TE MAHERE WHAKAHAUMANU O AHURIRI / AHURIRI LAGOON RESTORATION PLAN

August 2016

WHAKAIHI / DEDICATION

The Ahuriri Lagoon Restoration Plan is dedicated to Te Whe Philips (Te Hapū o Ngāti Wheke) and Colin Arps, whose passion and input were valuable contributions to the development of this Plan, and who both passed away before this Plan was completed.

NGĀ MIHI / ACKNOWLEDGEMENTS

Many people have been involved in, driven, and maintained an enthusiasm and vision for the rehabilitation of the Ahuriri Lagoon. From various walks of life, view points and interests their contribution has been vital to where we are now. In alphabetical order, and please excuse any omissions, thanks go to:

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A full list of all of those involved in the development of this plan can be found in Appendix A (Ahuriri Lagoon Restoration Plan Development Process).

Cover photo: The Ahuriri Lagoon area during the June 2013 flood, with Te Ahu Pātiki/Mt Herbert in the background.

RĀRANGI UPOKO / CONTENTS

1. HE KUPU WHAKATAKI / INTRODUCTION

The Ahuriri Lagoon Restoration Plan has been developed to provide a road map for the restoration of Ahuriri Lagoon. This Plan is a living document that will grow and evolve over time. Although the restoration of the Lagoon needs to be viewed in the wider geophysical, cultural and ecological context in which it exists, and within the ange of management issues affecting the site (such as access, surrounding landuse, and mahinga kai values), this Plan is focussed on restoration actions for the Environment Canterbury endowment land that are the Ahuriri Reserves. It is envisioned that the linkages with the greater landscape, and the management of the other issues for the site, will grow from this Plan or be the subject of other plans and/or works.

There has been community interest in the possibility of restoring the Lagoon within the Ahuriri Reserves for many years, and in 2014 a partnership was formed between Papatipu Rūnanga, the Te Waihora Management Board, Te Rūnanga o Ngāi Tahu, Department of Conservation, and Environment Canterbury to progress the development of a 20 year restoration plan for this purpose.

The Ahuriri Reserves, which take in a large extent of the former Ahuriri Lagoon area, are situated in a strategic location between Te Waihora/Lake Ellesmere and Christchurch City (Figure 1), and are by far the most significant wetland habitat in the Greenpark-Tai Tapu-Halswell-Christchurch Lowlands outside of Te Waihora itself.

Figure 1: The location of Ahuriri Lagoon.

Ahuriri Reserves cover approximately 250ha of Environment Canterbury endowment land (Figure 2). The Ellesmere Land Drainage Act of 1905 transferred the responsibility for the Halswell River Drainage District and its endowment lands from Selwyn County to the Ellesmere Land Drainage Board. The Ahuriri Lagoon area was added to these endowment reserves. In 1912, an amendment to the Ellesmere Land Drainage Act endowed a further area of Ahuriri land to the Board. The lands were vested to Environment Canterbury "as an endowment to provide funds for the purpose of removing obstructions to the flow of the Halswell River through Lake Ellesmere to the sea". Today they function as an attenuation basin and an important part of the Halswell River Rating District management.

These wetlands were once part of the Ahuriri Lagoon within the Reserve and are now fed from nearby springs and the Huritini/Halswell River. Pre-drainage of the Ahuriri Lagoon (Figure 3), a land area of approximately 194ha, was surrounded by koraha (or mudflats) and together these provided a significant mahinga kai resource (Appendix B). The large harakeke wetland also gave rise to a large flax mill that operated during the mid to late 19th century. This Ngāi Tahu mahinga kai area was formally recognised in the 19th Century through the establishment of the Ahuriri Fenton Reserve, Te Koraha, which is adjacent to the Environment Canterbury endowment lands.

In the middle of the Environment Canterbury endowment lands there is small land parcel that is a Department of Conservation (DOC) reserve called 'Ahuriri Lagoon Conservation Area'. The implementation of any actions in this reserve requires DOC approval and involvement.

Ahuriri Lagoon as a wetland has been neglected, poorly managed and largely forgotten by all but those who live close by. Drainage and swamp clearance has removed much of the original vegetation cover and the progressive incursion of farming operations has eroded the acreage of wetland habitat until today little more than ten hectares remain. The larger extent of Ahuriri Lagoon is still a wet environment, comprising: a core area of rushland; a narrow strip of mixed native/exotic riparian vegetation along the Halswell Canal; pockets of willow woodland and a large expanse of lowland wet grassland which is subject to ephemeral surface-water ponding following periods of heavy rainfall. Its large size, remnant area of rushland, lowland wet grassland habitats and ephemeral ponding habitats are utilised by a range of wetland birds and form part of one of New Zealand's most important bird movement corridors (Crossland, 2008).

Figure 2. Looking west across the Ahuriri Lagoon / Ahuriri Reserves area (photo credit: Brian Dimbleby).

