

Natural Environment Recovery Programme for Greater Christchurch

Whakaara Taiao

October 2013



For an electronic version of the Natural Environment Recovery Programme, see:

www.ecan.govt.nz/nerp

www.cera.govt.nz/recovery-strategy/natural-environment

If you have any comments on the Natural Environment Recovery Programme, please forward your comments to Environment Canterbury.

Email: nerp@ecan.govt.nz

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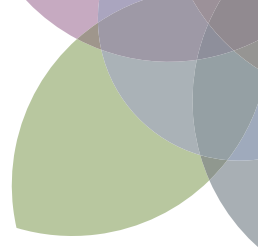
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The following organisations have assisted in the development of this document.

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Canterbury Earthquake Recovery Authority
Te Rūnanga o Ngāi Tahu
Christchurch City Council
Selwyn District Council
Waimakariri District Council

Other key partners

Ngā Papatipu Rūnanga
Canterbury District Health Board
Department of Conservation

Technical Advisory Group

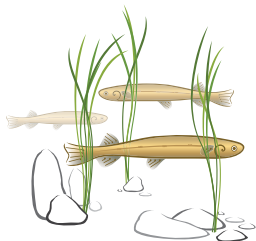
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Stronger Christchurch Infrastructure Rebuild Team (SCIRT)
Community organisations/non-governmental organisations (NGOs)
Universities
Crown Research Institutes (CRIs)
Consultant scientists

See appendix 3 for more details

Throughout the document we have chosen to include images of a number of indigenous species significant to the biodiversity and communities of greater Christchurch. These species not only provide an inspiration for the programme, but are also practical indicators for the recovery of the natural environment going forward.



Inanga or whitebait (*Galaxias maculatus*) is an indicator of the health of the lowland streams in greater Christchurch. A number of factors have combined to impact inanga populations, including wetland drainage, loss of spawning habitat, trout predation, pest fish increase, flood protection works, and migration barriers such as weirs and culverts. The Natural Environment Recovery Programme has projects to address many of these factors.











The annual whitebait migration of juvenile inanga was an important mahinga kai resource for Māori, and adult fish were also taken during their downstream migration to the ocean when they were rich and full of eggs. Whitebait is still an important cultural and recreational fishery in greater Christchurch. The one year lifecycle of inanga is typical of the whitebait species where the juvenile inanga migrate upstream from the sea in spring, then over the summer grow to maturity in freshwater habitats.



Kererū or native wood pigeon (*Hemiphaga novaeseelandiae*) are iconic birds that used to be more common across greater Christchurch. They eat the fruit of native plants such as miro, tōtara, ngaio, kahikatea, kōwhai, poroporo and coprosma, and introduced plants like tree lucerne, elderberry, cherry and plums. Kererū play a vital role in the regeneration of forests. It is now the only fruit-eater large enough to swallow fruit with large seeds, ensuring that future generations of trees such as miro and karaka are widely spread. In the urban areas habitat for the kererū and other birds, and seed sources for further dispersal, would be improved by providing a range of forest patches, including some larger areas as core sanctuaries, together with riparian and road edge linkages.

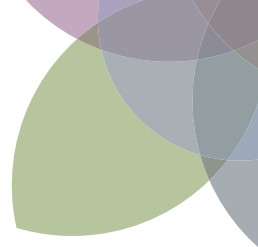
Kōwhai (*Sophora microphylla*) is an iconic and versatile plant of Canterbury – being common throughout the city in gardens, along waterways as well as surviving in remnant forest patches and on the plains. Its recognisable yellow glow produced by its flowering throughout late winter and spring is important not only ecologically but for people, who enjoy this marker of the start of longer days and the arrival of warmer weather. Flowering of kōwhai is staggered from July through to November, providing food for tūi, wood pigeon and bellbird for many months. Māori hold the tree in high esteem, valuing the durability of its hard wood and its many medicinal properties.

Key to colours used in tables throughout the document

Natural hazards	
Estuaries and coasts	
Surface water	
Groundwater	
Waste	
Air quality	
Biodiversity	
Recreation	
Contaminated land	
Mahinga kai	

Strategic partners' foreword

He kōrero whakatangi



Tēnā koutou katoa.

E ngā ihoiho o ngā maunga whakahī me ō koutou tini aituā nāia te uruhau ki a koutou katoa.

Nāia tātou te makiu e hoe kātahi ana kia eke tēnei waka ki uta.

Hai aha? Hai whakatinana i kā awhero o tāua mā, o pōua mā kia tiakina tō tātou taiao i tōna āhua tūturu mō ake tonu atu. Me manawa tīti tātou kia haumāiui te whai, ā, tēnā anō tātou katoa.

Our natural environment is a fundamental part of our shared heritage and culture. The Natural Environment Recovery Programme is vital for the environment in greater Christchurch.

Many of us choose to live in or near Christchurch because we appreciate and value the natural environment - the rivers, the beaches and harbours, the forests and Port Hills - and the activities these special places provide.

Through the changes the earthquakes have made to these places, we have become more aware of how important the natural environment is to our wellbeing.

We have also gained knowledge that can help us restore and enhance the natural environment and, through the recovery, we now have the opportunity to do this.

We better understand the consequences of living on land that is subject to rockfall, liquefaction or flooding. We want to improve the water quality and ecosystem health of rivers, streams, wetlands and estuaries. We recognise the many opportunities to improve recreation facilities during the rebuild and recovery.

In the community there is a strong desire to use available land to create forests, parks and gardens, to provide for recreation, and to integrate stormwater treatment.

We are already seeing collaborative, co-ordinated effort to address these challenges effectively. Our agencies are collaborating and communities are taking collective action.

The Natural Environment Recovery Programme is essential to these efforts by identifying the projects that are needed to address environmental issues, how they link with other recovery programmes, and who needs to work together to implement them.

This programme will help foster an environment that all those living in greater Christchurch appreciate, value and respect. We look forward to working with our communities on the recovery projects that matter most to them.

Dame Margaret Bazley

Chair of Commissioners, Environment Canterbury

Tā Mark Solomon

Kaiwhakahaere, Te Rūnanga o Ngāi Tahu

Bob Parker

Mayor, Christchurch City

David Ayers

Mayor, Waimakariri District

Kelvin Coe

Mayor, Selwyn District



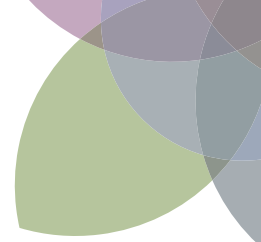
Paradise ducks/Pūtangitangi and other wetland birds have adapted to changes in their habitat.



Larger trees are retained in the land clearance programme

Contents

He rāraki upoko



Strategic partners' foreword	
<i>He kōrero whakatangi</i>	iv
1. Overview	
<i>Te tiro whānui</i>	1
2. Why a Natural Environment Recovery Programme?	
<i>He aha te take o Whakaara Taiao?</i>	6
3. Developing the programme	
<i>Te whakahiato</i>	9
4. Natural environment recovery projects	
<i>Ngā kaupapa Whakaara Taiao</i>	13
5. Integration	
<i>Te mahi kātahi</i>	17
6. What does success look like?	
<i>Ka pēhea te āhua o te akitu?</i>	20
7. Implementation – reviewing and reporting on the Natural Environment Recovery Programme	
<i>Te arotake me te pūrongo</i>	24
8. Transition plan	
<i>Te whakawhitinga</i>	25
Glossary of abbreviations	
<i>He rārangi kupu</i>	26
Appendix 1: Earthquake effects on the natural environment	
<i>Ngā mahi a Rūaumoko</i>	27
Appendix 2: Detail of projects	
<i>Ngā mokamoka</i>	32
Appendix 3: Stakeholders invited to workshops	
<i>Ngā kaiwhaipānga</i>	35
Appendix 4: Bibliography	
<i>He rārangi pukapuka</i>	36
List of figures	
Figure 1: Solid waste taken to Kate Valley Landfill, Burwood Landfill, Burwood Resource Recovery Park and Lyttelton Port, 2007/08–2011/12	7
Figure 2: <i>E.coli</i> at river sites	8
Figure 3: Number of days on which 24-hour air quality limit (50 microgram PM ₁₀) was exceeded	8
Figure 4: Interdependent themes in the Natural Environment Recovery Programme	18
List of tables	
Table 1: Overview of projects in the Natural Environment Recovery Programme	14
Table 2: Application of projects by place	16
Table 3: Project links to recovery programmes and plans, and to other plans and strategies	19
Table 4: Possible ways of monitoring the environment for NERP projects	21

1. Overview

Te tiro whānui

Toitū te marae o Tāne Toitū te marae o Tangaroa Toitū te iwi.

When the domains of Tāne and Tangaroa are nurtured and sustained, so too will people prosper and flourish.

Canterbury's series of earthquakes and aftershocks from September 2010 to 2012 changed the natural environment of greater Christchurch¹ considerably, including flow-on effects from disrupted infrastructure. As the infrastructure and region are being repaired and rebuilt, exciting opportunities to create an improved and healthier environment are emerging.



To revitalise greater Christchurch, the Government has committed to a broad, long-term Recovery Strategy for Greater Christchurch: Te Mahere Haumanutanga o Waitaha² (Recovery Strategy). As a result of community and stakeholder feedback on the draft Recovery Strategy, a Natural Environment Recovery Programme (NERP) was included as one of six key components³ in the final strategy.

Environment Canterbury is the lead agency overseeing the development of the NERP as part of the Recovery Strategy. In leading the programme, Environment Canterbury works with the strategic partners to coordinate the various projects and

work streams related to natural environment recovery. The projects within the programme have varying timeframes: some will be completed by 2016 and others will transition to be led by partner organisations at this time.

Natural environment significance

To the community, the natural environment is important for cultural, social and economic reasons. A healthy environment is critical to our personal and social health. We all rely on the environment to help provide our food, fresh water and wood; for regulating the climate, air quality and water runoff, purifying water, treating waste, reducing noise and controlling erosion; for cultural reasons; and for the benefit of tourism, agriculture and recreation.

¹ Greater Christchurch is defined in the Canterbury Earthquake Recovery Act 2011 as the districts of the Christchurch City Council, the Selwyn District Council, and the Waimakariri District Council, and includes the coastal marine area adjacent to these districts.

² <http://cera.govt.nz/recovery-strategy/overview>

³ The Recovery Strategy for Greater Christchurch contains six components of recovery: leadership and integration; economic recovery; social recovery; cultural recovery; built environment; and natural environment.



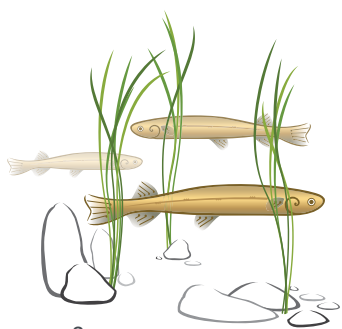
In addition, the natural environment is important to both our physical and psychological wellbeing, so actions that promote and protect our natural environment help us to flourish in life. In turn, where wellbeing is high, people and communities tend to behave in environmentally responsible ways and can, therefore, contribute to environmental sustainability.⁴

The natural environment of greater Christchurch is of special cultural and historical significance to Ngāi Tahu. Prior to European settlement Ngāi Tahu, and before them Ngāti Māmoē and Waitaha, had numerous kāinga and pā within the greater Christchurch area. From these settlements, Ngāi Tahu gathered and used mahinga kai – the natural resources from the network of springs, waterways, wetlands, grasslands and lowland forests. All were vital to the wellbeing and livelihoods of each settlement.

Mahinga kai

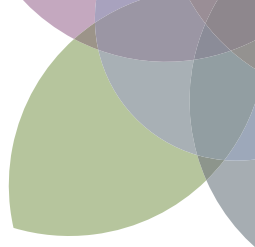
Mahinga kai is the concept that shows the complex, interconnected cultural beliefs and practices of Ngāi Tahu in relation to the environment. It describes not only the species gathered but also the places and practices involved in doing so. Mahinga kai, meaning to mahi ngā kai (work the food), is a management concept, a way of thinking that involves and understands the simultaneous protection and use of resources. Ngāi Tahu put this idea into practice using an integrated management model known as Kī Uta Kī Tai (from the mountains to the sea).

The Waitangi Tribunal stated that the issues involving mahinga kai were the most emotionally charged elements of Ngāi Tahu's claim. In the new millennium mahinga kai continues to be a vital ingredient of the wellbeing and livelihoods of Ngāi Tahu.



⁴ Mental Health Foundation 2010.

<http://www.mentalhealth.org.nz/file/MindNet/Issue-26/sustainability-and-flourishing.pdf>



Ngāi Tahu is recognised as a statutory partner in the earthquake recovery and rebuild process. Mahinga kai management remains paramount to local hapū and rūnanga, especially those who continue to live around, protect and use important mahinga kai, wāhi tapu and wāhi taonga. In particular, Ngāi Tūāhuriri holds traditional mana whenua over the majority of the affected area, and Ngāti Wheke shares some of this responsibility. It is critical to protect, rehabilitate, enhance and maintain such sites and resources, as well as to uphold the rights of Ngāi Tahu to access them.

Natural environment planning

Many agencies and non-governmental organisations plan for, manage and influence the state of the natural environment. Existing plans and strategies express community aspirations for the environment. Some are developed under the Resource Management Act 1991 (RMA) framework and have regulatory powers. Others developed under the Local Government Act 2002 (LGA) and other legislation also have statutory and strategic influence. Using existing mandates, local authorities are already working to rebuild and enhance waterways, infrastructure and buildings. By developing a recovery programme that recognises and links the various policies and strategies that are related to recovery, we can reduce duplication of effort and identify who is responsible for implementing the strategies.

As the Canterbury Earthquake Recovery Act 2011 (CER Act) defines it, recovery includes both restoring greater Christchurch to address the earthquake damage and enhancing the area in the process. The Recovery Strategy recognises the opportunity for enhancement in the rebuild, considering that “recovery inherently focuses on the future and there will be opportunities to





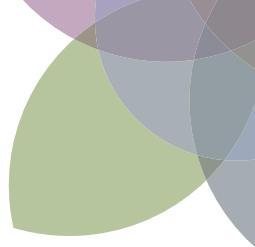
‘build back better’ when repairing earthquake damage”.⁵ For the Natural Environment Recovery Programme, much of the focus is on identifying opportunities to enhance the natural environment when planning work on infrastructure or the built environment. Projects for implementing the Natural Environment Recovery Programme can make the natural environment more resilient and functional, and be cost-effective over the lifecycle.

The Natural Environment Recovery Programme identifies ways to rehabilitate and improve the natural environment through the rebuild, and how the many promising opportunities will be taken. At the same time, it is unrealistic to expect earthquake recovery to restore the environment to a pristine condition. Rather, this programme aims to make continuing and incremental improvements to the pre-earthquake state of the natural environment, with no further degradation. Achieving this outcome will depend on project prioritisation and funding consideration of the most effective use of limited resources.

The natural environment does not need human intervention to recover. Given time and space it would recover to some new state on its own. In the urban setting though, because people are connected with the natural environment, in some places we need to take action to protect property and people from the environment, and to protect the environment from our impact.

