audit on research and monitoring.	Sustainability Office, UC Waterscape Action Group.	Not started
Complete roll out of signage next to storm water drain sumps in carparks on Otākaro/Avon river side of campus	December 2017	Engineering Services/Gary Busch	In progress
Document a riparian management plan and an in-stream and margin maintenance plan for the University Grounds staff. Include City Council landscape designers, land drainage maintenance, and Green Space unit representatives.	December 2017	Engineering Services, Sustainability Office	Not started
Developing resource sheets and communicating with campus laboratory staff and students, maintenance staff and contractors regarding the campus waterways, including best-practices guidelines for minimising contamination risks to storm-water inputs, and contingency plans in case of accidental spills.	2018	Sustainability Office plus rep from each target group.	Not started. Subject to resource.

Risk Factors

1. Lack of staff time for sufficient implementation of risk assessment, communications, and maintenance tasks to meet immediate and short term targets.
2. Lack of financial resources to implement waterways interventions
3. Lack of timely coordination or sharing information between different UC stakeholders responsible for implementation of master and landscape plans, and operations and maintenance
4. Negative impact on receiving environment (e.g. reduced water quality, increased sediment in stream bed) due to remediation of campus/new build sites

Strategic Pathway 5: Research and monitoring

We need to encourage research that contributes to the rehabilitation of the campus waterways and advances knowledge in sustainable management of freshwater ecosystems, particularly in urban environments.

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Taiao, Kaitiakitanga, Streams and Landscape	Healthy Habitats, Kaitiakitanga, Tohungatanga/expertise, Living Laboratory landscape for the movement and treatment of water

Long Term Strategic Goal (December 31, 2025): The University will provide an important contribution to the local and international knowledge and practice of restoring urban waterways.

UC Waterways Research Profile:	By When	Who	Status
Conduct desk top audit of research already conducted, or currently taking place on UC Waterways by UC staff and students. Bibliography form only.	April 2017	Sustainability Office/UC Waterscape Group	In progress
Develop a central depository for monitoring and research data on UC waterways.	February 2018	Sustainability Office/UC Waterscape Action Group	Not started.
Develop an annual, state of waterways report. This is simple dashboard reporting for laypeople/UC community. Includes cultural content, key ecological indicators, research and monitoring currently being conducted, intervention, and key issues that need to be addressed. No more than 3 pages.	February 2018	Sustainability Office/UC Waterscape Action Group	Not started

Monitoring and applied research for UC Waterways	By when	Who	Status
Develop a comprehensive, long-term waterways monitoring programme which covers all three streams, Monitoring must allow comparability of results between years. This includes; • Cultural content • annual macro invertebrate survey/biological activity • water quality • hydrological characteristics • Quantity of sediment in key silt traps (e.g. Engineering Pool) • monitoring the impact of climate change on UC waterways, including installing a water temperature data logger on the east side of Ilam campus. • Identifying pest fish and plants and any associated risks. • Consider Kainamu's (2013) recommendation that there is an opportunity to assess the role of mahinga kai as 'biological engineers' to effectively remove metals from UC waterways and along riparian zones.	End January 2018. To inform annual state of the waterways report.	UC Waterscape Action Group to advise and coordinate where opportunities and resources allow.	Some data available about Waiutuutu/Okeover stream.
Investigate spatial distributions and levels of heavy metals and other accumulating contaminants in the silt of campus waterways	Monitoring begins end 2018 (before silt removed from Engineering Pool)	Natural Resource Engineering	Not started. Could be integrated as an annual teaching lab.

Research for whole of watershed/catchment management	By When	Who	Status
Determining watershed/catchment boundaries for all three campus waterways.	Mapping of Ōtākaro/Avon, Kā Waimaero/Ilam stream only necessary if undertaking whole of watershed/catchment work for all three streams and if resources are available.	Natural Resource Engineering	Waiutuutu/Okeover watershed/catchment complete. (Charters et al)
Identify contaminants entering campus waterways via storm water, and other key impacting activities.	Completed for Waiutuutu/Okeover only.	Natural Resource Engineering	Completed for Waiutuutu/Okeover only. (Charters et al). Findings can be extrapolated to Ōtākaro/Avon, Kā Waimaero/Ilam stream if necessary.
Understanding the effects of storm water contaminants on aquatic life.		School of Biological Sciences	Partially completed
Determining fit-for purpose methods of removing contaminants from stormwater, before they enter campus waterways, including filters, raingardens Swales, tree pits, wetlands.	Ongoing	Natural Resource Engineering	In progress

Risk Factors

1. Lack of time and/or support for University General staff to contribute to the waterways working group and waterways restoration project.
2. Lack of time and resources for monitoring and research contributions by Academic staff
3. Lack of knowledge regarding appropriate storm water treatment and risk mitigation methods.
4. Inability to attract new academic staff and/or students to conduct necessary waterways related research and monitoring.
5. Insufficient financial resources available through Christchurch City Council and/or Environment Canterbury to address catchment-wide storm water issues.

Strategic Pathway 6: Teaching and learning

We need to develop the campus waterways as places of learning and encourage their use in teaching throughout a wide array of academic disciplines and educational levels.

Relevant Campus Master Plan Principles	Relevant Landscape Master Plan Principles, Outcomes or Themes
Streams and Landscape, Mana motuhake, Whakapapa, Mahi Toi	Healthy Habitats, Kaitiakitanga, Tohungatanga/expertise, Living Laboratory landscape for the movement and treatment of water

Long Term Strategic Goal By December 31 2025: Through implementation of its Waterways Plan, the University will develop excellence in interdisciplinary and experience-based learning in urban waterways restoration.

Activities/Interventions	By When	Who	Status
Annual audit/record of all courses using UC waterways as a teaching tool	April 2017, annual thereafter	Sustainability Office, UC Waterscape Action Group	In progress
UC Waterways demonstrated through teaching and research activities as a Living Laboratory through annual 'state of waterways report' and research/monitoring profile.	February, annually	Sustainability Office, UC Waterscape Action Group	In progress
Annual State of Waterways Report and research/monitoring profile promoted to other departments or disciplines to identify further opportunities for research and teaching, including Aotahi, School of Maori and Indigenous Studies, Geography, and Sociology.	2018/2019, or as opportunity arises	UC Sustainability Office, UC Waterscape Action Group	Not started

Risk Factors

1. Lack of resources and will amongst staff and the University towards aligning curricula and teaching to Living Laboratory and interdisciplinary studies;
2. Poorly developed or co-ordinated teaching resources leading to conflicting information being taught.
3. Classes may negatively impact on ecosystems, e.g., through collection or trampling.