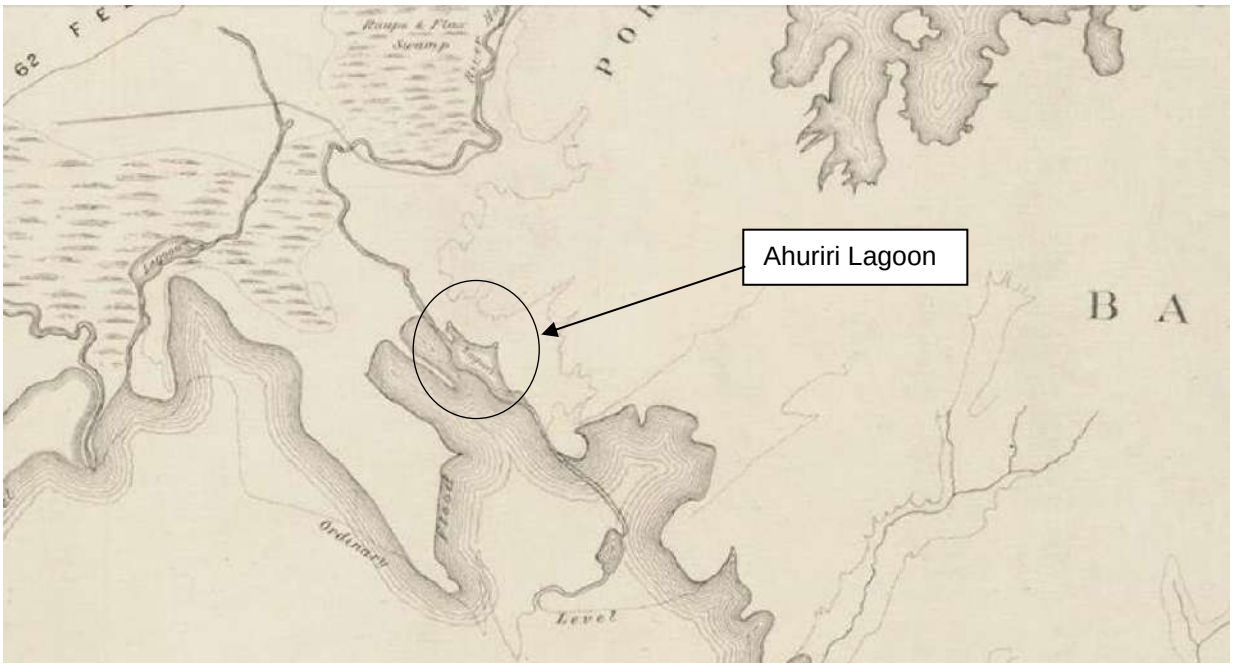


Figure 3. The location of Ahuriri Lagoon, pre-drainage, in 1865.

2. WHAKATAKOTO / VISION AND STRATEGIC DIRECTION

In 2014 the Huritini – Lower Halswell River Vision Document was endorsed by the Te Waihora Co-Governance Group outlining outcomes, recommendations and actions to provide current and future generations with sustenance, identity and enjoyment.

The Vision document outlined recommendations for improvement of the entire lower Huritini-Halswell catchment (including Ahuriri Lagoon, McQueens Lagoon and the old Huritini/Halswell River channel) to be implemented over a 40 year period to achieve the following outcomes:

- The reinstatement and restoring of Ahuriri Lagoon as a wetland of significance in the Canterbury region;
- Well informed community in the Huritini – Lower Halswell catchment;
- The state of the Huritini – Lower Halswell River cultural ecosystem is well monitored and understood;
- Enhanced in-stream, riparian and wetland habitat;
- Improved qualities, quantities and health of Mahinga Kai;
- Current land management practices are not comparible with the aims and outcomes of this document (the Huritini – Lower Halswell River Vision Document);
- Flourishing indigenous vegetation and fauna populations are improved and enhanced including linkages of indigenous corridors; and,
- A healthy thriving cultural ecosystem downstream in Te Waihora that is enhanced by the Huritini Halswell River.

The overall 40 year vision for the area was for it to be 'A fully functioning Mahinga Kai'. This vision, and the outcomes noted above, generally align with the vision for the wider catchment and that for Te Waihora/Lake Ellesmere. The restoration of the Lagoon (Figure 4) cannot be initiated or completed in isolation and needs to be viewed in the wider geophysical, cultural and ecological context in which it exists. There are many interest groups associated with the Lagoon and it will be difficult to satisfy all parties' needs. However, numerous studies have been completed on Ahuriri Lagoon in the past (Table 1, and References), all generally coming up with similar conclusions and actions. This Plan aims to provide a clear direction and synthesis of previous studies to provide a clear way forward.

In developing this Plan, it became apparent that there is enthusiasm from the community, represented in the Ahuriri Steering Group who have developed this Plan, and opportunity to enhance previous work completed on the site as well as put in place the mechanisms for the future restoration of the Lagoon to something that approaches the historical ecosystem that occurred on site. As part of the development process for this Plan, the site has been assessed, which identified: areas requiring varying degrees of input with regard to restoration; knowledge gaps; opportunities and, associations that can be developed through detailed design and management to recreate Ahuriri Lagoon into a fully functional wetland, that address the needs of the community and achieves the outcomes listed above.

Figure 4. Looking east across the Halswell Canal and the Ahuriri Lagoon / Ahuriri Reserves area (photo credit: Craig Pauling).

3. WHAKAHAERE RAUEMI / CURRENT MANAGEMENT

Environment Canterbury manage the land that is Ahuriri Reserves on behalf of the Huritini/Halswell River rating area. Management actions can be divided into reserves land management, river management, and other works including investigations and biodiversity plantings (Table 1).

Since Environment Canterbury/Canterbury Regional Council came into being in 1986, some wetland areas have been further protected through retirement from all grazing. In recent years the Ahuriri Reserves grazed areas have been kept on short term grazing licences of five-year terms or less. During the development of this Plan, the licences have been renewed on an annual basis. This allows greater flexibility in implementing any land management changes proposed in the final version of the Ahuriri Lagoon Restoration Plan. As the status remains as endowment land for the benefit of the rating area, it is hoped that there will still be areas for leased grazing available within the future management parameters. The farmer licensees are aware that the future management is being reviewed, but would still need reasonable notice if further areas are lost to grazing. These farmers have been seen as partners in the management of this land and have bought into existing licences. They will also own improvements on these licences (e.g. water supply and fences), and so are seen to have a stake in the land. On areas retired from grazing some improvements may have to be allowed to be removed by the licensee or some compensation negotiated if it is decided there is a benefit to Environment Canterbury for them to remain.

In addition, a rail trail cycle way was constructed in 2012 through the Ahuriri Reserves to become part of the Little River Rail Trail (Table 1). This Rail Trail cycleway is managed by the Department of Conservation and the Little River Rail Trail Trust, but the section through the Ahuriri Reserves is managed and maintained by Environment Canterbury.

Table 1. A summary of works undertaken at Ahuriri Reserves.