⁵ Recovery Strategy for Greater Christchurch: Te Mahere Haumanutanga o Waitaha





Natural hazards

Even before the earthquakes, greater Christchurch was vulnerable to, and had experienced, a wide range of natural events that create natural hazards for people and property. Environment Canterbury is the lead agency for gathering and providing information on natural hazards as required by the RMA. Recent events have helped to improve our understanding of the likelihood and consequences of natural hazards. Ongoing research and investigations are needed to improve our understanding of seismic risk; tsunamis; susceptibilities to rockfall, landslide and land damage; new flood risks to low-lying land arising from the effects of sea level rise, altered riverbed levels and intense rainfall events; extended droughts; and liquefaction risks. In the recovery and development of greater Christchurch, we must take account of areas that have significant natural or physical constraints, including those at high risk from natural hazards and, where necessary, avoid development in those areas.

In response to all of these issues and challenges, Environment Canterbury is leading the development of the Natural Environment Recovery Programme in partnership with strategic and key partners.

2. Why a Natural Environment Recovery Programme?

He aha te take o Whakaara Taiao?

A planned and integrated approach is required across the six components of recovery to protect resources, ecosystems and habitats; rehabilitate damaged areas; and enhance significant environments and environmental quality.

The earthquakes caused direct and observable change to the natural environment, including rockfall, landslides, liquefaction and changes to land levels. They have also had indirect and induced effects, some of which may take many years to become apparent.

Such effects are natural processes. We need to allow for these dynamic and variable characteristics of nature in land use planning and in design, construction and operation of the built environment. Other important environmental processes to take into account in future planning are climate change and sea level rise.

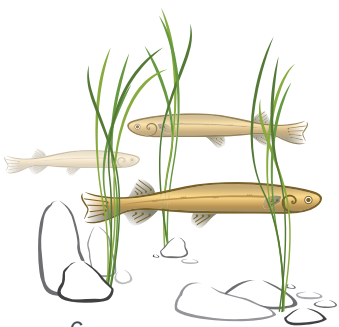
Before the earthquakes, pollution or other degradation was harming many of the natural systems of greater Christchurch. How to address these matters was well covered in existing plans and strategies. Operating at regional level were the Regional Policy Statement and the Natural Resources Regional Plan, and the Land and Water Regional Plan is now proposed. At the sub-regional level, the Greater Christchurch Urban Development Strategy has natural environment elements. At the territorial authority level, each district council has its own natural environment plans, policies and strategies.

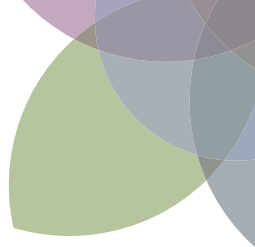
The Natural Environment Recovery Programme does not create a new planning layer in this process. Rather, it synthesises the existing regional, sub-regional and district plans and programmes, connects with the other recovery programmes, and focuses on collaboration to address the changes and opportunities triggered by the earthquakes.

The impact of the earthquakes has raised our awareness of the importance of the natural environment to our wellbeing. Having healthy rivers, open spaces and recreational facilities close to home, and reducing and managing our waste, have become more important for people. We now have the chance not only to repair the damage where necessary, but also to use more environmentally sustainable methods to protect and improve the quality and ecosystem health of our land and waterways.

The Recovery Strategy outlines the following aspects of the natural environment to be assessed by the NERP:

- hazards – new seismic risk profile, susceptibilities to rockfall, landslide and land damage, new flood risks to low-lying land arising from the individual and combined effects of sea level rise, altered riverbed levels and intense rainfall events
- coasts – coastal water quality and estuarine processes
- water – quality of groundwater and surface water in rivers, streams and wetlands
- biodiversity – the impacts of degraded air, land, freshwater and sea on biodiversity, and the changing land use patterns around the main waterways
- land – future treatment and uses of land no longer suitable for urban, residential or commercial use
- recreation – safe recreational opportunities in outdoor spaces, parks and waterways that may be created by improving the above aspects of the environment





- waste – the effective and sustainable management of all solid and liquid waste in order to avoid contaminating land, surface water and groundwater during the recovery and beyond
- air – effects of insulation and heating choices in the residential rebuild, dust from central city and residential demolitions, and infrastructure recovery
- implementation tools – the best means to achieve the recovery of the natural environment in tandem with the recovery of social, cultural, economic and built environments.

See Appendix 1 for an overview of the pre-earthquake condition, along with the earthquake effects and the actions and responses to them, for the above key issues that the Natural Environment Recovery Programme is addressing.

Solid waste

Waste amounts have more than doubled since the earthquakes, largely driven by demolition waste (Figure 1). The local councils and Environment Canterbury are prioritising the development of solutions to deal with the waste, including recycling as much as possible.

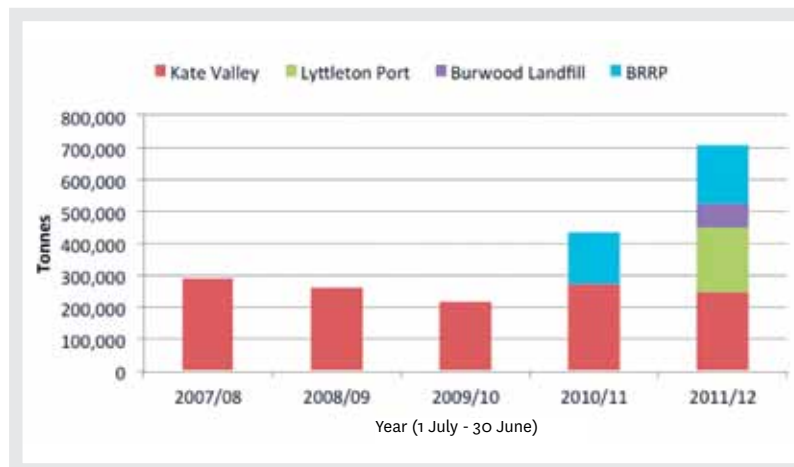


Figure 1: Solid waste taken to Kate Valley Landfill, Burwood Landfill, Burwood Resource Recovery Park (BURP) and Lyttelton Port, 2007/08–2011/12.

Note: Solid waste from 2011 included earthquake demolition waste.

Source: Environment Canterbury (June 2012)



Water quality

The earthquakes increased the levels of bacteria (*E.coli*) in the lower reaches of our city rivers, largely because of untreated wastewater discharges from damaged infrastructure following the major earthquakes (Figure 2). With major infrastructure repairs now complete, levels have recovered to pre-earthquake concentrations. Environment Canterbury and Christchurch City Council continue to monitor *E.coli* levels.

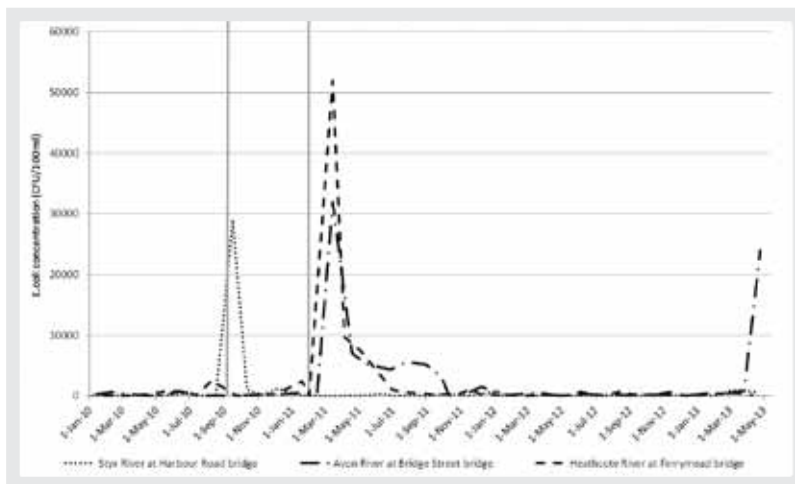


Figure 2: *E.coli*/100ml at river sites.

Source: CCC
(May 2013)

Air quality

Although air quality in Christchurch City had been improving, it declined in 2011 following the earthquakes. This decline is shown by the air quality indicator that measures the number of days on which the national air quality standard has been breached (exceedances) (Figure 3). Earthquake damage is partly responsible for the increase in exceedances: Environment Canterbury reports that 17 of the 32 high-pollution days recorded in 2011 were caused by liquefaction silt and dust in the air.

Overall air quality still needs to be improved across Christchurch, Kaiapoi and Rangiora to meet targets of only one exceedance each year. Environment Canterbury will continue to work in collaboration with other agencies to improve air quality through a mix of regulation, financial incentives, education and awareness.

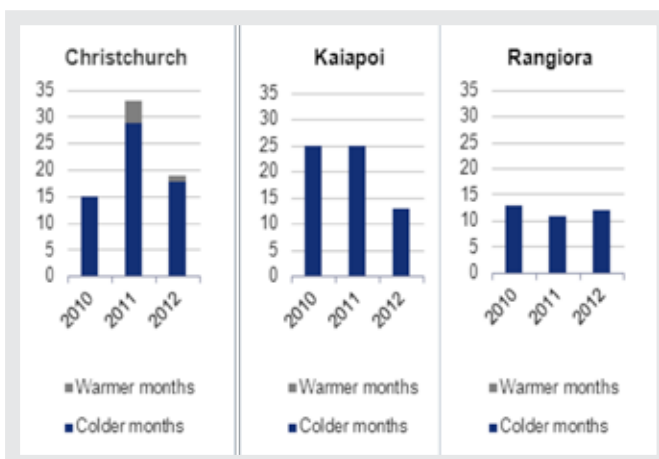


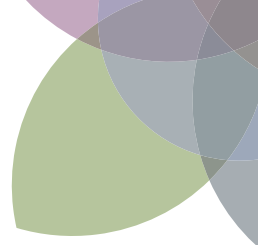
Figure 3: Number of days on which 24-hour air quality limit (50 microgram PM₁₀) was exceeded.

Source: Environment Canterbury
(November 2012)



3. Developing the programme

Te whakahiato



Recovery Strategy for Greater Christchurch

Te Mahere Haumanutanga o Waitaha

The Natural Environment Recovery Programme has been developed in the wider context of the Recovery Strategy, developed by the Canterbury Earthquake Recovery Authority (CERA), approved by Cabinet and released in May 2012. The Recovery Strategy is the key reference document that guides and coordinates all of the programmes of work across the multiple dimensions of the recovery. Its vision is for greater Christchurch to recover and progress as a place to be proud of – an attractive and vibrant place to live, work, visit and invest, *mō tātou, ā, mō kā uri ā muri ake nei* – for us and our children after us.

Goals

Ngā whāinga

The Natural Environment Recovery Programme must not be inconsistent with the Recovery Strategy, which provides the following goals for the natural environment:

6. Restore the natural environment to support biodiversity and economic prosperity and to reconnect people to the rivers, wetland and Port Hills – by:

- Ensuring recovery activities value, protect and sustainably manage the sources of our water;
- Ensuring ecosystems are healthy and functioning to support biodiversity and economic growth;
- Improving the quality and function of estuaries, waterways and wetlands to support the unique biodiversity that is endemic to Te Waipounamu;
- Providing safe public access to and opportunities for outdoor recreation, cultural, social and economic activities;
- Enhancing air quality through managing recovery activities that impact on air quality, such as heating, transport, demolition and construction;
- Storing, sorting and processing waste in an environmentally safe and effective manner, including minimising and recycling construction and demolition wastes.

The following goals for the other components in the Recovery Strategy are also relevant for the Natural Environment Recovery Programme:

1. CERA, the public and private sector and communities coordinate with each other to contribute to the recovery and future growth of greater Christchurch – by:

- considering the effects of on-going seismic activity;
- providing research and knowledge that will help to make well-informed decisions for a robust and enduring recovery.

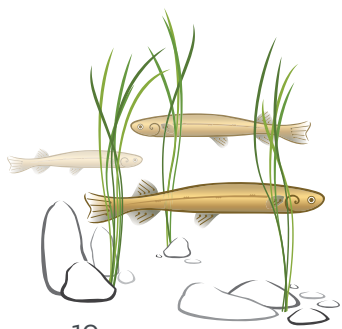
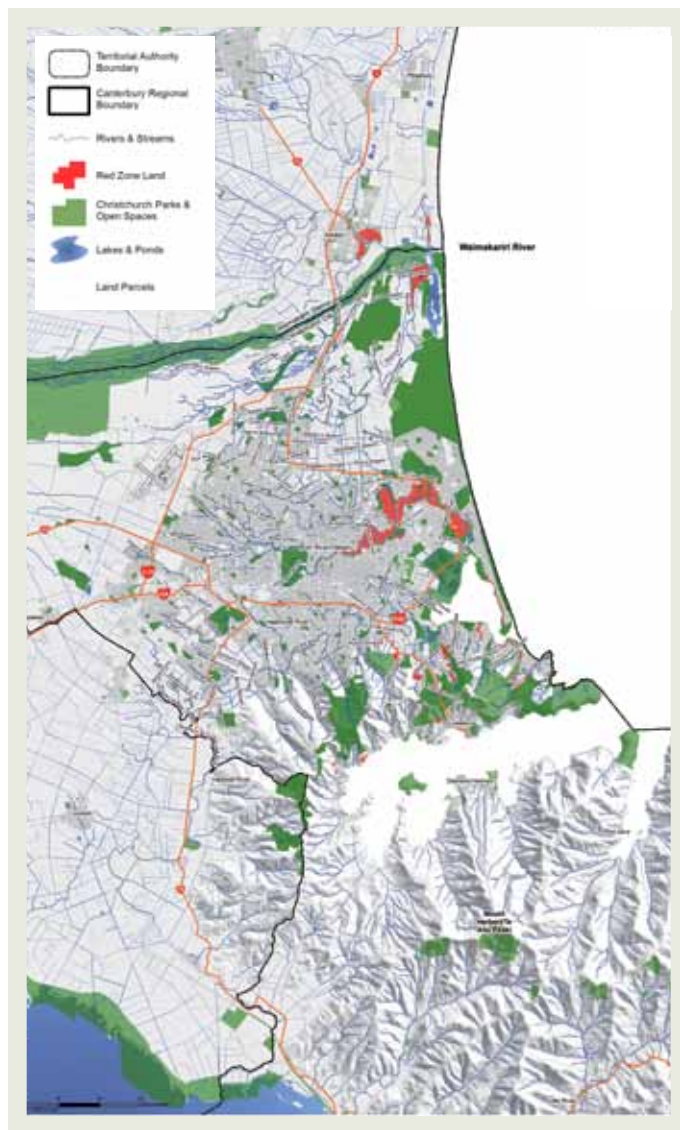
5. Develop resilient, cost effective, accessible and integrated infrastructure, buildings, housing and transport networks – by:

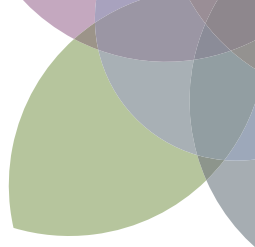
- zoning sufficient land for recovery needs within settlement patterns consistent with an urban form that provides for the future development of greater Christchurch;
- drawing on sound information about on-going seismic activity and environmental constraints, including other natural hazards and climate change.