Strategic Pathway 7: UC community engagement staff and students

We need to raise awareness and participation amongst staff and students in the campus waterways and their restoration

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Streams and Landscape, Kaitiakitanga, Mahi Toi, Mana motuhake, Taiao, Whakapapa	Manaakitanga, Mahinga Kai, Living Laboratory landscape for the movement and treatment of water, Healthy Habitats

Long Term Strategic Goal (By December 31, 2025): Through implementation of the University's Waterways plan, a wide range of staff and students will have an appreciation of the campus waterways and will be actively involved in restoration actions.

Activities/Interventions:	By When	Who	Status
Strengthen student and wider staff representation on the waterways working group.	December 2017	Sustainability Office. In consultation with UC Waterscape Group. BioSoc rep? General staff?	Not started
Conduct and promote planting events to staff and students as opportunity arises	Waiutuutu Box Drain? TBC	Sustainability Office/liaise with CCC, UC Grounds	Not started
Conduct guided tours, meetings etc. to raise awareness of the campus waterways project amongst interested students and staff and promote their active involvement in the project.	Ad hoc, as opportunity arises (e.g. Waiutuutu box drain, Eco Week, any major visible interventions, conferences)	Relevant members of UC Waterscape Action Group	Not started

Risk Factors

1. Few staff and students may be interested in being actively involved in restoring the campus waterways.
2. Lack of time for UC staff may mean that awareness raising and participation activities are not sufficiently implemented.

Strategic Pathway 8: Stakeholder and whole of watershed/catchment catchment community engagement

We need to mitigate and manage factors that impact upon campus waterways on a watershed/catchment -wide basis. We need to work cooperatively with other groups in the wider community to restore the ecology of the campus waterways for all to enjoy

Relevant Campus Master Plan Principles, Outcomes or Themes	Relevant Landscape Master Plan Principles, Outcomes or Themes
Streams and Landscape, Kaitiakitanga, Mahi Toi, Mana motuhake	Kaitiakitanga, Manaakitanga, Mahinga Kai, Living Laboratory landscape for the movement and treatment of water, Healthy Habitats

Long Term Strategic Goal (December 31, 2025): The University will be recognised as having improved its connections and collaborations with the local and wider Christchurch community, Christchurch City Council, and Environment Canterbury.

Activities/Interventions	By When	Who	Status
Liaise with local guardianship groups and other local community groups associated with UC waterways to raise awareness, encourage behaviour change, promote events, and identify opportunities for collaboration.	June/July 2018. Annual meeting, after the State of the Waterways report completed June/July every year	Sustainability Office/UC Waterscape Group as appropriate	Not started
Develop relationships with City and Regional Councils to address catchment-wide issues, to: 1) Revisit findings/data from ECAN 2010 Pilot Okeover Community Engagement Project 2) determine a fit for purpose, cost effective, evidence-based whole-of-catchment technical and social interventions 3) develop waterways awareness and storm water education programmes.	End 2018. Ilam sub-catchment currently not a priority for CCCC And ECAN. To be formalised if whole of catchment management programme mandated.	Sustainability Office/Engineering Services/UC Waterscape Group	Taking place in an ad-hoc basis through Waiutuutu/Okeover box drain project, naturalisation of Kā Waimaero stream, ECAN Immediate Steps Funding application
Liaise with other Christchurch-based river networks, e.g. Otakaro-Avon Network, Opawaho-Heathcote River Network, Styx River	2025		Not started

Annual walk during an open day/participation in Walking festival, Christchurch 360 Perimeter Trail	Investigate 2020		Not started

Risk Factors

1. Lack of time for Sustainability Office and other UC staff may mean that communication with local community groups is weak.
2. CCC and ECAN focus resources on other parts of city-wide catchments (e.g. fire-affected sub catchments on the Opāwaho-Heathcote river, Dudley Creek).

Appendix A: Priorities for 2017

Priorities for 2017	Priority	Priority Tasks/Activities for 2017
GOVERNANCE, LEADERSHIP AND MANAGEMENT	High/Ongoing	1. Influence the development of the campus landscape plan where possible until it is approved (May 2017) 2. Update and finalise UC Waterways Plan 2017-2025. Submit to Engineering Services and Capital Works managers. (April 2017) 3. Clarify/confirm processes for influencing implementation of landscape master plan (May 2017) 4. Clarify/confirm relationships between UC, CCC, and ECAN within context of current proposed projects, including a need for a more formal MOU. (end 2017) 5. Secure ongoing resourcing for coordination/support for the UC Waterscape Action Group (April 2017).
THE TREATY OF WAITANGI:	High/Ongoing:	1. Integrate cultural narrative and Matapopore Design principles into priority waterways interventions, as informed by the Campus Master Plan, Campus Landscape Plan, and advised by Mana Whenua 2. Integrate cultural narrative and Matapopore Design principles via planting plans and signage, as informed by the Campus Master Plan, Campus Landscape Plan, and advised by Mana Whenua and advised by Mana Whenua 3. Integrate cultural content into monitoring framework and annual state of the waterways report
ECOLOGICAL RESTORATION	High Medium (2017)	1. Funding application to ECAN Immediate Steps Biodiversity funding to remove sediment from Engineering Pool (24 Feb) 2. Naturalisation of Waiutuutu/Okeover Box Drain (June) – CCC owns this project. TBC 3. Develop broad restoration concepts for Ilam stream and Avon stream. Include identifying priority reaches for rehabilitation and most effective methods in general for restoration for each reach. (1 page only for each stream), (July-December) 4. Planting Ilam stream (determined by UC Grounds, CCC providing a concept plan tbc) 5. Develop rehabilitation plan for the reach of Waiutuutu/Okeover Stream west of box drain. (To be determined by CCC Box Drain project and Campus Landscape Master Plan)
SUSTAINABLE RESOURCE MANAGEMENT AND MAINTENANCE ON UC LAND:	High (2017)/ongoing	*Master and Landscape Plan Activities/Interventions* 1. Identify key issues concerning bridges and culverts. Integrate best practise for building access points, bridges and culverts. (Internal and External builds) 2. Continue to keep a watch for construction-related contamination events in Okeover/Waiutuutu and Otakaro/Avon, report to Grant Craig *Management/Maintenance Activities* 1. Integrate water quality issues into UC Design Guidelines (ANZEE). As requested by Rob O. 2. Identify potential risks to the campus waterways from campus activities, and ways to ameliorate those risks, including from storm-water inputs, waterways pests, silt and leaf litter inputs, and rubbish. 3. Developing an annual state of waterways report. 4. Document a riparian management plan and an in-stream and margin maintenance plan for the University Grounds staff, City Council landscape design and maintenance representatives.
RESEARCH AND MONITORING	Medium (2017)	*Research Profile* 1. Conduct desk top audit of research already conducted, or currently taking place on UC waterways by UC staff and students. Develop register 2. Develop monitoring framework for annual State of Waterways Report, including cultural content.
TEACHING AND LEARNING:	Medium (2017)	1. Audit of courses using UC Waterways as a teaching tool 2. UC Waterways conceptualised and demonstrated as a Living laboratory through annual ‘state of waterways report’.
UC COMMUNITY ENGAGEMENT: STAFF AND STUDENTS	Medium (2017)	1. Progress signage along waterways 2. Storm water signage by drains into Otākaro/Avon stream completed 3. Ad hoc, as opportunities for participation arises E.g. planting out CCC box drain project, show casing an successful immediate steps project, other significant interventions
STAKEHOLDER AND WHOLE OF CATCHMENT COMMUNITY ENGAGEMENT	Low/Ad hoc/As needed only	Liaise with local guardianship groups and other community groups associated with UC waterways to raise awareness, encourage behaviour change, promote events, and identify opportunities for collaboration. (June/July, after State of Waterways Report finalised)