Reserves management Environment Canterbury: • Manages the grazing licences within the Ahuriri Reserves area. The licences for these leases are currently renewed on an annual basis. Any weed control on leases is undertaken by the licensees. • Responds to customer enquiries relating to any issues regarding Ahuriri Reserves.
River management Environment Canterbury: • Manages the Halswell/Huritini River to ensure efficient drainage of the area. This requires water monitoring of levels and periodic work removing water weeds/macrophytes and other obstructions (e.g. debris and sediment).
Investigations Environment Canterbury has commissioned or undertaken the following investigations: • Crossland, A. 2008. Ahuriri Lagoon. Wildlife Values and Habitat Restoration Potential. Unpublished report prepared for Environment Canterbury. • EOS Ecology. 2015. Freshwater Ecological Values of the Ahuriri Reserves. Report prepared for Environment Canterbury. • Golder Associates. 2014. Ahuriri Reserves: Water level assessment to support restoration planning. Report prepared for Environment Canterbury. • Grove, P. 2010. Proposals for enhancement of wetland and riparian habitats in the 'Ahuriri Lagoon' Reserves. Environment Canterbury internal report. • Grove, P and Cochrane, P. 2012. Management of recently-retired Environment Canterbury endowment land at Ahuriri Reserves. Environment Canterbury internal report. • Grove, P. 2012. Report on the inspection of Environment Canterbury endowment land at Ahuriri Reserve. Environment Canterbury internal report.
Biodiversity plantings • The Whakaora Te Waihora programme has planted four sites within Ahuriri Reserves. Whakaora Te Waihora is a joint programme between Environment Canterbury, Te Rūnanga o Ngāi Tahu, and the Ministry for the Environment, and operates under a co-governance agreement between Environment Canterbury, Te Rūnanga o Ngāi Tahu, Selwyn District Council, and Christchurch City Council. The vision of the programme is "To restore and rejuvenate the mauri and ecosystem of Te Waihora (Lake Ellesmere) so that the Lake continues to provide current and future generations with sustenance, identity and enjoyment that it has to those in the past". To work towards achieving this vision, the programme has initiated works for biodiversity, science, engineering, culture, extension, communications. Amongst the biodiversity works the programme has planted a number of sites with native plants, including the four sites within the Ahuriri Reserves, which will help to increase habitat for native species and reduce sediment and nutrient inputs into the Lake. • Environment Canterbury planted and manages all plantings along the Rail Trail cycleway through Ahuriri Reserves.

Table 1 continued. A summary of works undertaken at Ahuriri Reserves.

Amenities
• The development and maintenance of the Little River Rail Trail and associated plantings.
• Brailsford, S. 2012. Restoration plan for the Little River Rail Trail Route through the Ahuriri Reserve. Report prepared for Waihora Ellesmere Trust and The Sustainable Drain Management Project.

4. TE TAKE ME TE ARATIKA / THE PROBLEM AND PROPOSED SOLUTION

4.1. The Problem

The reinstatement of historical ecosystems at the Ahuriri Reserves site in the form of a wetland or lagoon will require considerable augmentation, control, and management. As such, the naturalisation of the site is deemed 'constructed', as significant design, modelling, water level control, earthworks and native vegetation planting will be required to achieve the desired, long-term health of the Lagoon. The reinstatement of the Lagoon will not be achieved simply by flooding the land. To restore the Lagoon the site needs to be viewed within the wider context of the Te Waihora catchment and how it can be utilised to provide the vision and strategic outcomes in section 3 (Vision and Strategic Directions). Knowledge gaps need to be filled, which are outlined in section 4.2, in order to inform the detailed design and determine a pathway for additional works and expenditure.

4.2. The Solution

Ahuriri Lagoon can be restored to the vision in the Te Waihora Huritini – Lower Halswell River Vision Document, by implementing the actions in this Plan (section 5) to achieve the concept masterplan (section 4.3).

The concept masterplan was developed by discussing options with the Ahuriri Steering Group (Table 2), which were then presented in a design of the best-case scenario for the restoration of Ahuriri Lagoon (section 4.3).

This concept masterplan is a design of what could possibly be achieved, and investigations are required to fill knowledge gaps in order to determine what will be possible. These knowledge gaps are mostly around the existing geophysical character and water availability. Investigations required include:

- A water balance model (see section 4.2.1);
- Testing of site soils for salinity, plasticity, permeability etc.;
- Groundwater piezometers to assess groundwater conditions;
- Water level loggers to determine fluctuations in water level;
- Survey;
- An earthworks model (see section 4.2.2);
- Water quality assessment and modelling;
- Sediment budget assessment; and,
- Flood modelling.

4.2.1. Water Balance Model

The purpose of a water balance model is to confirm the ability of the wetland to perform satisfactorily from a hydrologic perspective, while maintaining appropriate plant cover despite climatic variations. There are dozens of examples of constructed wetlands and lakes where planted macrophytes have failed to thrive in the long term due to inappropriate hydrologic regimes, which lead to periods of prolonged inundation or drawdown and subsequent plant dieback from either drowning or drying out. This analysis should investigate inundation frequency and duration within the wetland to determine an optimum wetland bathymetry and hydraulic retention time to inform the preparation of wetland planting plans.

A water balance model relies upon daily rainfall runoff data exported from a proprietary model such as the MUSIC model. Rainfall data covering a maximum number of years, from the closest pluviometer station should be used. This analysis will allow determination of the average inundation in the wetland at varying depths, including average number of days water levels sit at or above the average Permanent Water Level of the adjacent Halswell Canal.

A limitation of the water balance model is that it is two dimensional and cannot fully account for incremental changes in water level, but rather assumes a shallow macrophyte bench surrounding a deep zone, however, the model is sufficient for determining inundation frequencies within macrophyte zones.

4.2.2. Earthworks Model

In response to the water balance modelling detailed above, an earthworks model will need to be prepared. This revised arrangement ensures the following is determined or achieved as a minimum:

- Macrophyte benches are typically 200mm to 300mm deep, apart from those zones transitioning in deep water zones;
- Greater than 50% macrophyte cover within the wetland as per the modelling and minimum requirements;
- Open water zones are at least 1.0m deep;
- A standing water level is determined;
- The wetland inlet/sedimentation zone size and depth determined;
- Batter grades; and,
- Planting media will be a minimum 250mm deep

Depending on the depth of excavations and the underlying soil profile, a geosynthetic or clay liner may be required. This would be subject to testing of site soils and confirmation by geotechnical engineer during the initial assessment. Existing site soils could be ameliorated during construction for use as planting media subject to guidance from a soil laboratory on appropriate amelioration methods.

The wetland bathymetry, or shape and depth of a wetland will be directly related to the availability of water and the seasonal variations that occur on site. From the water balance model a volume and frequency of events will determine the extents of the wetland and varying components i.e. extents of open water, depth, and macrophyte beds.