Area covered by the Natural Environment Recovery Programme

The Natural Environment Recovery Programme covers the area of greater Christchurch as defined in the Canterbury Earthquake Recovery Act 2011. That is, it includes the districts of the Christchurch City Council (CCC), the Selwyn District Council (SDC), and the Waimakariri District Council (WDC), along with the coastal marine area adjacent to these districts.

The focus of the Natural Environment Recovery Programme though is on the area most affected by the earthquakes, both directly and indirectly. These are generally the catchments of the spring fed streams (Halswell/Huritini, Heathcote/Ōpāwaho, Avon/Ōtākaro, Styx/Pūharakekenui, Kaiapoi and Ashley/Rakahuri), the Port Hills and Lyttelton Harbour/Whakaraupō. There was less impact on the natural environment on Banks Peninsula, Te Waihora and in inland areas.





Integration of Ngāi Tahu values

Rehabilitation should align with Ngāi Tahu knowledge and be supported by relevant research and mapping of indigenous species and habitats. The recovery opens up opportunities to reinforce and re-establish Ngāi Tahu historic and contemporary connections with the rivers, land and taonga. Through the Natural Environment Recovery Programme, many aspects of Ngāi Tahu identity can be expressed – including reo, kawa, tikanga, whakapapa, mātauranga, narrative, and historic and contemporary culture in public spaces, structures and interpretation materials. The programme anticipates the incorporation of suitable designs, motifs, pou whenua, whakairo, art, sculpture, interpretation, Māori names and signage related to Ngāi Tahu. Hapū and rūnanga will be involved in activities to recognise, protect, restore and manage wāhi tapu, wāhi taonga and cultural values, including surveying of significant sites, cultural interpretation and monitoring, and protection and restoration of mahinga kai.

Role of central government

Central government has a key role in leading, facilitating and coordinating the actions of others to achieve outcomes, as well as in leading specific recovery programmes that have an important link to the Natural Environment Recovery Programme. CERA is responsible for leading key programmes in the recovery components of leadership and integration, and economic, social and built environment. It is also leading the overall integration and monitoring of the recovery. The Ministry of Culture and Heritage and Sport New Zealand are responsible for cultural recovery programmes. For further detail of the linkages, see Table 3 in Section 5.

Role of local government

The regional, city and district councils play a pivotal role in the recovery. Their functions include providing a full range of services from infrastructure to community services, setting a regulatory framework (planning and consenting) and taking a longer-term statutory planning responsibility for greater Christchurch.

Engagement

In developing the Natural Environment Recovery Programme, Environment Canterbury has worked closely with strategic partners CERA, Te Rūnanga o Ngāi Tahu, Ngā Papatipu Rūnanga, CCC, WDC, SDC, CDHB and DOC. They have involved stakeholders across geographical, institutional and political boundaries in a collaborative way.

A Technical Advisory Group (TAG) whose members come from partner organisations has met monthly to guide and oversee the development of the programme document. The TAG began work on the programme in July 2012. It first produced an issues and options paper which assessed pre-earthquake versus post-earthquake conditions, and identified issues, existing work, risks and opportunities for the key themes identified within the Recovery Strategy, including: air, biodiversity, coasts, hazards, land, waste, water and recreation.

This document was shared among key stakeholders and discussed at an initial community stakeholder workshop held on 8 October 2012. Over 80 participants attended from a range of iwi,

community, non-government, research, local government and central government organisations and agencies. A second community stakeholder meeting was held on 6 December 2012. It focused on prioritising a draft list of projects identified to address the key issues. Feedback from this second workshop and other stakeholder engagement has formed the basis of the Natural Environment Recovery Programme. The workshops were facilitated by the Social Systems Group from the Institute of Environmental Science and Research (ESR). The ESR then prepared detailed reports of the workshop outcomes.¹

Areas of focus

The Natural Environment Recovery Programme is concerned with the air, the coast, surface water, groundwater, land and biodiversity and the ecosystem services they provide. Priority outcomes identified by stakeholders are to:

- improve understanding of the impacts of natural events facing greater Christchurch, which can in turn assist planning
- recognise and include Ngāi Tahu cultural and environmental values
- improve the water quality and ecosystem health of rivers, streams, wetlands and estuaries
- use available land to create forests, parks and gardens, provide for recreation, and integrate stormwater and wastewater treatment
- control weeds and pests
- protect and enhance indigenous biodiversity, and retain and replace trees for the many values they provide
- promote and provide signage of recreational facilities that are available, and repair and provide recreational facilities in the rebuild, with appropriate access for people with disabilities
- identify contaminated land so that people are not exposed to contaminants and/or contaminants are not released into the environment
- reduce the amount of demolition waste going to landfill, and reuse and recycle material achieve the 2016 targets to meet the requirements of the NES on air quality.

¹ www.ecan.govt.nz/nerp



4. Natural environment recovery projects

Ngā kaupapa Whakaara Taiao



The Natural Environment Recovery Programme lays the foundation for the long-term environmental recovery of greater Christchurch. The 17 projects set out in Table 1 on the following pages make up the Natural Environment Recovery Programme. For more detail, see Appendix 2.

These projects have been developed to address the key issues that were identified through the engagement with stakeholders. Each project will be led by one or more agencies, who are responsible for the funding and delivery of the project, with the support of others. Some of the projects require further information through investigations and monitoring, which will in turn be used in future management and ongoing planning.

The approach of this programme is both flexible and adaptive so that it can take account of emerging knowledge and understanding about the longer-term environmental effects of the earthquakes. Projects will be updated if necessary in response to new information, events, progress and feedback.

The environmental impact of the earthquakes varies within and between catchments or areas. A variety of habitats has been affected, and each of these habitats has been affected differently. Each one will have its own rate of recovery and its own level of sensitivity to change.

In some places, it will be necessary to take action to reduce environmental impacts on human activities or the built environment, or to reduce human impacts on the natural environment. In other places, the best approach will be to give the environment the space and time it needs to find a new state. There will also be places where a mix of these approaches is appropriate.

Table 1: Overview of projects in the Natural Environment Recovery Programme

Table 1: Overview of projects in the Natural Environment Recovery Programme

Project	Status	Lead agency/ agencies (bold) and partners	Priority / timeframe	Funding/ Cost per project
1. Investigate and plan for natural hazards				
Hazards investigations; land use planning Reassess the risks and susceptibilities of natural hazards. Report and map the results to inform land use planning and development.	Investigations undertaken by ECan - Funded. Further work required on assessing risks and consequences of hazards – yet to be funded. Land use planning is part of developing the Land Use Recovery Plan – under way	ECan, CERA, NHRP, GNS, UC, CCC, WDC, SDC, TRONT	High priority 2012–2014	Partly funded <\$1M
2. Investigate and monitor coasts and estuaries				
Te Tai o Mahaanui/Canterbury coastal investigations; estuary investigations Investigate and monitor earthquake changes in coastal and estuary processes and physical parameters. Build in sea level rise and climate variability.	Coastal work still to be budgeted. Sea level rise predictions need reviewing. UC/NIWA research continues. Bathymetry for Ihutai under way.	ECan, NIWA, UC, CCC, WDC, SDC, TRONT	2012–2015	Partly funded <\$100k
3. Reduce flood risks and restore drainage capacity of waterways				
Flood mitigation; stopbanks and other works; resilient sustainable infrastructure in rebuild Includes CCC land drainage recovery programme.	CCC revised minimum floor levels and published maps; CCC constructed temporary stopbanks; permanent stopbanks being planned – will depend on RRZ decision for some areas; WDC consent conditions require raised floor levels for new subdivisions; ECan repaired Waimakariri River stopbanks. Consider input to the Residential Red Zone and CCDU anchor projects including in Te Papa Ōtākaro/Avon River Precinct.	CCC, SCIRT, WDC, SDC, ECan, CERA, developers, TRONT	High priority 2012–2014 Ongoing during rebuild	Mostly funded >\$10M
4. Plan for stormwater management				
Stormwater Management Plans (SMPs) Develop an SMP for each catchment to fulfil the requirement for catchment-wide stormwater discharge consent. Important for planning for the RRZ and CCDU anchor projects including in Te Papa Ōtākaro/Avon River Precinct.	CCC has consents for stormwater in southwest area; lodged consent application for Styx River/Pūharakekenui catchment. CCC programmed SMPs for Avon 2013–14; Lower Heathcote 2015–16; Estuary/Ihutai, Lyttelton/Whakarapu, Akaroa, Coastal 2017–20; WDC – preparing strategy for SMP; SDC – Lincoln SMP and consent completed.	CCC, WDC, SDC, ECan, CERA	High priority Programmed by TAs	Partly funded <\$10M
5. Act on opportunities for stormwater treatment and improving the water quality and ecosystem health of waterways				
Stormwater treatment systems; stream and river restoration; riparian zones; establishment of constructed wetlands Use Low Impact Urban Design and Development/stormwater treatment systems/wetlands to attenuate stormwater flows, reduce sediment, and improve quality of stormwater into waterways. During rebuilding consider changing the form of waterways to enhance stream ecology. Plant river banks to provide food sources, habitat and shade.	Considered during development of SMPs. Included in greenfield developments as they are planned and consented. Requires new thinking for retro-fitting in existing developments. CCC work in progress for Dudley Creek, Wairarapa Stream. Wai-i Stream. Consider applying to the RRZ and CCDU anchor projects including in Te Papa Ōtākaro/Avon River Precinct.	CCC, WDC, SDC, SCIRT, ECan, CERA, TRONT, CPH, developers, UC, LU, NIWA, Landcare Research, NGOs, consultants, zone committees	High priority From 2013	Partly funded >\$10M
6. Manage sediment from liquefaction				
Investigations, assessment and advice on removal of sediments; sediment removal in rivers and tributaries; erosion and sediment controls	UC mapped extent of EQ sedimentation. CCC has consent for sediment removal. CCC investigating removal methods. Started Avon tributaries in 2012.	CCC, WDC, SDC, ECan, NIWA, consultants, UC, TRONT	Investigations 2012–13	Partly funded <\$1M
7. Rehabilitate, restore and enhance wetlands changed by the earthquakes				
Mapping, inventory, rehabilitation of existing wetlands	In ECan programmes, specific work for earthquake-affected wetlands to be planned and budgeted. UC summer student 2012–13 mapping Bexley Wetland vegetation. Consider link to RRZ Programme.	ECan, CCC, WDC, UC, SDC, TRONT, NIWA, zone committees	2013–2015	Mostly funded <\$1M
8. Act on opportunities to reduce sewage overflows and their effects				
Reduce the incidence and effects of sewage overflows During rebuild, improve wastewater infrastructure to reduce/avoid wet weather sewage overflows directly to waterways; minimise their effect.	CCC pre-EQ work designed to reduce overflows; post-EQ repair/replacement work to reduce overflows (with SCIRT) already under way. See CCC wastewater strategy and LTP 2013–22 Wastewater Activity Management Plans for more information. WDC pre- and post-EQ improvements include pipe repairs and household sewer inspection survey to minimise overflows to meet agreed service levels.	CCC, WDC, SDC, ECan, SCIRT, TRONT, Papatipu Rūnanga	As possible during rebuild. 2016 onwards	Mostly funded >\$10M

Table 1: Overview of projects in the Natural Environment Recovery Programme

<p>9. Protect groundwater and springs</p> <p>Land use controls to protect groundwater; springs, daylighting streams Ensure land use controls over the unconfined aquifer. Investigate potential effects of foundation systems on groundwater. Encourage the retention of natural springs and daylighting streams.</p>	<p>Covered in NRRP/ PLWRP. Ecan advises as new information/ research completed. Springs and daylighting new. Consider opportunities in RRZ and CCDU anchor projects including in Te Papa Ōtākaro/Avon River Precinct.</p>	<p>Ecan, CCC, WDC, SDC, SCIRT, CCDU, CERA, MBIE, TRONT, Papatipu Rūnanga, zone committees</p>	<p>From 2013</p>	<p>Mostly funded <\$1M</p>
<p>10. Control weeds and pests that have potential to affect biodiversity, or have impact on health and safety</p> <p>Control of weeds and pests Extend existing strategies and programmes for controlling weeds and pests to earthquake affected areas.</p>	<p>Land owner responsibility. Ecan and TAs need to promote existing strategies and identify species of concern post EQ.</p>	<p>CCC, WDC, SDC, DOC, CERA/ LINZ, Ecan, TRONT, NGOs</p>	<p>High priority</p>	<p>Partly funded <\$1M</p>
<p>11. Assess, retain and enhance biodiversity</p> <p>Assess, plan, rehabilitate and monitor highest-value ecosystems; biodiversity corridors, reserves, mahinga kai; inanga spawning areas Assess protected areas/highest-value ecosystems/species affected by earthquakes. Investigate and recommend sites suitable for biodiversity corridors, reserves and mahinga kai. Investigate establishment of an eco-sanctuary in available land along the Avon River/Ōtākaro. Rehabilitate inanga spawning sites.</p>	<p>Assessment work limited on Port Hills because of reduced access. Post-earthquake site investigations needed to recommend suitable species for replanting projects. Research done on pre-earthquake inanga spawning sites. Further work needed to determine current sites. Consider link to RRZ programme. Eco-sanctuary not funded >\$10M.</p>	<p>DOC, CCC, WDC, SDC, Ecan, CERA, TRONT, UC, Landcare Research, consultants, zone committees, NGOs</p>	<p>From 2013</p>	<p>Mostly funded <\$1M</p>
<p>12. Support community gardens, local food production and urban forestry</p> <p>Community gardens, local food production, urban forestry On available land, support development of community gardens, orchards, and local food production.</p>	<p>27 community gardens exist in greater Christchurch. Opportunities for community involvement need to be identified where land available. Canterbury Community Gardens Association and Soil and Health Association key to advocacy and coordination.</p>	<p>No lead agency NGOs, CCC, WDC, SDC, Ecan, TRONT, LU, SCION, Enviroschools</p>	<p>From 2013</p>	<p>Funding required <\$1M</p>
<p>13. Provide access to and opportunities for outdoor recreation</p> <p>Promote and advertise currently available facilities; maintain and develop recreation corridors, networks and facilities; provide for passive recreation, visual amenity and community wellbeing during rebuild Support repair and development of a network of walking paths, cycling and mountain bike tracks and other recreation facilities. Provide access for people with disabilities. Consider establishment of water sports areas alongside the Avon River/Ōtākaro.</p>	<p>Promotion and signage of current facilities needs immediate and urgent action. CCC, WDC, SDC have programmes for repair and rebuild of sports and community facilities. Water sports facility not funded >\$10M. Coastal Pathway partly funded.</p>	<p>Sport and Recreation Earthquake Leadership Group, CCC, WDC, SDC, Ecan, TRONT, DOC, CCDU, zone committees, NGOs</p>	<p>Current facilities work urgent From 2013</p>	<p>Mostly funded <\$10M</p>
<p>14. Manage earthquake waste</p> <p>Waste monitoring; waste disposal; increased recycling; controlling illegal dumping; Waste Management Plans Improve monitoring and tracking of earthquake-related waste; enforce and manage aftercare of storage, sorting and disposal sites. Maximise recycling at or near source. Reduce illegal dumping by increasing compliance monitoring and enforcement. Prepare waste management plans for future disasters.</p>	<p>Partially completed by Ecan. Difficulty accessing private contractors' data.</p>	<p>Ecan, CCC, WDC, SDC, waste industry, CanCERN, CERA, MfE, CDEM</p>	<p>From 2013</p>	<p>Mostly funded <\$10M</p>
<p>15. Manage contaminated sites</p> <p>Identification of Hazardous Activities and Industries List (HAIL) sites; comply with National Environmental Standard (NES) for contaminated land Undertake a programme of HAIL site identification. Inform and educate on the requirement to comply with the NES triggered by land use changes.</p>	<p>Ecan, TAS programmed to do this. Timeframe and resourcing may need to be changed.</p>	<p>Ecan, CCC, WDC, SDC, TRONT</p>	<p>2013-14 NES ongoing.</p>	<p>Mostly funded <\$10M</p>
<p>16. Track earthquake effects on emissions and air quality</p> <p>Monitoring and investigation of air quality; Air Plan compliance Continue monitoring changes in use of different heating appliances and air quality. If necessary amend Air Plan to meet 2016 targets and NES requirements.</p>	<p>Work under way by Ecan.</p>	<p>Ecan</p>	<p>2013</p>	<p>Mostly funded <\$100k</p>
<p>17. Act on opportunities to restore and enhance mahinga kai</p> <p>Progressively restore and enhance mahinga kai resources and sites and the traditions of customary use associated with such resources; promote the principle of Ki Uta Ki Tai as a culturally appropriate approach to enhancing, restoring and managing mahinga kai. Establish pā harakeke, rongoa and native plantings.</p>	<p>Ecan work in Tuia, CWMS immediate steps, CCC, WDC, SDC biodiversity projects, NGO programmes with sponsorship and grants.</p>	<p>Ngāi Tahu (Ngā Papatipu Rūnanga, TRONT), Ecan, WDC, SDC, DOC</p>	<p>From 2013</p>	<p>Partly funded</p>