Appendix B: Stakeholders in UC Waterways

Stakeholder	Role
Te Ngāi Tūāhuriri/ Te Ngāi Tahu Research Centre	Mana Whenua
Office of The Assistant Vice Chancellor Maori	Implementation of the Rautaki Whakawhanake Kaupapa Māori 2012 Strategy for Māori
University of Canterbury - General	
Engineering Services/Grounds Sustainability Office	Maintain the stream/river bank plantings, plus any storm water remediation elements retrofitted into the landscape. Assists with implementing landscape and transport plans. Coordinates UC Waterways Plan
Capital Works	Developed master, landscape and transport plans. Manages remediation and new build projects
Student Services	Implements transport plans.
University of Canterbury – teaching and research	
School of Biological Sciences	Freshwater Ecology Research Group. Monitors stream health. Conducts teaching and research
College of Engineering	Natural Resource Engineering. Monitors water quality and quantity. Conducts teaching and research
Waterways Centre for Freshwater Management	Joint partnership between Canterbury and Lincoln Universities.
Halls of Residence	
Campus Living Halls of Residence	Property adjoining Waiutuutu/Okeover stream
College House	Property adjoining Kā Waimaero/Ilam stream
Students	Eco-Club Network BioSoc Te Whare Ākonga o Te Akatoki (property adjacent to Waiutuutu/Okeover stream)
Local and Regional Authorities	
Christchurch City Council	Land Drainage - Operations Stormwater Network Planners CCC Fresh Water Ecologist and Botanist Greenspace Unit
Environment Canterbury	
Wider Community Stakeholders	
Christchurch West Melton Zone Committee	
Ilam and Upper-Riccarton Residents Association	
Neighbours of The Ilam Stream (NOTIS)	

Appendix C: UC Waterscape Action Group Terms of Reference

Purpose: To act as a strategic advisory group for the planning, management and operation of waterways within the University of Canterbury (UC) campus.

Goal: To achieve continual improvement of water quality and biodiversity of waterways within the UC campus

Objectives: That planning and strategy related to waterscapes with UC:

1. Ensures ongoing kaitiakitanga (guardianship) by Mana Whenua, Te Ngāi Tūāhuriri of UC waterways, with an emphasis on restoring mahinga kai values.
2. Provides leadership and innovation in urban waterway management.
3. Conceptualises UC waterways as a Living Laboratory, where students have the opportunity to conduct research and develop key graduate attributes;
4. Supports research conducted on campus which is designed to improve storm water quality and fresh water biodiversity.
5. Minimises the adverse environmental impacts of UC operations in general on UC waterways and the Avon-Otākaro catchment.
6. Protects UC's reputation as an institution acting responsibly towards its community and the physical environment, with the recognition of UC's location in a large urban watershed/catchment.
7. Promotes UC waterways as a valuable community asset by offering a safe, pleasant environment for pedestrians and their hauora (well-being);

Scope of interests and activities: Strategic issues of waterways management and planning including:

1. Integrating tangata whenua catchment management concepts into waterways management
2. Maintaining a long term view of UC waterways and their management, within the context of campus landscape planning and the UC campus master plan.
3. Maintaining a long term view of UC waterways within the context the Christchurch West Melton Zone Implementation Plan, the Canterbury Water Management Strategy and other statutory plans.
4. To respond to requests for comment on proposals affecting UC waterways.

Operational issues of waterways planning include:

1. Recognising and providing for restoration of mahinga kai values into UC waterways.
2. Integrating institutional, technological and cultural knowledge about UC waterways into the campus master planning process, plus site specific projects.
3. Identify, investigate and advise on storm water management and technologies, taking a whole-of-campus approach.
4. Overseeing monitoring of water quality and key biodiversity indicators
5. Contribute to UC Design Guidelines where appropriate.
6. Initiate and integrate student-based research projects.
7. Liaise with relevant CCC and ECAN staff where appropriate.

Membership and meetings: A number of the representatives of UC WAG have worked together on an ad hoc basis on campus waterways issues since the late 1990s. The group reconvened in May 2016 and holds considerable institutional knowledge. Membership consists of

- Associate Professor Tom Cochrane (Civil and Natural Resources Engineering) (Chair)
- Professor. Jenny Webster Brown (Director, Waterways Centre for Freshwater Management)
- Katie Collins, PhD student (School of Biological Sciences)
- Darryl Cone (Grounds Supervisor, Engineering Services)
- Professor Jon Harding (School of Biological Sciences)
- Nigel Harris (Te Ngāi Tūāhuiriri)
- Professor Angus McIntosh (School of Biological Sciences)
- Katie Nimmo, UC Sustainability Projects Facilitator (Engineering Services)
- Dr Frances Charters (Civil and Natural Resources Engineering)

The UC WAG meets four times a year, but more often when there are active projects requiring input.