Ground water levels will also be a determining factor in the bathymetry and construction methodology. Intercepting ground water at shallow depths will negate the requirement for a liner but will also affect the outcomes of a water balance model. As suggested in the report ‘Ahuriri Reserves: water level assessment to support restoration planning’ by Golder Associates (June 2014), implementation of a ground water monitoring program to form a greater hydrological picture is required. In addition, a nominated action will be to install water level loggers in McCartney’s Road Drain and other drains entering the site from the northern, Port Hills side of the canal to determine if there is sufficient water entering the system from these drains as an alternative to tapping into the Haslwell Canal as a water source for wetland rehabilitation.

Additionally, wetland bathymetry must avoid conditions which encourage mosquito breeding, limit dead zones (stagnant or standing water), and needs to encourage movement of water through the system. The following principles have been applied to the earthworks design for pest mosquito control:

- Deep permanent water should be retained to provide refuge for mosquito predators;
- Natural water level fluctuations are required to disrupt mosquito breeding cycles;
- During dry periods, isolated pools should be avoided; and,
- Access requirements should be considered for maintenance and mosquito control.

Water level control will be an important part of providing a healthy wetland system determining the amount of water entering the system, the retention time of water within the wetland and thus, flows out of the wetland. Golder Associates (June 2014) determined a ponding water elevation of 1.65m would likely keep ponding extents within the Reserve boundary. This would need to be investigated within flood modelling, which will ultimately determine a water level that would not flood-affect the upstream catchment. This will in turn inform and consider detailed design of inline weirs or diversion structures, sedimentation basins, and erosion protection.

A variety of mechanisms for controlling water levels and/or flows are possible. A series of sketches were discussed at a meeting of the Ahuriri Steering Group on 30 March 2016 that conceptually illustrated a range of structure types, embankment locations, heights etc., which could be used to influence water levels and flows in various parts of the Lagoon and River. Table 2 below summarises the options discussed with the Ahuriri Steering Group, including the additional ideas explored during the discussion.

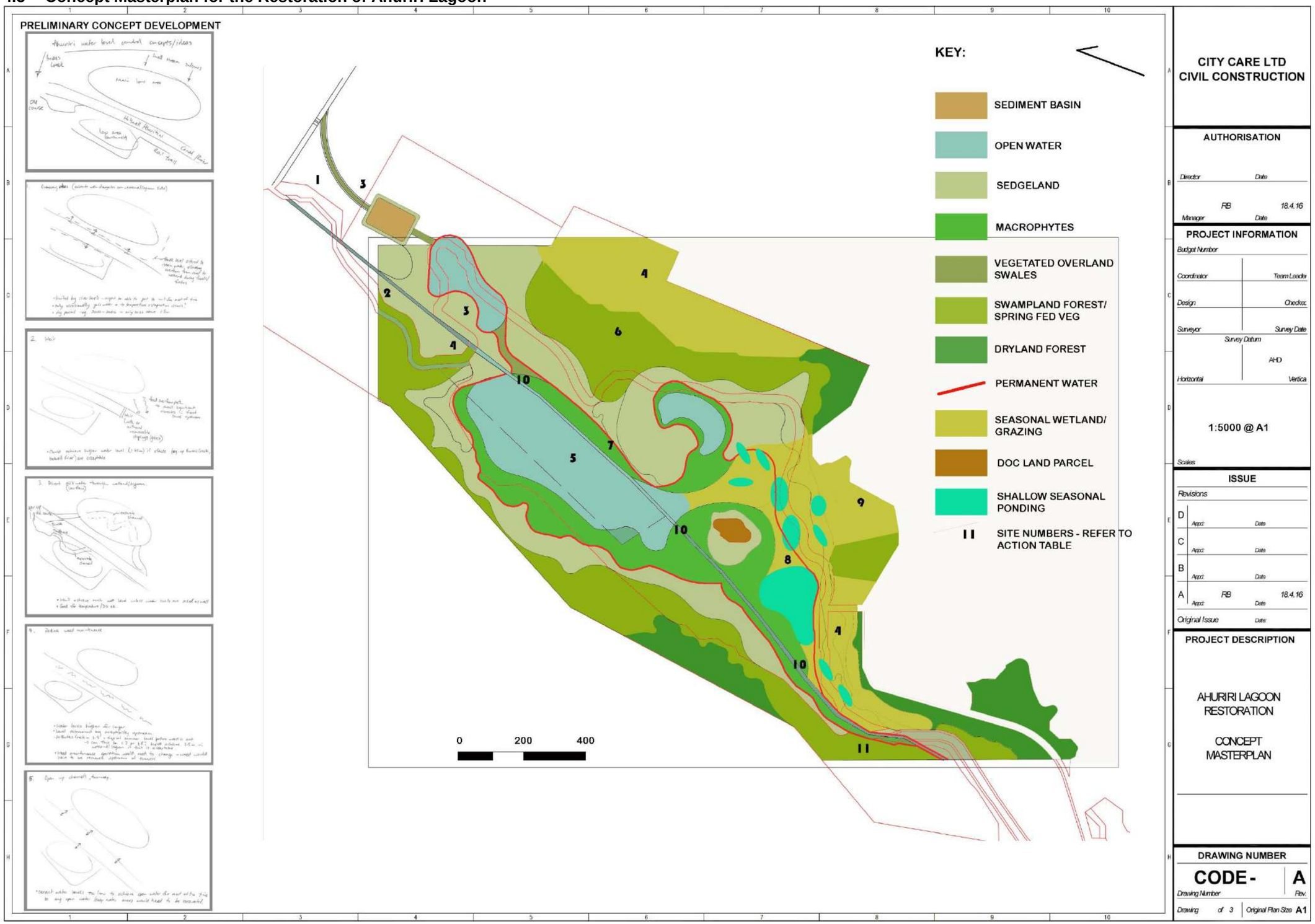
Table 2. Options discussed with the Ahuriri Steering Group on 30 March 2016, during the development of the concept design.