Application by place – Te takiwā

Some of the Natural Environment Recovery Programme projects apply across greater Christchurch. Others will be applied differently within different catchments and across catchments. Table 2 summarises the projects linked to different spatial areas. As decisions are made on land availability and future land uses in residential red zones and other areas, it will be possible to be more specific about the potential application of these projects.

Table 2: Application of projects by place

Place	Projects	
Greater Christchurch	<ol style="list-style-type: none"> 1. Investigate and plan for natural hazards 4. Plan for stormwater management 5. Act on opportunities for stormwater treatment and improving the water quality and ecosystem health of waterways 8. Act on opportunities to reduce sewage overflows and their effects 9. Protect groundwater and springs 10. Control weeds and pests that have potential to affect biodiversity, or have impact on health and safety 11. Assess, retain and enhance biodiversity 12. Support community gardens, local food production and urban forestry 13. Provide access to and opportunities for outdoor recreation 14. Manage earthquake waste 15. Manage contaminated sites 16. Track earthquake effects on emissions and air quality 17. Act on opportunities to restore and enhance mahinga kai 	
Kaiapoi River The Pines Kairaki Woodend	<ol style="list-style-type: none"> 2. Investigate and monitor coasts and estuaries 3. Reduce flood risks and restore drainage capacity of waterways 6. Manage sediment from liquefaction 7. Rehabilitate, restore and enhance wetlands changed by the earthquakes 	
Brooklands Lagoon/Te Riu o Te Aika Kawa; Styx River/Pūharakekenui; Lower Waimakariri; Ōtūkaikino	<ol style="list-style-type: none"> 2. Investigate and monitor coasts and estuaries 3. Reduce flood risks and restore drainage capacity of waterways 6. Manage sediment from liquefaction 7. Rehabilitate, restore and enhance wetlands changed by the earthquakes 	
Avon River/ Ōtākaro	Whole river	6. Manage sediment from liquefaction
	Middle	6. Manage sediment from liquefaction
	Lower	<ol style="list-style-type: none"> 2. Investigate and monitor coasts and estuaries 7. Rehabilitate, restore and enhance wetlands changed by the earthquakes
Heathcote River/ Ōpāwaho	Whole river	<ol style="list-style-type: none"> 3. Reduce flood risks and restore drainage capacity of waterways 6. Manage sediment from liquefaction
	Lower	<ol style="list-style-type: none"> 2. Investigate and monitor coasts and estuaries 7. Rehabilitate, restore and enhance wetlands changed by the earthquakes
Avon–Heathcote Estuary/Ihutai	<ol style="list-style-type: none"> 2. Investigate and monitor coasts and estuaries 3. Reduce flood risks and restore drainage capacity of waterways 7. Rehabilitate, restore and enhance wetlands 	
Halswell River/Huritini	<ol style="list-style-type: none"> 3. Reduce flood risks and restore drainage capacity of waterways 6. Manage sediment from liquefaction 7. Rehabilitate, restore and enhance wetlands changed by the earthquakes 	
Lyttelton Harbour/Whakaraupō	<ol style="list-style-type: none"> 2. Investigate and monitor coasts and estuaries 6. Manage sediment from liquefaction 7. Rehabilitate, restore and enhance wetlands changed by the earthquakes 	
Coast	2. Investigate and monitor coasts and estuaries	
Port Hills and Banks Peninsula	2. Investigate and monitor coasts and estuaries	



5. Integration

Te mahi kātahi

Stakeholders during the engagement process were clear that they would like us to take an integrated systems approach in developing and implementing the Natural Environment Recovery Programme, including by integrating the different environmental issues. It is a Ki Uta Ki Tai approach.

The Natural Environment Recovery Programme recognises that many issues to be addressed as part of recovery are interconnected. It aims for an integrated approach to all of these issues, from development through to implementation of its projects. Through the programme and each of its projects, we consider effects on the environment in terms of nine related themes. Figure 4 shows in a simplified way some of the connections and interdependencies between them.

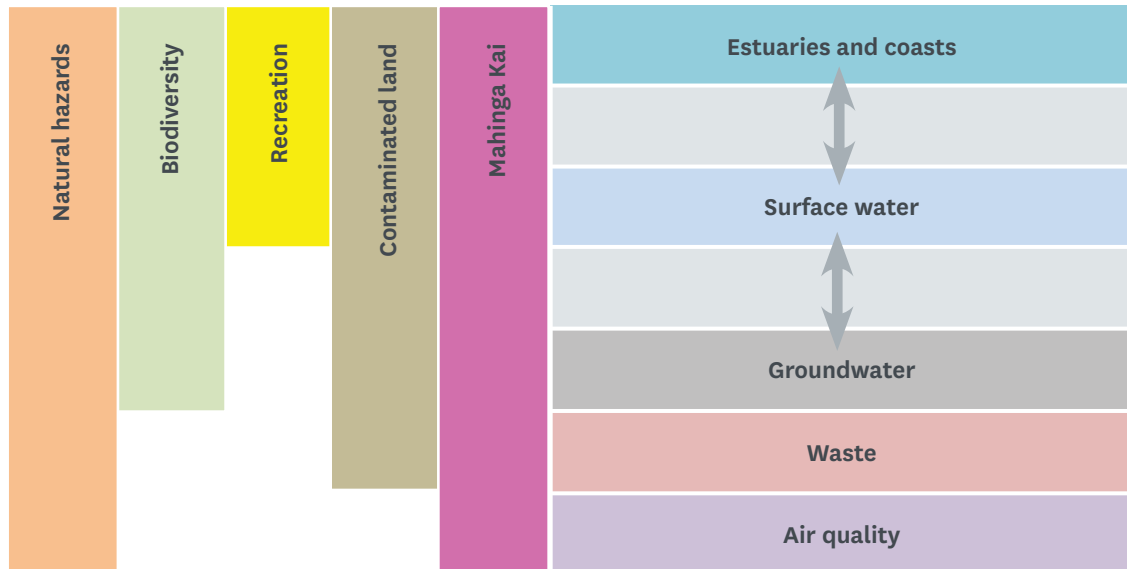
Ki Uta Ki Tai

Ki Uta Ki Tai is a term that has become synonymous with the way Ngāi Tahu think about natural resource management. It describes Ngāi Tahu's overall approach to natural resource management – from the mountains to the sea.

Ki Uta Ki Tai is a Ngāi Tahu paradigm and ethic. It is Ngāi Tahu's way of understanding the natural environment, including how it functions, how people relate to it and how it can be looked after appropriately. It involves not only a planning and policy framework, but also the development of monitoring, reporting, geographical information system analysis, information databases, area management and succession tools for natural resource management.



Figure 4: Interdependent themes in the Natural Environment Recovery Programme



If recovery is to be effective, the full set of recovery programmes must succeed, and each one must fit with and support relevant activities of the others. The Natural Environment Recovery Programme gives a natural environment perspective to a number of projects that are the responsibility of other CERA programmes. In these projects, CERA and Environment Canterbury will work with the project owners to meet the natural environment outcomes.

To integrate the Natural Environment Recovery Programme with the functions and responsibilities of the strategic and key partners, we have recognised their existing relevant plans, policies and programmes in describing the projects.

The Natural Environment Recovery Programme has strong connections with the Canterbury Water Management Strategy (CWMS) through the regional committee, Regional Implementation Programme (RIP), zone committees and Zone Implementation Programmes (ZIPs) that provide recommendations to meet the CWMS targets. The potential linkages are shown on Table 3.



Temporary stopbanks provide a riverside walkway.

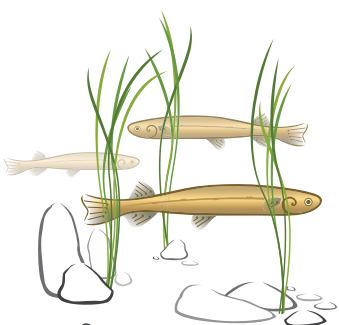


Table 3: Project links to recovery programmes and plans, and to other plans and strategies

Project	Recovery programme/plan												Other plans and strategies								
	Monitoring and Reporting Plan	Iwi Māori Recovery Programme	Central City Recovery Plan	Economic Recovery Programme	Community Resilience Programme	Heritage Buildings and Cultural Heritage Places Programme	Sport and Recreation Recovery programme	Land Use Recovery Plan	Infrastructure Programme	Residential Red Zone (RRZ) Programme	Demolitions and operations	Residential Rebuild	RPS/ RCEP	NRRP/PLWRP	CDEM Group Plans	District Plans	Stormwater Management Plans	CCC/WDC/SDC Water Strategies	ZIPs/RIP	Mahaanui Iwi Management Plan 2013	
1. Investigate and plan for natural hazards																					
2. Investigate and monitor coasts and estuaries																					
3. Reduce flood risks and restore waterways drainage capacity																					
4. Plan for stormwater management																					
5. Act on opportunities for stormwater treatment and improve the water quality and ecosystem health of waterways																					
6. Manage sediment from liquefaction																					
7. Rehabilitate, restore and enhance wetlands changed by the earthquakes																					
8. Act on opportunities to reduce sewage overflows and their effects																					
9. Protect groundwater and springs																					
10. Control weeds and pests that have potential to affect biodiversity, or have impact on health and safety																					
11. Assess, retain and enhance biodiversity																					
12. Support community gardens, local food production and urban forestry																					
13. Provide access to and opportunities for outdoor recreation																					
14. Manage earthquake waste																					
15. Manage contaminated sites																					
16. Track earthquake effects on emissions and air quality																					
17. Act on opportunities to restore and enhance mahinga kai																					

6. What does success look like?

Ka pēhea te āhua o te akitu?

To understand how the environment is affected during recovery, we need to monitor how it changes both naturally and through interventions. A monitoring and reporting framework will be developed for the Natural Environment Recovery Programme. It will be aligned with the CERA Monitoring and Reporting Plan.

We will identify a set of indicators to measure progress towards the Recovery Strategy goals. The challenge is to find measurements that can track the earthquake effects and recovery without being affected by other factors such as climate and weather events that vary the data between seasons or between years. Ideally the indicators chosen will have been used in measuring the natural environment over the long term before the recent earthquakes.

If monitoring shows that outcomes are unlikely to be achieved or that improvement can be made, this will be identified to the governance teams and changes to the programme will be recommended for approval. Table 4 identifies possible indicators for each of Natural Environment Recovery Programme's projects.



Table 4: Possible ways of monitoring the environment for Natural Environment Recovery Programme projects

Project description	Recovery Strategy goals and related outcomes	What does success look like? Indicator description	Possible indicator variables	Source of data
1. Investigate and plan for natural hazards	Drawing on sound information about ongoing seismic activity and environmental constraints, including other natural hazards and climate change.	A greater understanding of natural events and hazards facing greater Christchurch is established to influence future planning.		
2. Investigate and monitor coasts and estuaries	Improving the quality and function of estuaries, waterways and wetlands to support the unique biodiversity that is endemic to Te Waipounamu.	Faecal contamination reduces over time.	<i>E.coli</i> or enterococci concentration in estuary.	Source: ECan/CCC Historical: Yes Current: Yes
3. Reduce flood risks and restore drainage capacity of waterways		The flood-carrying capacity of rivers is restored to pre-earthquake levels.		
4. Plan for stormwater management	Ensuring ecosystems are healthy and functioning to support biodiversity and economic growth.	SMPs are developed as scheduled.	Record of SMP milestones and whether achieved or not.	Source: CCC/WDC Historical: No Current: No
5. Act on opportunities for stormwater treatment and to improve the water quality and ecosystem health of waterways	Ensuring ecosystems are healthy and functioning to support biodiversity and economic growth. Improving the quality and function of estuaries, waterways and wetlands to support the unique biodiversity that is endemic to Te Waipounamu. Outcome: Aquifers, rivers and streams meet, or are improved towards meeting over time as is practicable and affordable; NRRP/PLWRP water quality outcomes.	Ecosystem health and biodiversity in rivers, streams, wetlands and estuaries recover to or exceed pre-earthquake levels. Suspended solids concentrations reduce over time. Over time QMCI trends towards NRRP Table WQL5 targets.	Suspended solids concentrations – rivers/estuary. Ecological health measured by the QMCI score.	Source: ECan/CCC Historical: Yes Current: Yes Source: ECan/CCC Historical: Yes Current: Yes
6. Manage sediment from liquefaction		Inanga return to pre-earthquake spawning areas or make use of new areas for spawning. Length of riparian buffer along waterways increases.	Inanga spawning habitat on the Avon/ Ōtākaro and Heathcote/Opāwaho Rivers. Length of riparian buffer zones greater than 5m in width.	Source: ECan/CCC Historical: No Current: Yes Source: ECan, CCC, WDC, SDC Historical: No Current: No
		Sediment is removed from tributaries and main stems of rivers.	Amount of sediment removed (tonne).	Source: ECan/CCC Historical: No Current: No
		The frequency of turbidity trigger values (measured at representative locations and times) exceeded during a year in all monitored waterways reduces over time.	The frequency of turbidity trigger values exceeded during a year in all monitored waterways?	Source: ECan/CCC Historical: Yes Current: Yes

Table 4: Possible ways of monitoring the environment for Natural Environment Recovery Programme projects