Reporting and relationships: The UC WAG reports to the UC Senior Management Team through Program Director: Capital Works, and Manager of Engineering Services.

Appendix D: Silt Traps in Waiutuutu/Okeover stream

There are several silt traps in Waiutuutu/Okeover stream and to some extent, Engineering Pool also acts as a proxy silt trap. The UC is responsible for maintaining the silt traps (and mud fish habitat) between Ilam road and Engineering road, plus Engineering Pool.

The Christchurch City Council is responsible for maintaining two further silt traps; one is located just downstream of Rutherford, and the other is located in the Meanders section by Forestry.

In February 2017, UC submitted an application to ECAN's Immediate Steps programme for funds to remove silt from Engineering Pool. If this application is successful, it is anticipated that this work will take place in the summer of 2018/2019, due to constraints related to construction projects taking place in the vicinity of Waiutuutu/Okeover stream.

Appendix E: Policies, Plans, and Legislative Requirements Relevant to UC Waterways

Mana Whenua Te Ngāi Tūāhuriri

The Ngāi Tahu Claims Settlement Act (1998) is a statutory acknowledgement which is a recognition by the Crown of Ngāi Tahu's cultural, spiritual, historical and traditional association with specific areas of Crown owned land. It enshrines Ngāi Tahu mana and participation under the Resource Management Act (RMA) in these areas. Matapopore as mandated representatives of Te Ngāi Tūāhuriri therefore have significant input into the design, development and future management of waterways on campus.

Iwi management plans are afforded explicit statutory recognition under the Resource Management Act (1991), and waterway management on UC land is subject to the Mahaanui Iwi Management Plan (2013). This is a manawhenua planning document which provides "…a values… based policy

framework for the protection and enhancement of Ngāi Tahu values, and for achieving outcomes that provides for the relationship of Ngāi Tahu with natural resources across Ngā Pākihi Whakatekateka o Waitaha and Te Pātaka o Rākaihautū".

Ngā Take, or issues of significance relevant to waterway management on campus outlined in the Mahaanui Iwi Management plan include;

Issue WM1: Rights and interests.	Tāngata whenua have specific rights and interests associated with freshwater.
Issue WM2: Value of water.	Changing the way water is valued.
Issue WM3: Priorities for use	Priorities for use based on Ngāi Tahu values.
Issue WM4: Management of Water	Appropriate management scale, principles, tools and processes to deliver Ngāi Tahu cultural outcomes.
Issue WM6: Water quality:	The decline in water quality in the region as a result of point and non-point source pollution, low flows and loss of wetlands and riparian areas.
Issue WM10: Mixing of water:	There are cultural issues associated with the unnatural mixing of water between and within catchments.
Issue WM12: Beds and margins	Activities occurring within the beds and margins of rivers and lakes can adversely affect Ngāi Tahu values.
Issue WM13: Wetlands, waipuna and riparian margins:	Loss of wetlands, waipuna and riparian margins, and the cultural and environmental values associated with them.
Issue WM14: Drain management	Drain management can have adverse effects on Ngāi Tahu values, particularly mahinga kai.
Issue WM15: Invasive weeds:	The spread of invasive woody weeds and standing trees in the beds and margins of rivers.
Issue WM16: Coastal marine area:	The freshwater-saltwater interface is an important feature of freshwater management.[32]
Issue P6: Storm water	The discharge of storm water in urban, commercial, industrial, and rural environments can have effects on water quality.
Issue P8: Discharge to land[33]	Discharge to land can utilise the natural abilities of Papatūānuku to cleanse and filter contaminants, but must still be managed to avoid adverse effects on soil and water resources.
Issue TM1: Mahinga Kai	Loss of mahinga kai areas and opportunities in the takiwā.
Issue TM2: Indigenous biodiversity	The widespread loss of indigenous biodiversity has significant adverse effects on the relationship of Ngāi Tahu with ancestral land, water and sites, and the health of land, water and communities
Issue TM4: Restoration of indigenous biodiversity	Tāngata whenua have a particular interest in the restoration of indigenous biodiversity.

[32] Ngāi Tūāhuriri Rūnganga (2013) Issues WM1-16, pp 76
[33] Ibid Issues P6, P8. pp 102

Ihutai, or catchment specific issues include[34]

IH3:Decline in water quality	Poor water quality in the watershed/catchment as a result of discharges of storm water and other contaminants to water, and inappropriate land use and urban development.
IH4: Urban wastewater	Urban wastewater is discharged into Te Tai o Mahaanui
IH5: Waipuna	Loss and inappropriate management of waipuna as a result of urban development and redevelopment.
IH6: Modification of waterways	Physical modification of natural waterways in the watershed/catchment for flood control, drainage, storm water management, recreation and land development purposes. [35]

Subsequent to the 2011 earthquakes, Ngāi Tahu identified a range of key guiding principles for the Christchurch recovery and rebuild, which are also relevant to waterways planning and management as UC's campus' are also remediated and rebuilt. These include[36]

- Ngā Wai Tūpuna: Protection and enhancement of waterways and the appropriate use/reuse, treatment & disposal of water.
- Ngā Otaota Māori: Protection and enhancement of indigenous flora, fauna, habitats, ecosystems, & biodiversity, particularly those associated with waterways and wetlands
- Wāhi Tapu/Taonga: Acknowledgement, protection, enhancement and appropriate development and interpretation of culturally significant sites and areas.

Any future planning and day to day management of UC waterways must incorporate relevant elements of Mana Whenua Environmental Benchmarks and the Remediation and Rebuild Toolkits developed and used by Mana Whenua.

Environment Canterbury

The Canterbury Water Management Strategy (CWMS) was established in 2009 by Environment Canterbury to address critical water management issues in Canterbury. The CWMS vision is "...to enable present and future generations to gain the greatest social, economic, recreational and cultural benefits from our water resources within an environmentally sustainable framework." The strategy sets out targets for water management in Canterbury for the next 30 years. Targets most relevant to UC waterways include

1. Kaitiakitanga: actively involve rūnanga in water management and decision making. Increase the community understanding of customary values and users. Protect wāhi taonga and mahinga kai waterways.
2. Ecosystem health and biodiversity: protect, restore and prevent further loss of habitats and species in all natural aquatic environments – from the mountains to the sea – ki uta ki tai.
3. Environmental limits: set and achieve flow, watershed/catchment and nutrient limits consistent with all the target areas.