Options	Element	Description	Comments
1.	One way valves	Culverts would allow flow from the River to each side of the Lagoon, with a flap gate on the Lagoon side to prevent return flow.	Water level limited by river levels, may only occasionally allow water in. Could there be temperature/stagnation issues? There was a dry period between 2000-2005, where the water was only once above 1.5m. In this option the Huritini/Halswell River is not obstructed, so flood effects are limited to effect of higher volume of stored water, which is small compared to large flood volumes (Golder Associates, 2014).
	Bank levels	Bank levels altered to retain water to a certain level, allowing overflow from River to Lagoon and vice-versa during floods/freshes.	
2.	Weir	In-river structure to raise water levels, with or without removable stop-logs or gates.	Envisaged towards downstream end of Lagoon, but not as far downstream as Burneys Road, so that wide flood paths can bypass the weir at times of flood. Flood effects would need to be carefully modelled and understood.
	Flood overflow path		
3.	Diversion	Turn Huritini/Halswell River into the existing channels in the Lagoon, with the channels then widened. Block the existing straight path.	Won't achieve much open water unless water levels are raised as well, or lands excavated. Good for turnover of water within Lagoon. Longer flow paths may slightly increase drainage levels but could possibly increase flood capacity if channels large enough.
	Excavate channels		
4.	Reduce weed maintenance	Weed typically removed in main river when normal water level at Burkes Creek reaches about 1.5m. Raise this trigger level to approx. 1.7m. Leave more weed in this reach of River so that water level at low flows is higher.	Normal water level in Huritini/Halswell River would remain higher for longer. Would likely necessitate changes in practice for weed removal elsewhere on the River, e.g. install new weed barrier at or upstream of Burkes Creek to enable normal weed removal operation upstream of there. What would the effect be on flood levels – possibly very small.
5.	Open up channels	Increase connections between the Lagoon and Huritini/Halswell River on both sides.	Current water levels are too low to have much open water most of the time, so any open water or deep water areas would need to be excavated. Excavarions would be large/expensive.
	Excavation	Lower ground levels to increase frequency of inundation.	
6.	Divert Burkes Creek	Introduce water directly to north side of Lagoon.	Unknown if flows in Burkes Creek are sufficient to maintain a water level much higher than River level (if so, River inputs would be much reduced). High sediment load in Burkes Creek – it is likely that a sediment trap would be necessary, however, sediments are likely to be very fine so only a percentage will be able to be trapped. Need to divert Burkes Creek from a long distance upstream (near SH75), or raise water levels in Burkes Creek to enable diversion by gravity.
	Bank to limit overflows to Huritini/Halswell River	Existing outlets on north side blocked to retain water.	
7.	Groundwater inflow	Use a bore to deeper artesian aquifer to supply water.	Potential quantity/flow rate of water, seasonality, regulatory limits etc. would need to be investigated. Water quality likely to be generally higher than river or creek water.

At the 30 March 2016 meeting of the Ahuriri Steering Group, the consensus was that the concept design would require various combinations of the options in Table 1 for managing water level (Appendix A). There was a general preference towards achieving suitable water depth (and therefore quality) through excavation of ground rather than raising of water levels, so that flood effects could be more easily avoided. This may have cost implications which are not discussed at this stage, which in turn may limit, for instance, the area of open water that can be achieved. Raising of water levels to achieve greater open water is not discounted, but was not part of the emerging preferred option.

The concept masterplan for the restoration of Ahuriri Lagoon (section 4.3) was developed using LIDAR data to delineate zones (open water, sedge land, macrophytes etc.) and a water level of 1.65m, to create maximum static water. Existing vegetation and planted areas were also used to delineate boundaries and extents. The concept masterplan is a best case scenario for the restoration of the Ahuriri Lagoon without factoring in inputs required and outlined in section 4.2. Numerous inputs, from investigations, will determine the size and extents of the Lagoon and surrounding landscape.

4.3 Concept Masterplan for the Restoration of Ahuriri Lagoon



4.4. Constraints

Achieving the concept masterplan (section 4.3) will be constrained by the water level required to maintain areas of open water, while still not impeding drainage of the area or quality of the standing water.

The report 'Ahuriri Reserves - Water Level Assessment to Support Restoration Planning' (Golder Associates, June 2014) identified 1.65m as a maximum possible level of standing water that would avoid directly impacting neighbouring land. Above this level, standing water would back up into drains on neighbouring land. Even at this level, there may be some impediment to drainage of small areas of adjacent lands (although most is above 2m and would not be affected, except possibly in times of flood). Well drained flat land might typically have standing water in drains at least 300mm lower than the level of the land, so a desirable maximum from the neighbours' point of view might be around 1.35m.

The water level data indicates water levels currently reach 1.50m about 4% of the time (Appendix D). It is possible that a normal water level approaching this level could physically be achieved using gravity and rainfall alone (i.e. not pumping), however, the higher the standing water level, the less frequently it would be replenished, and there would occasionally be long periods with no replenishment. It would be very difficult to achieve good water quality at this level (i.e. 1.5m) even with, say, additional mechanical aeration and circulation (and the level would drop gradually in periods when evapotranspiration and seepage losses exceeded rainfall, groundwater and river inputs, which would be likely in dry periods). So water quality is a likely constraint on water level.

The flow capacity of the Halswell Canal and the floodplain (including the Lagoon areas) are important during times of flood. To avoid increasing flood levels, careful hydraulic design of any structures intended to divert or contain water will be needed. The banks alongside the Halswell Canal (made up of both natural deposits and sediment and organic material removed from the Halswell Canal artificially), the Rail Trail embankment, and the level of the Rail Trail downstream of Murrays Drain influence water levels during floods. If new structures alter flood flows, changing the levels of parts of these banks may be a way to avoid or mitigate adverse effects.

In the 23 June 2013 flood (Figure 5), which was an approximately 20-year flood event combined with a lake level at its highest level since 1941, peak flood levels reached 2.85m at Burkes Creek. At this level, the Rail Trail embankments and all other banks were underwater, and there were strong outflows from the Huritini/Halswell River to both sides of the Ahuriri Lagoon area. On the true right (southwest) side, this included outflows from about 700m upstream of Neills Road/Burkes Creek, some of which became trapped behind the Rail Trail embankment and other banks, and took several days to drain through temporary cuts made in the bank and culverts. On the true left (northeast) side, outflows from the river started at about Burkes Creek, filled the Lagoon area and (at high levels) returned to the river with little impediment. Both sides took about three weeks to drain to typical ground level. If flood levels were raised, there would be a risk of greater outflows from the River to the southwest side, or outflows in smaller events. This may be able to be mitigated by the enhancement of return paths to the river (e.g. lowering the banks in the general vicinity of the Burney Road/Ridge Road junction), as long as this would not add to the problem.