Project description	Recovery Strategy goals and related outcomes	What does success look like? Indicator description	Possible indicator variables	Source of data
7. Rehabilitate, restore and enhance wetlands changed by the earthquakes	Ensuring ecosystems are healthy and functioning.	Area of wetlands restored.	Change in the area of wetlands restored.	
		Number of wetlands mapped.	Number of earthquake-affected wetlands mapped.	Source: ECan Historical: Yes Current: Yes
8. Reduce sewage overflows and their effects		The number and volumes of sewage overflows fall.	Number sewage overflows per year. Volume of sewage overflows (litres).	Source: CCC Historical: Yes Current: Yes
	Ensuring recovery activities value, protect and sustainably manage the sources of our water.	Groundwater extracted for drinking water supplies meets NZ drinking water standards.	Groundwater – concentrations of major ions, nitrates, bacteria, halides, pesticides, volatile and semi-volatile organic compounds are below recommended limits.	Source: ECan Historical: Yes Current: Yes
10. Control weeds and pests that have potential to affect biodiversity, or have impact on health and safety			Percentage of annual drinking water samples meeting NZ drinking-water standards – by TA.	Source: CPH Historical: Yes Current: Yes
11. Assess, retain and enhance biodiversity		Invertebrate and fish diversity and abundance return to pre-earthquake status and show improving trends over time.	Fish and invertebrate surveys on Avon/ Ōtākaro, Heathcote/ Ōpāwaho, Styx/ Pūharakekenui and Waimakariri Rivers.	Source: CCC/ECan/UC Historical: Yes Current: Yes
			Land vegetation cover changes.	
12. Support community gardens, local food production and urban forestry		Number/area of community gardens is increasing.	Number of gardens/area covered.	Source: CCC Historical: Yes Current: Yes
		Area of urban forest is increasing.	Area of forest planted (ha).	Source: CCC/ECan Historical: No Current: Yes

Table 4: Possible ways of monitoring the environment for Natural Environment Recovery Programme projects

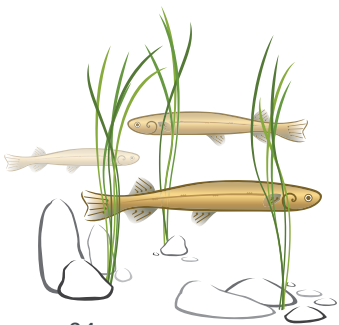
Project description	Recovery Strategy goals and related outcomes	What does success look like? Indicator description	Possible indicator variables	Source of data
13. Provide access to and opportunities for outdoor recreation	Providing safe public access to and opportunities for outdoor recreation, cultural, social and economic activities.	Proportion of Port Hills walking and biking tracks (by km) remaining closed due to earthquake impacts reduces over time.	Proportion of Port Hills walking and biking tracks (by km) remaining closed due to earthquake impacts.	Source: CCC - new Historical: No Current: No
		Recreational water quality ratings (river, estuary and coastal beaches) improve over time.	Recreational water quality ratings (river, estuary and coastal beaches).	Source: ECan Historical: Yes Current: Yes
		E.coli concentrations at recreational sites decrease over time.	E.coli concentrations at recreational sites.	Source: ECan/CCC Historical: Yes Current: Yes
14. Manage earthquake waste	Storing, sorting and processing waste in an environmentally safe and effective manner, including minimising and recycling construction and demolition wastes.	Heavy metals, bacteria and enteric viruses in river and estuary samples of fish/shellfish remain below FSANZ 2008 limits for safe food consumption, and trends are observed to identify any areas of concern.	Level of heavy metals, bacteria and enteric viruses in river and estuary samples of fish/shellfish relative to FSANZ 2008 limits for safe food consumption.	Source: ECan Historical: Yes Current: Yes
		Demolition waste to landfill is reduced to a practicable minimum, and reuse and recycling of material are developed as far as practicable.	Quantity and proportion of waste to Kate Valley Landfill, to Lyttelton Port reclamation, to Burwood Landfill and to Burwood Resource Recovery Park.	Source: ECan Historical: No Current: Yes
			Quantity and % of waste to recover/reuse.	
15. Manage contaminated sites			Hazardous waste collected from residential red zone.	Source: ECan/MFE Historical: No Current: Yes
			Number of HAIL sites on LLUR.	Source: ECan Historical: Yes Current: Yes
16. Track earthquake effects on emissions and air quality	Enhancing air quality through managing recovery activities that impact on air quality, such as heating, transport, demolition and construction.	There will be more HAIL sites recorded and improved quality of the information for the HAIL sites.. Air quality in Christchurch City and Waimakariri District air sheds meets the NES on air quality and meets 2016 applicable targets.	Number of exceedances of the 24-hour 50 microgram PM ₁₀ limit per year.	Source: ECan Historical: Yes Current: Yes
17. Act on opportunities to restore and enhance mahinga kai				

7. Implementation – reviewing and reporting on the Natural Environment Recovery Programme

Te arotake me te pūrongo

After Environment Canterbury Commissioners have adopted the Natural Environment Recovery Programme, it is important that provision is made for ongoing advocacy, advice and communication to integrate projects across the programme and to align the Natural Environment Recovery Programme with other recovery programmes.

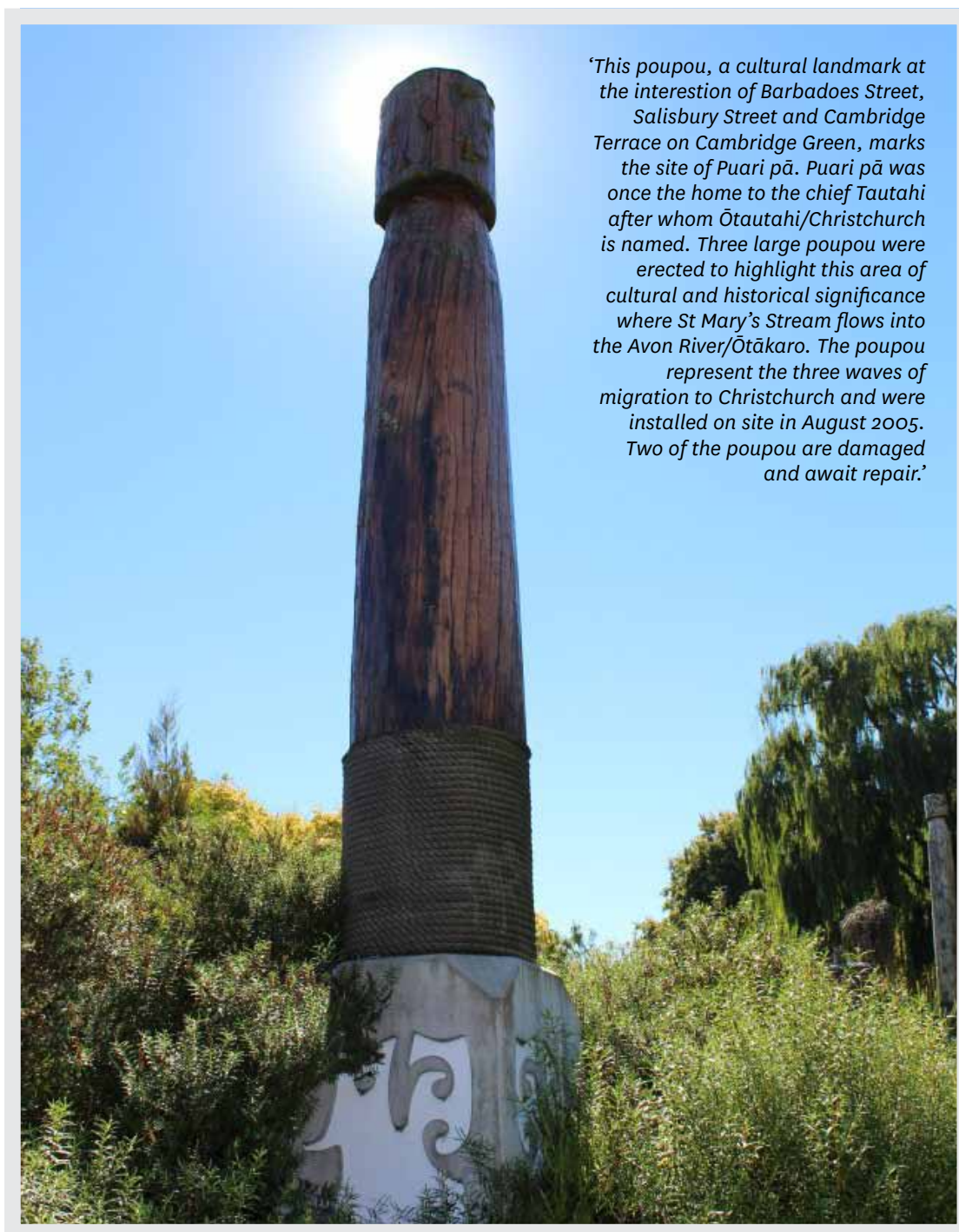
The NERP technical advisory group will continue and will report on the Natural Environment Recovery Programme's progress each quarter, and identify any risks to the programme, new issues and further opportunities emerging as the recovery continues.



8. Transition plan

Te whakawhitinga

A transition plan is required for when the CER Act expires in 2016. Until then the purpose of the NERP is to identify opportunities and ensure coordination and facilitation of action across central government, councils and the community sector. For projects that are already part of organisations' existing programmes they will continue if necessary through the transition. During 2015-16, projects that have not been absorbed into existing programmes and plans will be reassessed by the advisory group. If still critical to the recovery of the environment other mechanisms will be needed for action to be taken.



'This poupou, a cultural landmark at the intersection of Barbadoes Street, Salisbury Street and Cambridge Terrace on Cambridge Green, marks the site of Puari pā. Puari pā was once the home to the chief Tautahi after whom Ōtautahi/Christchurch is named. Three large poupou were erected to highlight this area of cultural and historical significance where St Mary's Stream flows into the Avon River/Ōtākaro. The poupou represent the three waves of migration to Christchurch and were installed on site in August 2005. Two of the poupou are damaged and await repair.'

Glossary of abbreviations

He rārangi kupu

CanCERN	Canterbury Communities' Earthquake Recovery Network	MBIE	Ministry of Business, Innovation and Employment
CCC	Christchurch City Council	MfE	Ministry for the Environment
CCDU	Christchurch Central Development Unit	NES	National Environment Standard
CDEM	Civil Defence Emergency Management	NGO	Non-governmental organisation
CDHB	Canterbury District Health Board	NERP	Natural Environment Recovery Programme
CER Act	Canterbury Earthquake Recovery Act 2011	NHRP	Natural Hazards Research Platform
CERA	Canterbury Earthquake Recovery Authority	NIWA	National Institute of Water and Atmospheric Research
CIAL	Christchurch International Airport Ltd	NRRP	Natural Resources Regional Plan
CPH	Community and Public Health, Canterbury District Health Board	pLWRP	Proposed Land and Water Regional Plan
CWMS	Canterbury Water Management Strategy	QMCI	Quantitative Macroinvertebrate Community Index – an index that characterises the macroinvertebrate community in a stream.
CWTP	Christchurch Wastewater Treatment Plant	RCEP	Regional Coastal Environment Plan
DOC	Department of Conservation	RIP	Regional Implementation Programme for the CWMS
ECan	Environment Canterbury	RMA	Resource Management Act 1991
EQ	Earthquake	RPS	Regional Policy Statement
EQC	Earthquake Commission	RRZ	Residential Red Zone
ESR	Institute of Environmental Science and Research	SCIRT	Stronger Christchurch Infrastructure Rebuild Team
FSANZ	Food Standards Australia New Zealand	SDC	Selwyn District Council
GNS	GNS Science	SMP	Stormwater Management Plan
HAIL	Hazardous Activities and Industries List	TA	Territorial Authority
LGA	Local Government Act 2002	TAG	Technical Advisory Group
LIDAR	Light Detection And Ranging – a remote sensing technology used to obtain data about ground elevations	TC3	Technical Category 3 land
LINZ	Land Information New Zealand	TRONT	Te Rūnanga o Ngāi Tahu
LIUDD	Low Impact Urban Design and Development (also known as Water Sensitive Urban Design, WSUD)	TYP	Three Year Plan – CCC's LTP 2013–2016
LLUR	Listed Land Use Register	UC	University of Canterbury
LPC	Lyttelton Port Company	WDC	Waimakariri District Council
LTP	Long-Term Plan	ZIP	Zone Implementation Programme for the CWMS
LU	Lincoln University		



	Pre- earthquake condition	Earthquake effects	Post-earthquake actions, effects and responses
<p>Hazards</p>	<ul style="list-style-type: none"> Greater Christchurch was vulnerable to a wide range of natural hazards. ECan is the lead agency for gathering and providing information on natural hazards as required by the RMA (section 35). This informs planning and works under the CDEM Act 2002. For TAs, asset plans for water and wastewater had to consider natural hazards and include mitigation measures. Hazard management also occurred at subdivision approval and through the Building Act. 	<ul style="list-style-type: none"> Large volumes of silt were released onto land through liquefaction. Over 900,000 tonnes were removed. Localised settlement, land tilting and land levels changed. Waterway flood capacities were reduced by siltation and lateral spreading; flood risk increased. Rockfall and rock roll, cliff collapse and landslides occurred in hill areas. Sewerage pipes broke and sewage was discharged into waterways. Hazard risk profiles changed; seismicity was elevated; hills became more susceptible to rockfall, cliff collapse and landslide. Sea level rise will raise the water table, increasing liquefaction risks for infrastructure and buildings. 	<ul style="list-style-type: none"> Height of existing stopbanks was raised and temporary stopbanks built. Permanent protection is being planned. Need to update information on hazards, climate change and sea level rise in order to make informed decisions about risk avoidance, reduction, readiness, response and recovery. Provide sufficient land to allow for natural variations and future changes. Repairs to the Courtenay and Kaikanui stormwater basins are under way. Apply minimum floor levels to offset flood risk in risk-prone areas. Consider engineering works to retain unstable land and rock sources. Longer-term effects will take many years to become apparent and be understood. Risks must be reassessed on an ongoing basis. LIDAR survey needs to be extended along the coastal area of the Waimakariri District (east of SH1) between the Waimakariri and Ashley/Rakahuri Rivers. Additional riverbed cross-sections for Cam and Kaiapoi Rivers and Courtenay Stream could show post-quake shift in river channel and riverbed levels and identify areas where excess sediment has accumulated. Additional funding would be required to investigate sufficient cross-sections to identify all significantly affected areas and then to remove the sediment. Sediment removal has ongoing benefits for aquatic ecology.
<p>Coasts and estuaries</p>	<ul style="list-style-type: none"> The Avon-Heathcote Estuary/Ihutai was recovering following the diversion of CCC wastewater discharge to ocean pipeline (March 2010). WDC ocean outfall (2006) removed wastewater discharge from Cam, Kaiapoi and Waimakariri rivers. Improvements to management of stormwater and sewage overflows. 	<ul style="list-style-type: none"> Topography of the Avon-Heathcote Estuary/Ihutai changed. Tidal prism reduced by 14%. Up to 40% of the estuary was covered by liquefaction mounds. Liquefaction mounds in Brooklands Lagoon/Te Riu o Te Aika Kawa; sediments ejected had lower concentrations of heavy metals and organic matter than the pre-existing mudflats. Estuary rehabilitation may be accelerated by burying polluted sediments; biota buried by the liquefaction. Water quality in waterways was affected by discharge of raw sewage; recreational activities stopped for many months; shellfish from estuary contained high concentrations of micro-organisms from faecal matter; water quality at beaches returned to pre-earthquake conditions by November 2011. Coastal cliffs collapsed. Birds shifted roosting/nesting sites. Marine animals affected. 	<ul style="list-style-type: none"> Plan for and provide additional buffer space to allow for effects of coastal processes. Plan for changed land uses in areas at risk from coastal processes. Continue to improve wastewater reticulation and reduce sewage overflows in all TA areas. Take opportunity to increase the area of estuarine wetland in the lower rivers and margins of the estuaries. Continue surveys of estuaries to understand the changes and implications.