[34]Ngāi Tūāhuriri Rūnganga (2013) Issues TM1,2,4 pp. 231
[35] Ibid, Issues IH3,4,5,6, pp231
[36] Ngāi Tahu (n.d).

4. Recreational and amenity opportunities: maintain and improve existing diversity and quality of recreational sites, opportunities and experiences.

Zone Committees are responsible for developing water management programmes that give effect to these targets for their respective areas, by making recommendations for the best way to manage water in their area. UC lies within the Christchurch West Melton Zone. The Christchurch West Melton Zone Committee published a Zone Implementation Plan (ZIP) in 2013, which gives effect to the targets set by the Canterbury Water Management Strategy within Christchurch City boundaries. Priority issues relevant to UC waterways identified in this ZIP include;

1. Enhancing and managing waterways for recreation, relaxation and amenity.
2. Improving surface water quality and safeguarding surface water flows.
3. Enhancing degraded ecosystems, indigenous biodiversity, valued introduced species and landscapes.[37]

Christchurch City Council

Christchurch City Council (CCC) has developed a range of strategies, policies, and management practices relevant to UC waterways. These include;

1. Surface water strategy (2009)[38]
2. The Ōtākaro/Avon Catchment Vision and Values (2016).[39]
3. Public Open Space Strategy (2010-2040)[40]

CCC gives consideration to six values when planning for the long term management of waterways in Christchurch. [41] These include;

Ecology	The ability of a waterway and its surrounds, to sustain animal and plant life.
Drainage	The ability of the waterway to drain flood water from surrounding land.
Culture	The importance of the waterway to the kiwi way of life, including the values for Mana Whenua of waiora and mahinga kai.
Heritage	The features or the waterway that have importance in describing our local history (such as water wheels or treatments to river edges)
Landscape	The importance of the waterway in making the local area attractive.
Recreation	The importance of the waterway for sports and other recreational activities.

[37] Environment Canterbury (2013)
[38] Christchurch City Council (2009)
[39] Christchurch City Council (2016)
[40] Christchurch City Council (2010)
[41] Christchurch City Council (2003)

Appendix E: UC Waterways as a Living Laboratory

School of Biological Sciences

Paper	Student Activity
BIOL 112	To assess whether the restoration of Okeover Stream has been successful, students learn how to sample macroinvertebrates from one site on campus (i.e., Okeover Stream) and compare it with data collected prior to restoration, and with several other streams which have not been restored (e.g., the Avon River). Approximately 275 students attend this course.
BIOL 273	UC waterways have not recently been used as part of this course. However there is potential for both Okeover and Avon to be sampled on campus to assess the freshwater invertebrate diversity.
BIOL 375	30 plus students use site on Okeover near glasshouses to train students in biomonitoring sampling techniques for macroinvertebrates and physico-chemical measures. The samples they take from there are also used as a data point in a biomonitoring exercise comparing the 'health' of various waterways across Canterbury.
WATR 201	Students visit Ilam Springs and Ilam Stream on the fieldtrip. The purpose of the fieldtrip and their assignment is to understand the "use" of Christchurch groundwater; for drinking, ecosystem support, and for domestic use.
WATR 203	Summer freshwater field skills course. Samples may be taken from campus streams

Waterways Centre for Freshwater Management

Paper	Student Activity
ENGE 414	Students test groundwater wells on Ilam fields to see how groundwater level affects stream flow/depletion.
ENCN 499	

Natural Resource Engineering

Paper	Student Activity
ENNR322 Ecological Engineering 1	3 hour field lab in the Avon River on campus: students learn and practice water quality field sampling techniques 3 hour water quality analysis lab: students analyse stormwater-affected water sample from the Okeover and compare its quality to lower Avon river sample and wastewater sample to understand the different chemical and physical characteristics of such waters

ENNR320 Integrated catchment analyses	Streamflow gauging – currently downstream Avon (at Riccarton bush), but some years it has been conducted on Okeover stream Hydrological modelling of Okeover watershed/catchment (some years)
ENNR405 Ecological and Bioresources Engineering	1.5 hour lab: students use the Structural Engineering Lab stormwater treatment facility to conduct infiltration testing as an example of post-construction monitoring techniques to assess the ongoing effectiveness of stormwater management measures in the Okeover 1.5 hour lab: students use the Okeover as an example site to assess the ecosystem services contributed by the current restoration works between the Okeover Community Garden and Engineering Road. The students then also use the boxed channel area upstream towards Ilam Road to assess opportunities for ecological restoration.

Current Post Graduate Students (2017)	**Research Topic**
Salina Poudyal (PHD Candidate)/Natural Resource Engineering	First flush TSS and heavy metals from urban car parks under a low intensity rainfall climate. Field testing on campus.
Nekelia Gregoire (Masters Candidate)/Natural Resource Engineering	Different filter materials to guide design of retrofittable treatment into downpipes to remove dissolved metals. Field testing on campus.
Courtnay Bremner (Masters Candidate) /Natural Resource Engineering	Use of biofilms on media to treat stormwater pollutants
Vicky Southworth (Masters Candidate) /Natural Resource Engineering	Identifying and addressing barriers to implementing water sensitive urban design
(Honours student) /Natural Resource Engineering	How pollutants (with a focus on heavy metals) transform from source to receiving environments. Foundry roof being sampled, then at point of discharge into Otakaro/Avon river.
(Honours student) /Natural Resource Engineering	Monitoring stormwater off the SEL building upstream of raingarden, then downstream of raingarden, with the purpose of assessing info and outflow water quality.
PHD Candidate (to be recruited) /Natural Resource Engineering	Watershed/catchment scale modelling methods that relate at source data to receiving water quality data.