Figure 5. The Ahuriri Lagoon area in flood in June 2013.

5. WHAKATINANA / ACTIONS AND IMPLEMENTATION

5.1. Priority Actions

5.1.1. Identification of priority actions

The priority actions to achieve the concept masterplan (section 4.3) have been developed: using a RAMS site assessment (Appendix J) to generate priority actions; visual identification of issues; as well as building on previous actions nominated by Environment Canterbury and the Ahuriri Steering Group, not yet implemented. These are specific to the 11 sites within the Ahuriri Lagoon site (see section 4.3).

Other actions have been identified to fill knowledge gaps required for the detailed design and are not specifically identified in the RAMS assessment. The following actions in section 5.1.2. are not to be viewed in isolation, and should be read in conjunction with previously completed and adopted management plans where applicable.

5.1.2. Priority actions

Table 3 contains the priority actions required to achieve the concept masterplan.

Actions have been assigned priority based on the severity of the threat the action addresses and the cost of implementing the action. Performance targets within the table have, to the greatest extent possible, been made specific and measurable as well as the recommended course of action to pursue this target detailed. Cost estimates are derived from established commercial rates.

1. High priority: These actions should be implemented within the first year.
2. Medium priority: These actions should be implemented within five years.
3. Low priority: These actions should be considered as achievable within ten+ years.

As discussed in section 4.2 (The Solution), as there are knowledge gaps that need to be filled in order to determine what will be possible, the highest priority actions are investigations (as part of the detailed design, and concept design, preparation) to fill these knowledge gaps.

Table 3. Actions required to achieve the concept masterplan for the restoration of Ahuriri Lagoon.

Action	Priority	Outcome	Implementation Schedule										Cost
			2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
Explore Funding Opportunities													
Approach possible funding sources.	High	To facilitate implementation of this Plan											
Detailed Design Preparation													
Undertake detailed survey to inform future detailed design including tributary drains, culverts, gates, and other structures including Huritini/Halswell River bathymetry. In Addition, undertake a detailed survey of land parcels, boundaries and access points, and investigate potential boundary adjustments and/or land purchase, retirement or swaps in line with the vision. (see Note 1 below).	High	Results by June 2018											$10,000*
Install water level loggers in tributary drains to determine availability of alternative water source to canal (see Note 2 below).	High	Results by June 2018											$3,000*
Install groundwater piezometers to assess ground water conditions (see Note 3 below).	High	Results by June 2018											$3,000*
Undertake soil sampling across the site to characterise site soils particularly for salts and water holding capacity (see Note 4 below).	High	Results by June 2018											$10,000*
Undertake water balance assessment to determine volume of and retention of available water for wetland rehabilitation (see Note 5 below).	High	Results by end of 2018											$7,500*
Undertake water quality assessment and model improvements through the rehabilitated wetland.	High	Results by end of 2018											$7,500*
Undertake detailed assessment of high or low regeneration potential sites – ecology, topography etc.	Med	Results by end of 2018											$7,500*
Assess sediment budget, source nodes, and mitigations in the wider catchment and point sources (see Note 6 below).	High	Results by end of 2018											$10,000*
Confirm flooding impacts/benefits of the wetland reinstatement (see Note 7 below).	High	Results by end of 2018											$15,000*
Concept Design Preparation													
Undertake concept design based on best practice principles and information to date – LIDAR, MIKE or HECRAS models, topography, ecology factoring in regeneration Potential, and constraints on site.	High	Results by mid 2018											$15,000*
Undertake concept arrangement and design of water level control structures and investigate constructability.	High	Results by mid 2018											Included above
Detailed Design													
Undertake detailed design for the rehabilitation of Ahuriri Lagoon.	High	Results by June 2019											$30,000*
Maintenance													
Annual maintenance required to assist existing plantings. For Ahuriri sites: 1, 2, 10, and 11 (see page 13 for site locations).	High	Increased ecological outcomes											
Investigate an alternative methodology to canal cleaning with regard to depositing excavated material on top of banks. For Ahuriri sites: 1, 2, 3, 4, 5, and 10 (see page 13 for site locations).	Med	Increased ecological outcomes											
Create data base/map of all plantings that have occurred in the Ahuriri Reserve. For all Ahuriri sites.	Low	Data base for long-term monitoring and capturing work in progress (WIP)											
Willow control to continue and a program implemented for their staged but complete removal – dependant on contribution to habitat in lieu of alternative canopy species. For all Ahuriri sites.	Low	Best practice ecological rehabilitation											
Actions from RAMS Assessment (Appendix J)													
Determine where efforts are to be concentrated based on % Regeneration Potential of RAMS i.e. focus on high % sites.	High	Prioritised areas of focus developed											
Willow control. For Ahuriri sites: 7, 10, and 11 (see page 13 for site locations).	Low	Staged removal in line with best practice ecological rehabilitation											
Grazing management. For Ahuriri sites: 1,3, 4, 5, 6, 8, and 9 (see page 13 for site locations).	Med	Assess farm practices inline with above											
Land swap. For Ahuriri sites: 3 and 9 (see page 13 for site locations).	Low	Amicable agreements with all stakeholders											
Instream works. For Ahuriri sites: 1, 2, 3, 4, and 10 (see page 13 for site locations)	Low	Focused best practice ecological rehabilitation											

* Costs are indicative only.

Table 3 continued. Actions required to achieve the concept masterplan for the restoration of Ahuriri Lagoon.