Surface water	Pre- earthquake condition	Earthquake effects	Post-earthquake actions, effects and responses
	<ul style="list-style-type: none"> ■ Water quality was affected by stormwater runoff containing contaminants and sediment; wastewater overflows; and the abundance of bird life. Fine sediment build-up on riverbeds was affecting diversity and health of aquatic ecosystems. ■ CWMS was in operation; Christchurch-West Melton and Banks Peninsula zone committees had not been established. ■ Springs in upper catchments were drying up; flows were being augmented in some places; springs were affected by human actions. ■ Riparian management included planting, buffer distances and fencing. ■ Greenfield developments included stormwater treatment systems. ■ CCC had a programme for developing SMPs. 	<ul style="list-style-type: none"> ■ Large volumes of sediment entered waterways due to liquefaction – both directly and via stormwater systems. Suspended solid levels in rivers were very high immediately after earthquakes. ■ Liquefaction caused uplift and siltation of riverbeds. ■ Stormwater quality was impacted by silt, sediment and other earthquake effects – effluent, liquefaction, waste materials from damaged residential and commercial properties – with ongoing water quality issues from human activity. ■ Sewage and trade waste discharges to waterways resulted in high ammonia levels, low dissolved oxygen levels and accumulation of some contaminants in riverbed sediment; Māori and other cultural values affronted by discharges; waterways closed for recreational use until November 2011. ■ River banks were destabilised, with associated erosion of rivers and streams; lateral spreading caused banks to slump and/or move inwards, narrowing river channels. ■ Raised water tables have caused surface flooding and ponding, and affected drainage systems, reducing stormwater quality and creating problems with mosquitos and other risks to public health. ■ Tūtaepatu lagoon overtops from time to time with lack of drainage. ■ Inanga/whitebait spawning areas suffered minor to severe damage. ■ Lake levels for Wairewa became uncertain. 	<ul style="list-style-type: none"> ■ CCC brought forward development of Avon River/ Ōtākaro SMP to 2013/14. ■ Preparation of SMPs and comprehensive discharge consents will address issues within catchment-wide drainage systems that have been altered by land settlement and sedimentation. ■ Effects on infrastructure and waterways have been assessed, as has the impact on water quality and ecosystem health of the rivers. ■ Bank stabilisation and repair of stopbanks and bridges have been necessary. ■ Earthquake-damaged wastewater pipes are being repaired to address increased levels of stormwater inflow during rainfall events. ■ Removal of sediment from waterways has begun to restore capacity, improve stability and enable benthic habitat restoration - may also release sediment and other contaminants. ■ Stormwater treatment is retrofitted where practicable during the repair of stormwater systems. Stream and river restoration work and stormwater quality improvement projects following the earthquakes need to continue as permitted by resourcing. ■ Need to review effectiveness of post-earthquake land drainage weir levels. Also need to discourage land owners from digging drains without consent. ■ There are opportunities to protect, reinforce and re-establish Ngāi Tahu's historic and contemporary connections with the rivers, land and taonga; and to recognise and incorporate mana whenua values into future restoration and development of the rivers to strengthen cultural identity and wellbeing, and restore and enhance the mahinga kai values of rivers, streams, wetlands and riparian margins. ■ CCC developing land drainage recovery programme.

	Pre- earthquake condition	Earthquake effects	Post-earthquake actions, effects and responses
Groundwater	<ul style="list-style-type: none"> ■ CWMS were in operation; Christchurch-West Melton and Banks Peninsula zone committees had not been established. ■ Deep aquifers used for urban supply were secure against contamination, and drinking water satisfied the NZ drinking water standard. 	<ul style="list-style-type: none"> ■ Groundwater quality was largely unaffected. ■ Damage to wells, pipes and reservoirs created the potential for drinking water contamination, requiring chlorination of some of CCC water supply until late 2011. ■ The number and flow rates of springs, including in hill areas, increased. In some places, springs stopped flowing. ■ Groundwater level monitoring network suffered extensive damage. ■ Tuahiwi – reported effects on groundwater/well levels. 	<ul style="list-style-type: none"> ■ Need to track effects of EQ on groundwater quantity/availability. ■ Sea level rise is expected to increase groundwater levels and consequently liquefaction risk. ■ Use of treated timber for deep piles in the rebuild may affect groundwater quality. ■ Further work is required on mapping springs – link with Aqualinc work.
Biodiversity	<ul style="list-style-type: none"> ■ Wetland bird numbers and diversity were increasing. Through construction and management of wetlands, more habitats were being provided ■ Restoration planting was taking place on public land. ■ Diversity of benthic invertebrates, a common indicator of waterway health, was low. Species tolerant to pollution and sediment were prevalent. ■ Naturalisation of channelised waterways in CCC had been occurring for many years. ■ Weirs in rivers were preventing fish passage. ■ Some riparian management was undertaken in rural and urban areas. ■ Local government agencies and land owners carried out pest and weed control activities. ■ Significant urban whitebait/inanga fishery was operating on the Avon/Otakaro and Heathcote/ Ōpāwaho Rivers. ■ Trees and plantings were a valuable part of greater Christchurch for their regulation of water flows, soil erosion, climate, and air quality; for provision of shade, habitat, recreation and amenity; for carbon sequestration; and as a biofuel 	<ul style="list-style-type: none"> ■ Aquatic biodiversity was reduced by sedimentation in some places; silt smothered the habitat of the plants and animals in waterways. ■ The success of inanga breeding may have been affected; inanga fishery was lost because of contaminated rivers. In 2012 advisories were issued against eating inanga because of high E. coli levels. ■ Avian botulism caused the death of birds in the 2011/12 and 2012/13 summers. Cause of the botulism uncertain but may be related to the change to the biology in the CWTP treatment ponds. ■ Restricted access to areas in the Port Hills means sites with threatened species may not have been assessed, and has reduced the control of weeds and pests. ■ Areas of coastal forest damaged; tree die-off because of changed ground conditions. ■ Coastal cliffs were damaged, causing relocation of breeding sites for marine mammals and birds and modification of ecological sites. ■ Seabird habitat on some Banks Peninsula headland cliffs has been lost, displacing seabird colonies to new areas that may provide less protection. Some marine animal colonies have also shifted. ■ Liquefaction sediment impacted on terrestrial plants and animals. ■ Wetland habitat changed. ■ Mahinga kai was affected. 	<ul style="list-style-type: none"> ■ In residential areas where homes have been abandoned or neglected, the number of weeds and pests has increased, which can harm native species and habitats. ■ In hazardous rockfall areas, stock have been excluded and weed and pest management is not being conducted. Extensive areas of dry grass provide fuel for wild fires, which will prove difficult to control. Weeds may spread into ecologically important areas. ■ Consider letting ecosystems return to their own equilibrium without intervention. ■ Volunteerism has increased through the earthquakes; there are opportunities to use volunteers to undertake monitoring, planting and other biodiversity-related activities. ■ WDC has allocated some funding to ensure biodiversity recovery on its parks and reserves following the earthquakes. WDC has also undertaken a survey to identify important ecological aquatic habitats in the district, including trout spawning locations since the earthquakes.

	Pre- earthquake condition	Earthquake effects	Post-earthquake actions, effects and responses
Recreation	<ul style="list-style-type: none"> ■ ECan, CCC, SDC, WDC and DOC managed outdoor recreation locations. ■ There was a lack of overall strategic management of outdoor recreation assets and areas. ■ Paths and tracks provided for walking and mountain biking in the Port Hills, forests, and river corridors. ■ Water-based recreation was available on the rivers, estuaries, harbours and ocean. Watercraft became congested on the Avon River/Ōtākaro, especially at Kerr's Reach, and waterweeds could be a problem. Water quality in the rivers and estuaries compromised recreation. ■ An international water sports lake had been proposed near the airport but CIAL opposed it because of bird strike risk. Henderson's Basin had been investigated as a possible site but was not pursued. 	<ul style="list-style-type: none"> ■ Tracks and paths in the Port Hills were closed because of rockfall risk. ■ Riverside paths were damaged and in some places covered by stopbanks. ■ Some Bottle Lake Forest Park tracks were closed, with area being used for waste storage and sorting. ■ Pegasus walkway flooded and impassable for a time, especially near Pine Beach. ■ Surface water quality was affected by emergency wastewater discharges until November 2011. ■ Outdoor water-based recreation, fishing and other food gathering were prevented in rivers, estuaries, along beaches and in the sea. ■ Recreational sailing was affected by the uplift on the southern margin of the Avon-Heathcote Estuary/Ihutai. ■ Community cohesion based around local sports events was fragmented; negative effects on health because of reduced availability of facilities; additional costs incurred for increased travel to new venue and/or for accessing alternative forms of recreation. 	<ul style="list-style-type: none"> ■ Opportunities for groups to co-locate and share common space as facilities are rebuilt. ■ Coastal Pathway supported by CCC.
Waste	<ul style="list-style-type: none"> ■ Household waste management for CCC had improved with introduction of 3-bin systems to divert waste from landfill; in Waimakariri, waste sent to landfill was decreasing from 2008/09 levels and diversion increasing. ■ Hazardous waste was managed, although household hazardous waste was harder to monitor and control. ■ The established construction and demolition waste management industry was designed to handle about 225,000 tonnes of municipal waste and about 600,000 tonnes of construction and demolition waste each year. 	<ul style="list-style-type: none"> ■ Approximately 9 million tonnes of construction and demolition waste will be produced (equivalent to 40 years of waste normally sent to landfill) – meaning creation of new sites (additional to the 47 known existing sites) for storage, sorting, processing and disposal of waste. ■ Areas in Bottle Lake Forest Park are being used for waste storage, sorting and disposal. Truck movements have affected the neighbouring communities. ■ The incidence of illegally dumped construction and demolition waste is higher. ■ Household hazardous waste volumes have increased in Christchurch and Waimakariri due to home clearances, demolitions and relocations. ■ A large proportion of buildings older than 20 years contain some asbestos materials. Any break up of these materials during the earthquake or in demolition can pose a risk of asbestos dust exposure. 	<ul style="list-style-type: none"> ■ New storage, sorting and disposal sites increase the risk of release of contaminants and will require ongoing monitoring, enforcement and aftercare. ■ Environment Canterbury is collaborating with strategic partners on managing hazardous substances, resolving waste management issues, including illegal dumping, and managing contaminated land risks during the demolition process. ■ Industry and TAs are working together to find solutions for recycling or reusing waste. ■ A grant from Government's Waste Minimisation Fund is assisting the collection and disposal of household hazardous waste from the residential demolition process. ■ CERA has identified buildings that may contain asbestos, and asbestos information has been provided to the property owners. MBIE requires that only licensed asbestos removal contractors are permitted to remove asbestos. Debris containing asbestos is transported to the Kate Valley landfill in plastic lined and covered bins ■ Lyttelton Port Co. (LPC) is using inert demolition material to reclaim land. The LPC reclamation process will be monitored to ensure harbour water quality and amenity values are maintained. Monitoring will cover any impacts on Rāpaki.

	Pre- earthquake condition	Earthquake effects	Post-earthquake actions, effects and responses
<p>Contaminated land</p>	<ul style="list-style-type: none"> ■ The extent of contamination of land was unknown. Potentially contaminated sites were being identified and cleaned up or managed. ■ Some HAIL sites had been identified. Information is stored and managed in ECan's LLUR database and provided on request. ■ Sections 30 and 31 of the RMA require ECan to identify and monitor contaminated land; control lawful discharges to air, land and water; carry out enforcement actions (on illegal discharges); and control the effects of use of contaminated land. 	<ul style="list-style-type: none"> ■ During the earthquake a number of underground fuel storage tanks were ruptured and forced to the surface with some minor releases of products. Other minor spillages of hazardous substances were noted, but no major or significant releases were observed. In the initial emergency response phase, discharges to air, land and water occurred during demolition and repair work. ■ Old disposal sites were opened up and new sites were created to receive, process and store materials. Materials that were accepted, handling and processing methods and site containment and operations at times did not fully follow current best practice. 	<ul style="list-style-type: none"> ■ Land use changes may expose contaminated land or uncontrolled fill, potentially releasing pollutants to the environment. As the demolitions proceed, disturbance of pre-existing contaminated land is a risk. A requirement to comply with the NES will be triggered by land use changes, subdivision, soil disturbance and sampling, and removal of fuel storage tanks. Rebuilding, including the installation of deep foundations and piles, will trigger NES requirements. Other consents will also be required by ECan. Acceptable levels of residual contaminants will depend on short- and long-term land uses, which may in turn depend on the feasibility and cost of site remediation. Some sites may not be remediated beyond containment and capping or site management. ■ Carry out earthworks, site excavations and foundations using ECan's Erosion Control and Sediment Management guidelines and contaminated site and land requirements.
<p>Air quality</p>	<ul style="list-style-type: none"> ■ Christchurch has had a long-standing air quality problem caused primarily by fine airborne particles from domestic open fires and wood burners. ■ During the winter, some Canterbury towns had a serious air pollution problem primarily caused by domestic home heating and influenced by climate and topographical factors. ■ The NES for PM₁₀ is 50 micrograms of PM₁₀/m³ of air (averaged over 24 hours). ECan is responsible for assisting Christchurch and Kaiapoi to meet the target of no more than three exceedances per year by 1 September 2016 and no more than one exceedance by 1 September 2020. The air shed of Rangiora must reach only one exceedance per year by 1 September 2016. ■ The Air Plan (Chapter 3 of the NRRP) provides methods and rules to assist with achieving this reduction. 	<ul style="list-style-type: none"> ■ The number and type of different heating devices used have changed because thousands of chimneys fell, because emergency repairers installed alternative heating devices in homes, and through the abandonment and demolition of houses. ■ Dust from liquefaction, demolition and earthworks had some effects on air quality in winter 2011. ■ The number of days exceeding 50µg of PM₁₀/m³ of air increased in 2011, mainly due to 'coarse fraction' PM₁₀ (not from home heating), but returned to pre-2011 levels in 2012. 	<ul style="list-style-type: none"> ■ Environment Canterbury will monitor air quality in Christchurch, Kaiapoi and Rangiora over the next 2–4 years to update air quality projections and understand how the earthquakes have affected air quality. The overarching objective for air quality in Canterbury is to meet the NES for air quality by 2016. The monitoring will be used to calibrate air quality models and target areas where changes are required to meet the NES. ■ Investigate options to install ultra-low emission domestic wood burners. ■ Install additional insulation during repairs and rebuilding of existing houses.