Appendix F: Research conducted on UC Waterways

Theses	**Format/location/owner of dataset**
Blakely, T. (2003). Factors influencing benthic communities and colonisation in a Christchurch urban stream. *Unpublished BSc (hons) thesis, University of Canterbury*.	School of Biological Sciences
Charters, F. (2016) Characterising and modelling urban runoff quality for improved stormwater management. https://ir.canterbury.ac.nz/handle/10092/12602	Natural Resource Engineering
Eden, J. (2016) The impact of heavy metals on benthic macroinvertebrate communities in Christchurch's urban waterways https://ir.canterbury.ac.nz/handle/10092/12833	Waterways Centre for Freshwater Management
Murphy, L (2015) Quantifying Spatial and Temporal Deposition of Atmospheric Pollutants in Runoff from Different Pavement Types. https://ir.canterbury.ac.nz/handle/10092/10467	Natural Resource Engineering

Published Articles or Reports	**Format/location/owner of dataset**
Blakely, T.J., Harding, J.S. **(**2005). Longitudinal patterns in benthic communities in an urban stream under restoration. *New Zealand Journal of Marine and Freshwater Research* **39**: 17-28. PDF (700KB) http://www.biol.canterbury.ac.nz/ferg/urban.benthic.shtml	School of Biological Sciences
Blakely T.J., Harding J.S., McIntosh A.R. and Winterbourn M.J. (2006). Barriers to the recovery of aquatic insect communities in urban streams. *Freshwater biology* **51**: 1634-1645 (pdf available on request).	School of Biological Sciences
Bond, J. and Arbouw, P, (2010) Improving urban waterway health: local public perceptions of stormwater and the Okeover Stream, Christchurch. Report No R10/40, Environment Canterbury. *https://api.ecan.govt.nz/TrimPublicAPI/documents/download/1394138*	Environment Canterbury
Cadórniga, I., Cochrane, T.A., O'Sullivan, A. (2013) Spatial and temporal modelling of heavy metal contaminant loadings to urban streams. https://ir.canterbury.ac.nz/handle/10092/8765	Natural Resource Engineering
Charters, F. (2014) Modelling stormwater management options for enhancing water quality of urban streams.https://ir.canterbury.ac.nz/handle/10092/9913	Natural Resource Engineering
Charters, F., O'Sullivan, A.D., Cochrane, T. (2014) Modelling Stormwater Contaminant Loads in Older Urban Catchments: Effects of Climate Influences on Selecting Management Options. https://ir.canterbury.ac.nz/handle/10092/10946	Natural Resource Engineering
Charters, F., Cochrane, T. A., & O'Sullivan, A. (2014). Modelling stormwater management options for enhancing water quality of urban streams. In *Proceedings* (pp. 10pp). Christchurch, New Zealand.	Natural Resource Engineering

Charters, F., O'Sullivan, A.D., Cochrane, T. (2014) Modelling Stormwater Contaminant Loads in Older Urban Catchments: Effects of Climate Influences on Selecting Management Options. https://ir.canterbury.ac.nz/handle/10092/10946	Natural Resource Engineering
Charters, F. J., Cochrane, T. A., & O'Sullivan, A. D. (2015). Particle size distribution variance in untreated urban runoff and its implication on treatment selection. *Water Research*, *85*, 337-345. doi:10.1016/j.watres.2015.08.029	Natural Resource Engineering
Charters, F. J., Cochrane, T. A., & O'Sullivan, A. D. (2016). Untreated runoff quality from roof and road surfaces in a low intensity rainfall climate. *Science of the Total Environment*, *550*, 265-272. doi:10.1016/j.scitotenv.2016.01.093	Natural Resource Engineering
Cochrane, T. A., Wicke, D., O'Sullivan, A. (2011) Developing a public information and engagement portal of urban waterways with real-time monitoring and modelling. *Water Science & Technology.* 63.2. 238-254 http://www.urbanwaterways.info/files/documents/WST_2011_043_Monitoring%20system_without%20cover%20page.pdf	Natural Resource Engineering
Fraga, I., Charters, F. J., O'Sullivan, A. D., & Cochrane, T. A. (2016). A novel modelling framework to prioritize estimation of non-point source pollution parameters for quantifying pollutant origin and discharge in urban catchments. *Journal of Environmental Management*, *167*, 75-84. doi:10.1016/j.jenvman.2015.11.003	Natural Resource Engineering
Harding, J.S., Neumegen, R.E and Smith, I.L. (2005). Spiders, culverts and urban streams. *Freshwater Ecology Newsletter September* (PDF 209KB). http://www.biol.canterbury.ac.nz/people/harding/Harding%20J.S.%20Neumegan%20Smith%202005.pdf	School of Biological Sciences
Harding J.S. Jellyman P. (2015). *Earthquakes, liquefaction and the response of urban stream communities*. NZJMFR 49(3): 346-355.	School of Biological Sciences
Hewson, K.I.; O'Brien, L.K.; Barker, R.M.; Weston, J.G. (2006), Restoring the waterways of the University of Canterbury, Christchurch, New Zealand. Pp 205-218 *in* W.L. Filho; D. Carpenter (eds.) *Sustainability in the Australasian University Context.* Environmental Education, Communication and Sustainability volume 22. Peter Lang Publishing Group, Frankfurt, Germany.	Sustainability Office, University of Canterbury
O'Sullivan, A.D., Wicke, D., Cochrane, T. (2010) Geospatially web-interfaced telemetric monitoring system to track contaminant transport. https://ir.canterbury.ac.nz/handle/10092/9913	
O'Sullivan, A., Wicke, D., & Cochrane, T. (2012). Heavy metal contamination in an urban stream fed by contaminated air-conditioning and stormwater discharges. *Environmental Science and Pollution Research*, *19*(3), 903-911. doi:10.1007/s11356-011-0639-5	Natural Resource Engineering
Wicke, D, O'Sullivan, A.D., Cochrane, T., (2009) Environmental CSI of the Okeover stream in Christchurch. https://ir.canterbury.ac.nz/handle/10092/3737	Natural Resource Engineering