Action	Priority	Outcome	Implementation Schedule										Cost
			2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
Actions from RAMS Assessment (Appendix J)													
Riparian plantings. For Ahuriri sites: 1, 2, 3, 4, 5, 10, and 11 (see page 13 for site locations).	Med	Increased ecological outcomes											
Forest plantings. For Ahuriri sites: 4, 6, 9, and 11 (see page 13 for site locations).	High	Pioneer species and canopy construction											
Enforcement and Compliance													
Advocate for best management practices in stormwater management to be included in al new developments upstream.	Med	Condition the demonstrated performance of stormwater management											
Build capacity within Council planning and compliance staff to review the design and construction of WSUD devices.	Med	Develop and increase expertise of around water-sensitive urban design (WSUD) within Environment Canterbury, Council staff through attendance at relevant training courses											
Advocate for best management practices in stormwater management to be included in al new developments upstream.	Med	Condition the demonstrated performance of stormwater management											
Education													
Establish demonstration sites throughout the catchment providing examples of best practice riparian management.	Med	Identify in consultation with relevant stakeholder suitable demonstration sites. Established demonstration sites											
Continue to provide weed management information to the community, targeting weed identification, removal techniques, alternative replacement with native species, impacts of dumping garden waste in bushland etc.	Med	Reviewed and updated weed educatio initiatives											
Raise awareness and understanding of aquatic weeds and appropriate control.	Med	Reviewed and updated weed education initiatives											
Work with land holders to create buffer along creeks and drainage lines for habitat creation and improvement of water quality.	Med	Fund or continue to fund work with landholders											
Monitoring													
Establish or consolidate baseline monitoring programs for planting, water quality, Community engagement, weeds, fauna etc.,	Med	To record WIP to inform future work and provide a benchmark for lessons learned											
Establish or consolidate baseline monitoring programs for planting, water quality, Community engagement, weeds, fauna etc.	Med	To record WIP to inform future work and provide a benchmark for lessons learned											
Ahuriri Steering Group													
Environment Canterbury to review current structures, and establish a revised Steering Committee/Group to guide and manage the implementation of the Restoration Plan.	Med	Revised Steering Committee/Group maintaining community support for the implementation of the Ahuriri Lagoon Restoration Plan											
Annual review of the Ahuriri Lagoon Restoration Plan conducted by the Steering Committee/Group.	Med	Annual review conducted											

Notes for Table 3

Note 1. Channel geometry survey: Land levels are well known from LIDAR information, but ground levels below the water surface are not well known. Survey of the main river channel and Burkes Creek are required to allow these watercourses to be adequately represented in a hydraulic model. A recommended survey plan has been developed, comprising five cross-sections on the main river, four cross-sections on Burkes Creek, and one cross-section on the Old Course/Murrays Drain outlet, plus a centreline long section. (It is anticipated this work can be coordinated with other Environment Canterbury work in the catchment).

Note 2. Burkes Creek flow monitoring: Monthly spot gaugings at or near SH75 for one year, plus monitoring of one flood or fresh following heavy rain (approx. over 15mm in 6 hours, or 30mm in 24 hours at Coopers Knob), to allow understanding of baseflow and correlation of Burkes Creek flow to Huritini/Halswell River flows, groundwater levels, and rainfall. Sediment sampling during flood to establish typical suspended sediment concentration and size distribution.

Note 3. Groundwater monitoring: Find information for existing borehole, and the constraints on use. Measure potential yield.

Note 4. Sediment information: Shallow (approx. 2m) sediment bore from infilled lagoon (northwest of Halswell/Huritini River)

Note 5. Seasonal water balance modelling for Lagoon: Should include sensitivity to climate variability (at least high, average, and low scenarios). Sensitivity to climate change and other medium term effects (e.g. urbanisation, Central Plains Water). In conjunction with water quality modelling – temperature, dissolved oxygen, and possibly sediment depending on the option or options modelled, may need to be compartmentalised (e.g. Huritini/Halswell River/connecting channel/Lagoon part A/Lagoon part B etc.).

Note 6. Sedimentation study: Analyse sediment bore to assess current sedimentation rate from flooding. Investigation of practical sediment trap options (siting and sizing of traps) to maximise sediment trapping while minimising Lagoon infill.

Note 7. Effects modelling – flooding and drainage: Model effects of option/options on flood levels in a range of events (e.g. 2 year, 10 year, and 50 year flood events, plus a typical “fresh” (small flood) situation). Assess effects of option/options on water levels in adjacent watercourses – e.g. Huritini/Halswell River 500m upstream of Burkes Creek, Burkes Creek at Bains Drain confluence, Murrays Drain at Neills Road, Matthews Drain and Rifle Range Drain at Environment Canterbury land boundary, and on adjacent land. A catchment-wide 2D hydraulic model was developed by Environment Canterbury in 2011, however, it is only suitable for extreme flood events (50 year and above). A similar (combined 1D and 2D) more refined model would need to be developed over the course of 2016/17 to answer drainage, urbanisation and small to medium flood questions as part of a review of the Halswell Drainage District. It is anticipated that (with modification to represent the option/options) this model will also be suitable for identifying flood and drainage effects.

6. HE PŪTEA TAUTOKO / FUNDING

Achieving the concept masterplan in this Restoration Plan is outside of the scope of the current Environment Canterbury budget for the restoration of Ahuriri Lagoon, and consequently further funding is required.

Funding may be available from a number of foundations, New Zealand Government grants, council grants, and other organisations for implementation of this Plan. The attainment of funds from these sources would be dependent on successful application to the relevant bodies, taking into consideration their criteria and requirements. There are also exist numerous examples of off-set, compensation and environmental credit policies, which should be investigated to determine their applicability in the current context.

Funds for natural resource management projects are available and must be spent effectively and accountably. A number of the actions under consideration require substantial capital and/or maintenance costs, and an expanded commitment of staff resources. Relatively high capital costs, for instance, will be associated with construction beyond the scope of this Plan.

Ongoing co-ordination of multiple natural resource programs within the wider Te Waihora catchment, with effective partnerships, will require staff resources to manage new responsibilities.

Potential contributors may include: Environment Canterbury, Ngāi Tahu, Christchurch City Council, Selwyn District Council, Department of Conservation, the Government, philanthropy, and corporate sponsorship (such as TrustPower and Central Plains Water). This is by no means an exhaustive list, and any possible funding should be extensively researched for possible contributions and funding criteria.