1. Investigate and plan natural hazards

Hazards investigations

Reassess the risks and susceptibilities of natural hazards including rockfall, rock roll, landslide, liquefaction, flooding, groundwater levels, and coastal/tsunami inundation, and provision for climate change and sea level rise. Extend LIDAR survey north to Ashley River/Rakahuri.

Report and map the results to inform land use planning and development. Design systems for ongoing collection of appropriate geotechnical and groundwater data to inform development decisions, and continued monitoring of hazards. Ensure the information is appropriately stored and readily available for future decision making.

Land use planning

Take a multi-risk based approach to ensure hazards, climate change and sea level rise are planned for in land use planning and development. Identify areas where development should be avoided or restricted. Plan and provide for sufficient buffer space between the natural and built environments to allow for natural variability, natural extreme events, human-induced changes and uncertainties.

2. Investigate and monitor coasts and estuaries

Te Tai o Mahaanui/Canterbury coastal investigations

Investigate and monitor changes in coastal processes and physical parameters following the earthquakes, changes in land and seabed levels and effects on coastal areas, including Lyttelton Harbour/Whakaraupō. Review and build in sea level rise projections and increased climate variability impacts. Consider effects of future earthquakes on gravel and sediment supply. Use to inform land use planning and development and other plans, strategies and work programmes.

Estuary investigations

Investigate and monitor the coastal and sedimentation processes in the Avon-Heathcote Estuary/Ihutai and Brooklands Lagoon/Te Riu o Te Aika Kawa. Include seabed levels, hydrodynamics, shoreline geomorphology and effects of the earthquakes on physical and biological estuary functions. Build in sea level rise projections and increased climate variability impacts. Use to Inform planning and development of riparian and wetland areas.

3. Reduce flood risks and restore drainage capacity of waterways

Flood mitigation

Reduce potential flood damage from river and/or tidal flooding, including predicted sea level rise, by appropriate mitigation measures including land use planning. Where necessary, set physical limits such as minimum floor levels, land acquisition and installation of structural measures such as stopbanks and flood retention systems. Extend LIDAR survey on the coastal strip north of Kaiapoi to the Ashley River/Rakahuri. Undertake additional riverbed cross-sections for Cam and Kaiapoi Rivers and Courtenay Stream, which could show post-quake shift in river channel and riverbed levels and identify areas where excess sediment has accumulated. CCC land drainage recovery programme provides mechanism for planning.

Stopbanks and other works

Reconnect the river channels in the lower reaches of rivers to their floodplains through the retreat or removal of roads, buildings and stopbanks. Although the CCC Waterways, Wetlands and Drainage Guide suggests avoiding the use of stopbanks - as they cause loss of floodplain storage, loss of riparian environment, loss of views of the waterway and potential failure from damage, vandalism and geotechnical causes - this is not always possible in an existing area. If stopbanks are necessary, construct them close to the areas requiring protection, to allow for re-introduction of river and/or tidal flows as part of naturalisation of the areas between the stopbanks and the river. Integrate stopbanks into natural landscaping, and where appropriate combine them with path and cycleway formation. Consider opportunities for informal recreation in areas between stopbanks and the river. The placement of stopbanks will directly influence stormwater management planning.

Resilient sustainable infrastructure in rebuild

Provide repaired and replacement infrastructure using locations, capacities, materials and methods that are resilient to natural events and human-induced changes. Where possible, especially where there is now space, use the environment as natural infrastructure for the appropriate use, reuse, treatment and disposal of water.

4. Plan for stormwater management

Stormwater Management Plans (SMPs)

Under the NRRP/pLWRP, SMPs are to be developed for each river catchment, to fulfil the requirements of having a catchment-wide stormwater discharge consent. Each SMP to be implemented within greater Christchurch will involve hydrological modelling and technical investigations to guide development of best practice stormwater management systems for the purposes of improving water quality and quantity (especially controlled release of water during storm events). Technical investigations include assessments of ecological, landscape, recreational, heritage, cultural values associated with stormwater management and how these can be incorporated, enhanced and/or protected to meet regional targets and national guidelines. For these reasons SMPs will guide/influence the surface water projects in Project 5.

5. Act on opportunities for stormwater treatment and to improve the water quality and ecosystem health of waterways

Stormwater treatment systems

Use LIUDD and stormwater treatment systems to attenuate stormwater flow rates, reduce sediment inputs and improve the quality of stormwater being discharged into waterways. Stormwater treatment systems include on-site rainwater collection, green roofs, permeable paving, litter traps (sales, grates, grills); soakage systems (swales, soakage chambers, soakage basins); bio-retention areas (planted sand filters with peak flow ponding storage); detention basins (wet ponds, dry basins) and constructed wetlands (with surface/subsurface flow). Under the pLWRP any public reticulated stormwater system established after 11 August 2012, including any extension to any existing public reticulated stormwater system, the discharge of stormwater must be subject to a land-based treatment system or wetland treatment prior to any discharge to a river.

Stream and river restoration

Identify areas where earthquake changes to streams have improved the habitat and ensure these are retained.

Take opportunities during rebuilding to change the form of waterways to enhance stream ecology - e.g., altering cross-sectional and longitudinal shape of waterways. Consider changing from hard engineering bank protection (such as gabion baskets and retention walls) to more natural methods (such as sloping banks and indigenous plantings). Increase habitat diversity for biota by introducing variability to riverbed and bank material. Take ecological and hydrological advice, consult with other river users and, where appropriate, narrow river low flow channels to increase water velocity, assist flushing of sediment and increase habitat diversity. Where practicable, remove or alter weirs, culverts, flood gates and other obstructions to enable upstream migration of aquatic adult insects and fish. Consider the risk of lateral spread and avoid placing infrastructure and buildings close to rivers to minimise the risk.

Riparian zones

A healthy riparian zone of sufficient width, in combination with a restored instream habitat, will provide benefits to the terrestrial and aquatic environments. Ensure better-functioning riparian areas by planting river banks to provide food sources, habitat and shade, supplementing exotic plantings with more indigenous species. Use these areas to provide buffers between land use and waterways, to slow overland flows and trap pollutants. Minimise impervious surfaces in the riparian zones.

Establishment of constructed wetlands

Identify, map and prioritise areas that would be suitable as wetlands including those locations that may support improved treatment of stormwater discharges and water quality management. Integrate with development of SMPs and consider in future use of RRZ. Design, construct and maintain new wetlands to provide for biodiversity, cultural, recreational and educational opportunities. Develop and expand estuarine wetlands in the lower reaches of the rivers and margins of the Avon-Heathcote Estuary/Ihutai and Brooklands Lagoon/Te Riu o Te Aika Kawa.

6. Manage sediment from liquefaction

Investigations, assessment and advice on removal of sediments

Determine how much and where earthquake-related sediment has been deposited in open channel drains, tributaries and rivers. Provide advice on methods, benefits, costs and priorities for removal and remediation. Continue to monitor water levels in the Avon/Ōtākaro, Heathcote/Ōpāwaho and Styx/Pūharakekenui Rivers.

Sediment removal in rivers and tributaries

When ecological advice requires it, remove sand and silt in controlled and ecologically sensitive ways from areas with significant liquefaction. Methods should minimise movement of sand/silt to settle downstream. In some places, stony substrate may need to be reinstated.

Erosion and sediment controls

Require the use of ECan's Erosion Control and Sediment Management guidelines, and compliance with contaminated site requirements when earthworks, excavations and foundation works are undertaken, and during recovery works, such as bank stabilisation and bridge repairs.

7. Rehabilitate, restore and enhance wetlands changed by the earthquakes

Mapping, inventory, rehabilitation of existing wetlands

Map and assess the state of existing wetlands. Identify and prioritise wetlands or areas within wetlands for rehabilitation, enhancement or extension because of the earthquakes, to provide for biodiversity, habitat diversity, and cultural, recreational and educational opportunities. Plan for future changes including sea level rise, increased climate variability and changes in land surface level. Use to Inform planning, design and development of riparian and wetland areas.

8. Act on opportunities to reduce sewage overflows and their effects

Reduce the incidence of sewage overflows

During rebuild, improve wastewater infrastructure to reduce/avoid the frequency and volumes of wet weather sewage overflows directly to waterways. In emergency situations a risk-based approach is required to assess options that are available, and the best outcome for public health might be surface water discharge. The pLWRP Policy 4.9(a) and (e) requires that there are no direct discharges to surface water bodies of untreated sewage, wastewater or bio-solids or untreated industrial or trade waste; and Rule 5.64: The discharge of treated sewage effluent into surface water or a natural wetland is a non-complying activity.

Reduce the effects of sewage overflows

Install systems to minimise the effects of sewage overflows on waterways.

Develop waterway rehabilitation plans to rehabilitate the effects of significant and prolonged emergency sewage discharges into a waterway following a disaster.

9. Protect groundwater and springs

Land use controls to protect groundwater

Ensure land use controls over the unconfined aquifer. Track effects of earthquakes on groundwater quantities.

Investigate and assess foundation systems and their potential effects, including timber and other piling materials. If investigations warrant it, control the types of piling systems able to be used near drinking water sources.

Springs and daylighting streams

Encourage and promote the retention of natural springs to enable spring water to flow into streams and rivers – rather than directing the flow to engineered stormwater systems. Ensure springs are mapped and recorded.

As opportunities and funding permit, daylight environmentally significant or important streams by restoring streams previously diverted into a culvert, pipe or drain to a naturalised open waterway. Ensure the risk of lateral spread is managed for properties adjoining these streams.

10. Control weeds and pests that have potential to affect biodiversity, or have impact on health and safety

Control of weeds and pests

Extend existing strategies and programmes for controlling weeds and pests to earthquake-affected areas. Provide increased funding and resources as required.

11. Assess, retain and enhance biodiversity

Assess, plan, rehabilitate and monitor highest-value ecosystems

Conduct ecological assessment of protected areas and highest-value ecosystems and species that have been affected by the earthquakes. Identify what is required to rehabilitate and improve these areas, ecosystems, habitats and species. Publish maps of biodiversity hot spots so caution is taken to protect these hot spots in remediation.

Biodiversity corridors and reserves

Investigate and recommend sites of adequate area suitable for development of biodiversity corridors and reserves. Promote the use of indigenous plants in the restoration. Investigate the establishment of an eco-sanctuary in available land along Avon River/Ōtākaro

Inanga spawning areas

Determine location of saltwater wedge in rivers/streams changed by earthquakes. Use information and existing knowledge to locate inanga spawning sites. Where required, remove liquefaction silt from inanga spawning areas, erect silt-trapping fences, establish appropriate spawning vegetation, re-grade banks and re-plant. Continue control measures for aquatic weeds.

12. Support community gardens, local food production and urban forestry

Community gardens, local food production and urban forestry

On available land, support the development of community gardens, orchards and local food production. Assess proposals for larger developments for their effects on the environment.

13. Provide access to and opportunities for outdoor recreation

Promote current facilities that are available

Promote and advertise facilities/tracks that are open and available for use, including those accessible to people with disabilities. Provide on-site signage to indicate the status of the facilities/tracks, and clearly indicate detours.

Recreation corridors and networks

Undertake feasibility studies for providing source to sea/Ki Uta Ki Tai recreation corridors along rivers, on coast and around city perimeter, accessible to people with disabilities as appropriate, with links to other open spaces/areas and recreational transport routes.

Repair/improve existing paths/tracks and build new ones. Signpost paths/tracks to show connections. Ensure adequate visual and physical connection to waterways through sensitive provision and sympathetic landscaping, e.g., boardwalks, ramps, tracks, jetties, open space areas.

Maintain and develop recreation facilities

Support maintenance and improvement of recreation access and networks. Support integrated recreation facilities and hubs, heritage trails, access onto waterways, open spaces and landscaping for active and passive uses. Consider the establishment of water sports areas and facilities on or alongside Avon River/Ōtākaro.

Provide for passive recreation, visual amenity and community wellbeing during rebuild

Provide for visual amenity functions of natural areas, enhancing aesthetics of areas and highlighting features to enhance people's sense of place. Support opportunities for quiet appreciation as well as community interaction, interpretation, and learning about environmental and cultural heritage.

14. Manage earthquake waste

Waste monitoring

Improve the monitoring and tracking of earthquake-related waste to understand how waste is being managed and identify gaps and opportunities for improved management. Maintain strong data links with waste carriers, processing facilities and disposal sites.

Waste disposal

Monitor, enforce and manage aftercare of storage, sorting and disposal site.

Increased recycling

Maximise recycling at or near the source. Encourage reuse and recycling of demolition materials. Encourage new technologies and methods for end-of-life reuse, recycling or recovery of difficult waste streams such as treated timber.

Controlling illegal dumping

Reduce illegal dumping by increasing compliance monitoring and enforcement.

Waste management plans

Prepare waste management plans for future disasters that are likely to produce large quantities of waste and other material.

15. Manage contaminated sites

Identification of Hazardous Activities and Industries List (HAIL) sites

Undertake a programme of HAIL site identification to ensure earthquake recovery works that involve earthworks, or redevelopments, are able to progress with minimal environmental impact.

NES for contaminated land

Inform and educate on the requirement to comply with the NES which will be triggered by planned or actual land use changes, subdivision, soil disturbance and sampling, and removal of fuel storage tanks.

16. Track earthquake effects on emissions and air quality

Monitoring and investigation of air quality

Gather data on changes to heating appliances in use to enable air quality projections to be made for Christchurch, Kaiapoi and Rangiora. Continue monitoring of ambient air quality in Christchurch, Kaiapoi and Rangiora. Undertake additional monitoring of PM_{2.5} and analysis of the components of PM₁₀ to assist with determining the source of particulate matter. Assess performance, resilience, sustainability and cost of alternative sources, e.g., ultra-low emission wood burners. Provide dispersion modelling of Christchurch, Kaiapoi and Rangiora to help predict likely effects of changes in wood burner numbers, locations of houses, locations of industry etc.

Air Plan compliance

Continue to apply the policies, methods and rules of the Air Plan with the aim of meeting the NES requirements (Christchurch and Kaiapoi no more than three exceedances per year by September 2016 and no more than one exceedance by 1 September 2020; and Rangiora no more than one exceedance per year by September 2016).

17. Act on opportunities to restore and enhance mahinga kai

Progressively enhance and restore mahinga kai resources and sites and the traditions of customary use associated with such resources, by continuing to develop Ngāi Tahu led restoration projects; creating mahinga kai cultural parks; organising wānanga to teach tamariki about mahinga kai traditions; and investigating mahinga kai opportunities for existing protected areas, proposed restoration projects and open place/reserve settings. Promote the principle of Ki Uta Ki Tai as a culturally appropriate approach to mahinga kai enhancement, restoration and management, in particular management of whole ecosystems and landscapes, in addition to single species; and the establishment, protection and enhancement of biodiversity corridors to connect species and habitats.