Wicke, D, Cochrane, T. O'Sullivan, A., Hutchison, J., Funnell, E., (2009) *Developing a rainfall contaminant relationship model for Christchurch Urban Catchments.* http://www.urbanwaterways.info/files/documents/NZWWA_final%20paper_Daniel%20Wicke.pdf	Natural Resource Engineering
Wicke, D, Cochrane, T, O'Sullivan (2010) *Contaminant Sources, Transport and Fate in Stormwater Runoff in Christchurch.* http://www.urbanwaterways.info/files/documents/5a011.pdf	Natural Resource Engineering
Wicke, D. Cochrane, T, O'Sullivan (2010) *An Innovative Method for Spatial Quantification of Contaminant Buildup and Wash-off from Impermeable Urban Surfaces*. https://ir.canterbury.ac.nz/handle/10092/4137	Natural Resource Engineering
Wicke, D., Cochrane, T. A., & O'Sullivan, A. D. (2012). Atmospheric deposition and storm induced runoff of heavy metals from different impermeable urban surfaces. *Journal of Environmental Monitoring*, *14*(1), 209-216. doi:10.1039/c1em10643k	Natural Resource Engineering
Wicke, D., Cochrane, T. A., & O'Sullivan, A. (2012). Build-up dynamics of heavy metals deposited on impermeable urban surfaces. *Journal of Environmental Management*, *113*, 347-354. doi:10.1016/j.jenvman.2012.09.005	Natural Resource Engineering
Wicke, D., Cochrane, T. A., O'Sullivan, A. D., Cave, S., & Derksen, M. (2014). Effect of age and rainfall pH on contaminant yields from metal roofs. *Water Science and Technology*, *69*(10), 2166-2173. doi:10.2166/wst.2014.124	Natural Resource Engineering
Winterbourn M.J., Harding J.S. and McIntosh A.R. (2007). Response of the benthic fauna of an urban stream during six years of restoration. *New Zealand Natural Sciences* **32**: 1-12 (PDF 222KB).	School of Biological Sciences

Technical Reports and Posters	**Format/location/owner of dataset**
Barr, E. and Webster-Brown, J. (2016) Fluctuations in the flow of artesian springs in Christchurch, Summer Scholarship Report, WCFM Report 2016-003. http://www.waterways.ac.nz/documents/Technical%20reports/WCFM%20TR%202016%20003%20Flucuations%20in%20the%20flow%20of%20artesian%20springs.pdf	Waterways Centre for Freshwater Management
Blakely, T.J., Harding J.S. and McIntosh A. (2003). Impacts of urbanization on Okeover Stream, Christchurch. *Freshwater Ecology Research Group, Department of Zoology, University of Canterbury, Christchurch* (PDF 2MB). http://www.biol.canterbury.ac.nz/people/harding/Blakely%20Harding%20J.S.%20et%20al.%202003_Okeover%20Restoration%20CCC%20report.pdf	School of Biological Sciences
Blakely, T.J. & Harding, J.S. (2004), Restoring Okeover Stream - what factors affect instream recovery? Freshwater Ecology Research Group, School of Biological Sciences, University of Canterbury, Christchurch. Poster available online (PDF, 1 MB).	School of Biological Sciences
Blakely, T., Harding, J. and McIntosh, A. (2004), Road culverts - unrecognised barriers to upstream caddisfly dispersal. Freshwater Ecology Research Group, School of Biological Sciences, University of Canterbury, Christchurch. Poster available online (PDF, 895 KB).	School of Biological Sciences

Brown., A. M., Scouller., J.M. (2014), Continuous water quality monitoring in urban waterways. Final Year Project. Dept. Of Civil and Natural Resources Engineering, University of Canterbury. Project Supervisor: Cochrane, T.A.	Natural Resource Engineering
Cottam, D. (1999), The importance of riparian cover and allochthonous inputs for the biological health of Christchurch waterways. Unpublished Master of Science thesis, University of Canterbury, Christchurch.	School of Biological Sciences
Farrant, S. (2006), Contaminant characterisation of stormwater discharge into Okeover Stream and treatment recommendations. Unpublished report for ENNR 429 Natural Resources Engineering Project, Civil Engineering, University of Canterbury. PDF Available online.	Natural Resource Engineering
Kainamu, A *"An Assessment of the Value and Feasibility of Mahinga Kai at UC"* (PDF, 1.3MB) (UC Sustainability Summer Scholarship Project)	UC Sustainability Office
Knight, G. (2005) Upper Okeover Stream Catchment Project. Unpublished report for GEOG 451, Department of Geography, University of Canterbury.	Geography
Nelson, C.J.O. (2000), Management of low flows in the Okeover Stream, Unpublished Environmental Engineering Project, University of Canterbury, Christchurch, New Zealand.	Natural Resource Engineering
O'Brien, L.K. (2003), Developing the Fauna and Flora of Okeover Stream. Waterways & Wetlands Team, Water Services Unit, Christchurch City Council, Christchurch.	Christchurch City Council
Powell, T and Lieu, H "Monitoring and Modelling Stormwater Networks on the University of Canterbury Campus: A Data Collection System to Callibrate the MEDUSA model for the Okeover Stream Catchment" (PDF, 1.25MB) (UC Sustainability Summer Scholarship Project)	Natural Resource Engineering
Scott, N. (2010) "Whose stream is it anyway? Community identification in Okeover Stream, Canterbury" (PDF 1.2MB) (UC Sustainability Summer Scholarship Project)	Geography
Setiawan, I., Jenkins, B., Morgan, L (2017) Investigations into the drying reaches of the Avon river (in press)	Summer scholarship technical report available on WCFM website in May 2017
Stern, S. J., Broughton, L. J. (2016) “Hydrologic and hydraulic Modelling of the Okeover Stream Catchment” Poster. Project Supervisors	Natural Resource Engineering
Taffs, E. (2007), Quantifying Stormwater Contaminants in Water and Sediments in the Okeover Stream, Christchurch. Natural Resources Engineering Group, Department of Civil Engineering, University of Canterbury. Available online.	Natural Resource Engineering
Welsh, S. (2005) GIS Creation of the Okeover Stream Headwaters Section. Unpublished report for GEOG 451, Department of Geography, University of Canterbury.	Geography