Establish pā harakeke and gardens with weaving plants, rongoā and native plantings.

Residents associations and region wide NGOs

Beckenham Neighbourhood Association
 Roimata Community
 Southshore Residents Association
 Project Lyttelton
 CanCern
 One Voice Te Reo Kotahi
 Sustainable Ōtautahi Christchurch
 Canterbury Community Trust

Universities, scientists and consultants

Aquatic Ecology Ltd
 EOS Ecology
 Lucas Associates
 Wildlands
 Institute of Environmental and Scientific Research (ESR)
 Landcare Manaaki Whenua
 National Institute of Water and Atmosphere (NIWA)
 Lincoln University
 University of Canterbury
 WaterWays Centre for Freshwater Management
 Natural Hazards Research Platform

Central and local government

Canterbury Earthquake Recovery Authority (CERA)
 Department of Conservation
 Ministry for the Environment
 Ministry of Culture and Heritage
 Community Public Health
 North Canterbury Fish and Game
 Sport NZ
 Christchurch City Council
 Environment Canterbury
 Selwyn District Council
 Kaiapoi Community Board

Recreation and Sport

Arawa Canoe Club
 Canterbury Rowing Association
 Christchurch Singletrack Club
 Coastal Pathway
 Sport Canterbury
 Waka Ama
 Waimakariri Sailing and Power Boat Club

Industry

Canterbury Waste Services Ltd
 Home Heating Association
 Trans Pacific Industries
 Transwaste Canterbury
 Canterbury Employers Chamber of Commerce

Iwi and Rūnaka

Mahaanui Kurataiao Ltd
 Ōnuku Rūnanga Inc.
 Te Hapū o Ngāti Wheke
 Te Ngāi Tūāhuririri Rūnanga
 Te Rūnanga o Koukourārata
 Te Taumutu Rūnanga Society Inc.
 Wairewa Rūnanga Incorporated

Environmental, Conservation and Heritage

Banks Peninsula Conservation Trust
 Canterbury Botanical Society
 Community Energy Action
 Forest and Bird
 Green Effect Trust/Trees for Canterbury
 Ornithological Society
 Summit Road Society
 Te Ara Kākāriki
 Te Kōhaka o Tūhaitara Trust
 Travis Wetland Trust
 Waihora Ellesmere Trust
 Waiora Landscapes
 NZ Historic Places Trust

Water issues groups and zone committees

Ashley-Rakahuri Committee
 Banks Peninsula Zone Committee
 Christchurch West Melton Zone Committee
 Lyttelton Harbour/Whakaraupō Issues Group
 Selwyn Waihora Zone Committee
 Waimakariri Zone Committee
 Avon Heathcote Estuary Ihutai Trust
 Avon Ōtākaro Network
 Okeover Stream group
 Styx Living Laboratory
 Water Rights Trust

Acts of Parliament

Resource Management Act 1991

Health Act 1956

Building Act 2004

Hazardous Substances and New Organisms Act 1996

Local Government Act 1974

Local Government Act 2002

Conservation Act 1987

Reserves Act 1977

Iwi management plans

Te Whakatau Kaupapa 1992

Mahaanui Iwi Management Plan - March 2013

Ngāi Tahu Freshwater Policy

Ngāi Tahu Hazardous Substances and New Organisms Policy 2008

Hazards and climate change

MfE (2008) Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand

MfE (2008) Coastal hazards and climate change: A guidance manual for local government in New Zealand

CCC (2010) Climate Smart Strategy

GNS – 6 technical reports on rockfall and cliff collapse hazard

ECan – active fault studies for WDC, SDC started

Drilling programme investigating landslides, and inclinometers installed for monitoring land movement – CCC

TC3 EQC /Insurers drilling programme

MBIE guidelines on TC3 foundations

CCC – Investigation of land stability in Port Hills and Banks Peninsula

ECan – Investigation of liquefaction potential in SDC, WDC, CCC

EQC, T&T, GNS – Mapping of depth to shallow groundwater for liquefaction risk assessment

ECan – Reassessment of inundation/evacuation zones for tsunami

CCC – Report into damaged ground, potential landslides

ECan – Report on risk of groundwater contamination from treated wood piling systems in TC3 zones

Coasts and estuaries

ECan/NIWA – Hydrodynamic/morphodynamic model of the estuary being developed

Ihutai Management Plan 2013

Waihora Ellesmere Trust Community Strategy 2003

Whakaora te Waihora 2011

Te Waihora Joint Management Plan

Waste

NZ Waste Strategy 2010

Waste Minimisation Act 2008

Canterbury Hazardous Waste Management Strategy

CCC, WDC and SDC – Waste Management and Minimisation Plans

Construction and demolition waste management

RRZ Household Hazardous Waste Programme

Contaminated land

Contaminated Land Management Strategy 2008

Contaminated Land Information Management Strategy

Government plans and strategies

Recovery Strategy for Greater Christchurch - Mahere Haumanutanga o Waitaha – CERA 2012

Regional plans and strategies

Regional Policy Statement (RPS)

Natural Resources Regional Plan (NRRP)

Proposed land and Water Regional Plan (pLWRP)

Canterbury Water Management Strategy (CWMS)

Regional Implementation Programme (RIP)

Zone Implementation Programmes (ZIPs)

District plans

CCC, WDC and SDC District Plans

Flood management and land drainage

MfE (2010) Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand

CCC – Land Drainage Recovery Programme for Dudley Creek, Wairarapa Stream, Wai-iti Stream 2012–13

ECan – Halswell floodplain investigation 2012

Heathcote River Floodplain Management Strategy 1998

Mid-Heathcote River/Ōpāwaho Linear Park Master plan: 2009

Waimakariri District Flood Hazard Management Strategy 2003

ECan – Ashley River floodplain investigation 2008

ECan (2010) Sediment Control and Earthworks Guidelines 2010

CCC (2003) Waterways, Wetland and Drainage Guide 2003

CCC Surface Water Strategy

CCC (2012) Draft Wastewater Strategy 2012

SDC (2009) 5 Waters Strategy 2009

Stormwater Management Plans – various

WDC – Stormwater Bylaw 2011

Groundwater/water supply	Recreation
CCC (2009) Water Supply Strategy 2009	CCC (2010) Public Open Space Strategy 2010
Biodiversity	Spaces & Places Plan for Sport and Recreation in Greater Christchurch 2012
The NZ Biodiversity Strategy 2000	CCC (2006) Aquatic Facilities Plan 2006
Canterbury Biodiversity Strategy	CCC Metro Sport Facilities Plan
Canterbury Regional Pest Mngt Management Strategy.	CCC Public Open Space Strategy
CCC Biodiversity Strategy	National Environment Standards
CERA's Residential Red Zone Vegetation retention methodology	NES for contaminated land
Land and Vegetation Regional Management Plan	NES for air quality

Technical reports

Barr et al. (2012)	Effects of the Canterbury earthquakes on Avon-Heathcote Estuary/Ihutai macroalgae http://ecan.govt.nz/publications/Reports/effects-canterbury-earthquakes-avon-heathcote-estuary-ihutai-macroalgae.pdf
Christchurch City Council (2012)	Rockfall, rock roll and landslides – multiple reports http://www.ccc.govt.nz/homeliving/civildefence/chcheearthquake/hillsidecrackrepairs.aspx
Christchurch City Council (various dates)	Wastewater overflow information Retrieved January 2013 An assessment of the effects of overflows <i>Includes locations, flows, contaminants, effects</i> 2012 Wastewater overflow information for Christchurch <i>Sites and dates where overflows occurred in 2012 and reasons why</i>
Christchurch City Council and CERA (2012)	Flood spread maps Retrieved December 2012 from http://maps.cera.govt.nz/advanced-viewer/?Viewer=Ccc-Floor-Levels <i>Maps showing flood spread and floor levels for 50 and 100 year average return interval events with 0.5m sea level rise.</i>
Christchurch City Council and Environment Canterbury (2011a)	Ecological effects of the Christchurch February earthquake on our city rivers http://ecan.govt.nz/publications/Reports/eq-effects-summary-river-lowres.pdf <i>Studies looked at aquatic ecosystems in Avon River/ Ōtākaro and Heathcote River/ Ōpāwaho to find out the extent of earthquake changes and to assess what could be done about them.</i>
Christchurch City Council and Environment Canterbury (2011b)	Ecological effects of the Christchurch February earthquake on our city estuary http://ecan.govt.nz/publications/Reports/eq-effects-summary-estuary-lowres.pdf <i>The earthquakes changed land height and the shape of the Avon-Heathcote Estuary/Ihutai bed. There was liquefaction throughout the estuary and input of sewage. Studies quantified the degree of change and effects on ecosystems.</i>
Christchurch City Council and Environment Canterbury (2012)	Wastewater overflows: compliance strategy agreement for wet weather wastewater overflows to rivers http://ecan.govt.nz/publications/General/compliance-strategy-agreement-wastewater-overflows.pdf <i>Agreement between the parties with supporting information on the CCC sewerage system and effects of the earthquakes and rebuilding. The strategy gives the City Council 5 years' relief from compliance requirements with its current overflow discharge consent to allow monitoring of the impact of SCIRT's rebuild on overflow compliance and to develop and implement a network upgrade programme to comply with the consent overflow containment requirements.</i>
Environment Canterbury (2007 to 2012)	Healthy Estuary and Rivers of the City programme Retrieved January 2013 from http://ecan.govt.nz/get-involved/local-projects-community-groups/avon-heathcote-estuary-ihutai-trust/Pages/healthy-estuary-rivers-christchurch.aspx <i>The most recent reports (as at January 2013) from the link above related to the earthquakes are shown below.</i> R12/77 Heavy Metals in fish and Shellfish 2012 Survey R12/110 The sediments and biota of the Avon-Heathcote Estuary/Ihutai and tidal reaches of the Avon and Heathcote rivers - Summary report on data collected in 2011 R12/111 Water quality for contact recreation - Summary report on data collected over the summer of 2011-12 R12/112 Water quality of the Avon and Heathcote rivers - Summary report on data collected in 2011 R12/113 Water quality of the Avon-Heathcote Estuary/Ihutai - Summary report on data collected in 2011

Environment Canterbury (2011)	Groundwater status reports http://ecan.govt.nz/services/online-services/monitoring/Pages/effects-groundwater.aspx <i>Three reports on effects of the earthquake sequence on groundwater. The third includes results from the previous two and overall conclusions: see the link below, retrieved in January 2013:</i> http://ecan.govt.nz/publications/General/earthquake-impacts-groundwater-update-3-010911.pdf
Environment Canterbury (2012),	Canterbury regional urban stream sediment and biofilm quality survey Retrieved in January 2013 from http://ecan.govt.nz/publications/Reports/r12-5-canterbury-urban-stream-sediment-biofilm-survey.pdf <i>Lower concentrations of copper, lead and zinc were found in April–May 2011 compared with previous surveys. Elevated concentrations of zinc had persisted in Heathcote River/ Ōpāwaho. Also provides descriptions of catchments, stormwater and its contaminants and their effects.</i>
GNS Science (2012)	From warnings to effective response and recovery Proceedings of the 6th Australasian Natural Hazards Management Conference 21–22 August 2012, University of Canterbury. GNS Science Miscellaneous Series 45. 74 p. Retrieved in January 2013 from http://www.hazardseducation.org/conference/2012/6th%20ANHMC%20Proceedings%20v2.pdf . <i>Abstracts of papers covering a very wide cross section of hazards-related issues</i>
Hicks, M et al. (2011)	Mapping earthquake induced topographical change and liquefaction in the Avon–Heathcote Estuary http://ecan.govt.nz/publications/Reports/eq-effects-estuary-topography-liquefaction-niwa.pdf
Hudson, R H (2010)	Cam River enhancement – issues and options Environmental Management Associates, Christchurch. Report 2010-03 for Waimakariri District Council. Retrieved from; http://www.waimakariri.govt.nz/Libraries/Agendas/Utilities_and_Roading_Committee_18_December_2012.sflb.ashx Page 18
Hudson, R H (2011)	Kaiapoi River rehabilitation and enhancement – issues and options Environmental Management Associates, Christchurch. Report 2011-07 for Waimakariri District Council. http://waimakariri.govt.nz/libraries/Public_Documents/Kaiapoi_River_rehabilitation_and_enhancement_Issues_and_Options_V1_o_received_18th_July_2011_by_Dr_Henry_Hudson.sflb.ashx
Institute of Environmental Science and Research Limited (ESR) (2012a)	Natural Environment Recovery Programme: A summary report on a stakeholder workshop for Environment Canterbury Monday 8 October 2012 by Graeme Nicholas and Jeff Foote, Institute of Environmental Science and Research Limited (ESR) www.ecan.govt.nz/nerp
Institute of Environmental Science and Research Limited (ESR) (2012b)	Natural Environment Recovery Programme: A summary report on a stakeholder workshop for Environment Canterbury Monday 8 October 2012 by Graeme Nicholas and Jeff Foote Institute of Environmental Science and Research Limited (ESR) www.ecan.govt.nz/nerp
Institute of Environmental Science and Research Limited (ESR) (2012c)	Natural Environment Recovery Programme: A Summary Report for participants on a stakeholder workshop for Environment Canterbury, Thursday 6 December 2012 by Graeme Nicholas , Ann Winstanley , Jeff Foote www.ecan.govt.nz/nerp
Institute of Environmental Science and Research Limited (ESR) (2012d)	Natural Environment Recovery Programme: Report on a stakeholder workshop for Environment Canterbury, Thursday 6 December 2012 by Graeme Nicholas , Ann Winstanley , Jeff Foote www.ecan.govt.nz/nerp
James, A and McMurtrie, S (2011a)	Christchurch February earthquake: effect on aquatic invertebrates http://ecan.govt.nz/publications/Reports/eq-effects-invertebrates-upper-avon-eos.pdf
James, A and McMurtrie, S (2011b)	Christchurch February earthquake: effect on freshwater fish of the upper Avon River http://ecan.govt.nz/publications/Reports/eq-effects-fish-upper-avon-eos.pdf
James, A and McMurtrie, S (2012)	Post-quake ecology of the lower Avon River: current state of the fish and invertebrate community http://ecan.govt.nz/publications/Reports/post-quake-ecology-lower-avon-river-0712.pdf
McMurtrie, S (2011)	Christchurch February earthquake: effect on invertebrates of the lower rivers http://ecan.govt.nz/publications/Reports/eq-effects-invertebrates-lower-rivers-eos.pdf
Rutherford, J C and Hudson, N (2011)	Effects of wastewater overflows on oxygen and ammonia in the Avon and Heathcote rivers ECan Report No. U11/8 http://ecan.govt.nz/publications/Reports/eq-effects-river-modelling-effects-sewage-discharges-niwa.pdf
Taylor, M and Blair, W (2011)	Effects of seismic activity on Inanga spawning grounds on city rivers http://ecan.govt.nz/publications/Reports/eq-effects-inanga-spawning-groundAs-ael.pdf
Zeldis et al (2011)	Effects of the Canterbury earthquakes on Avon–Heathcote Estuary/Ihutai ecology ECan Report U11/14 http://ecan.govt.nz/publications/Reports/eq-effects-niwa-estury-biota.pdf

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