Presentations and Conference Proceedings	
Charters, F., O'Sullivan, A., & Cochrane, T. (2014). Modelling Stormwater Contaminant Loads in Older Urban Catchments: Effects of Climate Influences on Selecting Management Options. In *Proceedings* (pp. 10pp). Sarawak, Malaysia. Retrieved from http://www.13icud2014.com/programme.php	Natural Resource Engineering
Charters, F., Cochrane, T. A., & O'Sullivan, A. (2016). Modelling Sediment and Heavy Metals Loads in Stormwater from Different Impermeable Urban Surfaces. In *WaterNZ Modelling Symposium*. Wellington, New Zealand.	Natural Resource Engineering
Charters, F. J., Cochrane, T. A., & O'Sullivan, A. D. (2016). Characterising urban zinc generation to identify surface pollutant hotspots in a low intensity rainfall climate. In *World Water Congress and Exibition*. Brisbane, Australia.	Natural Resource Engineering
Charters, F. J., Cochrane, T. A., & O'SullivAn, A. D. (2016). Predicting event-based stormwater contaminant loads from individual urban surfaces. In *Water New Zealand Stormwater Conference*. Nelson, New Zealand.	Natural Resource Engineering
Hewson, K., Barker, R. (2007) Introduction to UC Waterways Project Urban Waterways Forum, University of Canterbury 13 February 2007 (PDF, 4 MB)	Christchurch City Council and UC Sustainability Office
Thin, J (2007) Water at the University of Canterbury: a brief historical overview Urban Waterways Forum, University of Canterbury,13 February 2007 (PDF, 1.1 MB)	Social Science Research Centre, University of Canterbury
Farrant, S., Taffs, E., O'Sullivan., A (2007) Quantifying stormwater contaminants into Okeover Stream Urban Waterways Forum, University of Canterbury 13 February 2007 - (PDF, 163 KB)	Natural Resource Engineering
Harding, J (2007) What do we know about the ecology of campus waterways? (PDF, 887 KB) Urban Waterways Forum, University of Canterbury 13 February 2007	School of Biological Sciences
McIntosh, A (2007) Where to from here and how? Factors influencing ecosystem rehabilitation - (PDF, 252 KB) Urban Waterways Forum, University of Canterbury 13 February 2007	School of Biological Sciences
O'Brien, L.K., Barker, R. (2005), Restoring in-stream values and habitat for Canterbury mudfish in Okeover Stream, Christchurch. Pp 180-188 *in* Dawson, M. (ed.), *Greening the City: Bringing biodiversity back into the urban environment*. Proceedings of Royal New Zealand Institute of Horticulture conference in Christchurch, 21 – 24 October, 2003. http://www.rnzih.org.nz/pages/publications.htm#Greening_the_city http://www.rnzih.org.nz/pages/AbstractOBrienBarker.htm	Christchurch City Council and School of Biological Sciences

UC Waterways Plan 2017-2025 References

Christchurch City Council (2003) *Waterways, Wetlands and Drainage Guide – Ko Te Anga hakaora Mō Ngā Rēpō.* Christchurch. Pp 1-2,

Christchurch City Council (2009) *Surface Water Strategy.* Christchurch. https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/strategies/surface-water-strategy-2009

Christchurch City Council (2010) *Public Open Space Strategy 2010-2040.* *https://www.google.co.nz/?gws_rd=ssl#q=ccc+green+space+wellbeing* Accessed: 9/2/2017

Christchurch City Council (2016) *Surface water quality monitoring report for Christchurch City Waterways: January December 2015.* Christchurch https://www.ccc.govt.nz/assets/Documents/Environment/Water/Monitoring-Reports/City-Wide-Surface-Water-Quality-2016-PDF-6.03-MB.PDF

Christchurch City Council (2016): *Ōtākaro/Avon Catchment Vision and Values.* Christchurch https://www.ccc.govt.nz/assets/Documents/Environment/Water/Avon-River-Catchment-Vision-Values.pdf

Environment Canterbury (2010) *Canterbury Water Management Strategy.* https://ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-water-management-strategy/. Accessed 28/2/2017

Environment Canterbury/Christchurch West Melton Committee (2013) *Zone Implementation Plan.* Christchurch. http://www.crc.govt.nz/publications/Council/christchurch-west-melton-final-zip.pdf Accessed 30/3/2017

Environment Canterbury (2016) *Canterbury Land & Water Regional Plan* *http://files.ecan.govt.nz/public/lwrp/FINAL-LWRP-260117.PDF* Accessed 28/2/2017

Golder Associates (2008) *Okeover Stream Ephemeral Reach: Restoration Options and Cost Estimates.* Report #087813133. Christchurch. Report held electronically by the Sustainability Office, University of Canterbury.

Kainamu, A (2013) *An assessment of the value and feasibility of Mahinga Kai at UC.* UC Sustainability Office, Ngai Tahu Research Centre, and the Waterways Centre for Freshwater Management. WCFM Report 2013-005. http://www.sustain.canterbury.ac.nz/summer/Mahinga_Kai_at_UC.pdf

Mahaanui Kurataiao Ltd (2012) *State of the Takiwā 2012: Te Āhuatanga O Te Ihuatai. Cultural Health Assessment of the Avon-Heathcote Estuary and its Catchment.* https://www.takiwa.org.nz/docs/2012_AvonHeathcoate.pdf

Ngāi Tahu (n.d) *Whakaoratia Ōtautahi: Ngāi Tahu aspirations for Christchurch Recovery and Rebuild.* (http://ngāitahu.iwi.nz/wp-content/uploads/2013/06/Whakaoratia-Otautahi.pdf. Accessed 17/06/2015

Ngāi Tūāhuriri Rūnganga (2013) *Mahaanui: Iwi Management Plan.* Mahaanui Kurataiao Ltd. Christchurch. http://www.mkt.co.nz/iwi-management-plan/ Accessed 30 March 2016.

O'Sullivan, A., Wicke, D., & Cochrane, T. (2012). Heavy metal contamination in an urban stream fed by contaminated air-conditioning and stormwater discharges. *Environmental Science and Pollution Research*, *19*(3), 903-911. doi:10.1007/s11356-011-0639-5

Tau T.M. Goodall, A., Palmer, D., Tau, R. (1990) *Te Whakatau Kaupapa: Ngāi Tahu Resource Management Strategy for the Canterbury Region.* Aoraki Press, Wellington, New Zealand. (5:22).

Te Rūnanga o Ngāi Tahu (2004). *State of the Takiwā, Cultural Monitoring and Reporting on the Health of our Environment.* Scoping Document. Otautahi/Christchurch

UC Waterscape Action Group (2016) "*UC Waterways; Issues and Options"* http://www.sustain.canterbury.ac.nz/documents/Waterways_on_UC_Campus_V7_December_2015.pdf. University of Canterbury. Sustainability Office

UC Waterways Group (2006) *Draft Waterways Plan*. University of Canterbury. Sustainability Office