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ĀPITIHANGA / APPENDICES

8. APPENDIX A: AHURIRI LAGOON RESTORATION PLAN DEVELOPMENT PROCESS

Date	Event
23 May 2013	Field-trip to Ahuriri Reserves by the members of the Te Waihora Management Board and Donald Couch (Environment Canterbury Commissioner). Discussions during this field-trip informed the drafting of the Huritini – Lower Halswell River Vision Document.
August 2013	Huritini – Lower Halswell River Vision Document drafted by the Te Waihora Management Board.
19 September 2013	Letters from Donald Couch (Environment Canterbury Commissioner) to Maire Kipa (Chair of Te Rūnanga o Wairewa), Claire Williams (Chair of Te Rūnanga o Ngāi Tūāhuriri), June Swindells (Chair of Te Hapū o Ngāti Wheke), Charles Crofts (Te Rūnanga o Koukourārata), Pere Tainui (Chair of Te Rūnanga o Ōnuku), Julie Robilliard (Chair of Te Taumutu Rūnanga), and Terriana Smith (Chair of the Te Waihora Management Board), regarding: • That Environment Canterbury wishes to partner with Papatipu Rūnanga and the Te Waihora management Board to develop a restoration plan for the Ahuriri Reserves area; and, • Environment Canterbury welcome Rūnanga nominating a representative to work with staff.
25 October 2013	Meeting of the Te Waihora Co-Governance Group. Donna Lill (Environment Canterbury) gave an update to Co-Governors on the development of a restoration plan for Ahuriri Reserves, including the following points: • Environment Canterbury is progressing with development of a restoration plan for the Ahuriri Reserves land. Currently this work has two main components – a short-term (3-year) work programme and a longer term (20-year) vision and plan. • It is essential that Environment Canterbury, Papatipu Rūnanga, and the Te Waihora Management Board actively partner to engage with stakeholders and further develop plans for Ahuriri Reserves. • The 20-year vision and plan will be a comprehensive plan, providing a 20-year vision across all aspects of management, as well as possible enhancement and rehabilitation of the area. • This work is aligned with Whakaora Te Waihora, and with the Te Waihora Management Board's Huritini – Lower Halswell River Vision document.
13 December 2013	Meeting of the Te Waihora Co-Governance Group. Donna Lill (Environment Canterbury) gave an update to Co-Governors on the development of a restoration plan for Ahuriri Reserves, including the following points: • Tabling the draft of a 3-year action plan. • On-ground actions completed include planting by the Whakaora Te Waihora programme. • There will be a meeting to discuss how a 20-year vision and plan can be progressed.
February 2014	Huritini – Lower Halswell River Vision document endorsed by the Te Waihora Co-Governance Group.
4 February 2014	Meeting regarding a Restoration Plan for Ahuriri Reserves (meeting 1). Attended: Stephen Bragg (Environment Canterbury), James Caygill (Te Rūnanga o Ngāi Tahu), Donald Couch (Environment Canterbury Commissioner), Charles Crofts (Te Rūnanga o Koukourārata), Brian Dimbleby (Environment Canterbury), Dan Harrison (Environment Canterbury), Donna Lill (Environment Canterbury), Adrienne Lomax (contracted to Whakaora Te Waihora, meeting notes), Riki Nicholas (Te Rūnanga o Wairewa), David Perenara-O'Connell (Environment Canterbury), Te Whe Phillips (Te Hapū o Ngāti Wheke), Terriana Smith (Te Taumutu Rūnanga/Te Waihora Management Board), Andy Spanton (Te Rūnanga o Ngāi Tahu), Debbie Tikao (Te Rūnanga o Ōnuku), George Tikao (Te Rūnanga o Ōnuku/Te Waihora Management Board), and Claire Williams (Te Rūnanga o Ngāi Tūāhuriri). Key points from the meeting notes: • Donald Couch welcomed everybody.

	• Donna Lill presented an overview of the area and the proposed process for developing and implementing a long-term plan for the area in Environment Canterbury ownership. • The group was asked to consider their response to the proposal for a Partnership Group to be formed, consisting of representatives from each Papatipu Rūnanga, Te Waihora Management Board, and Environment Canterbury. This Partnership Group would oversee the development and confirm the restoration plan; with a Steering Group undertaking the work of plan development. It is proposed there would also be a wider stakeholder group which would be consulted to provide input to be considered in plan development. • There was some discussion about whether or not each Rūnanga needs to be represented in addition to the Te Waihora Management Board or if the Board can act on their behalf. Each Rūnanga would need to determine this for themselves. Representatives were asked to consider and discuss this with their respective Rūnanga prior to the next meeting. • Implications for Rūnanga were raised and Donna clarified that the area under discussion is limited to that owned by Environment Canterbury and there are no cost implications, other than time, for the Rūnanga. This project sits under the Whakaora Te Waihora programme; planning and consultation with stakeholders will be undertaken under Whakaora Te Waihora. • It was agreed that Donna should draft Terms of Reference for a Partnership Group and for a Steering Group and circulate to those in attendance today.
February 2014	A draft Terms of Reference is developed for the Partnerships Group and Steering Group.
4 March 2014	Meeting regarding a Restoration Plan for Ahuriri Reserves (meeting 2). Attended: Stephen Bragg (Environment Canterbury), Annabel Butler (Whakaora Te Waihora), Donald Couch (Environment Canterbury Commissioner), Brian Dimbleby (Environment Canterbury), Donna Lill (Environment Canterbury), Adrienne Lomax (contracted to Whakaora Te Waihora, meeting notes), Riki Nicholas (Te Rūnanga o Wairewa), Te Whe Phillips (Te Hapū o Ngāti Wheke), Terriana Smith (Te Taumutu Rūnanga/Te Waihora Management Board), Andy Spanton (Te Rūnanga o Ngāi Tahu), George Tikao (Te Rūnanga o Ōnuku/Te Waihora Management Board), Apologies: James Caygill (Te Rūnanga o Ngāi Tahu), Charles Crofts (Te Rūnanga o Koukourārata), Anake Goodall (Te Waihora Co-Governance Group), Dan Harrison (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), David Perenara-O'Connell (Environment Canterbury), Peter Ramsden (Te Rūnanga o Koukourārata/Te Waihora Management Board), Rei Simon (Te Rūnanga o Wairewa), Debbie Tikao (Te Rūnanga o Ōnuku), and Claire Williams (Te Rūnanga o Ngāi Tūāhuriri). Key points from the meeting notes: • The purpose of this second meeting is to discuss the Terms of Reference for the Ahuriri Reserves Restoration Plan Partnership Group and Steering Group (circulated prior to the meeting). • Each Rūnanga to be asked to state who they wish to represent them in this process, either their Te Waihora Management Board representative or someone different. Riki Nicholas confirmed that Te Rūnanga o Wairewa will be represented by Rei Simon. • It was noted that the Partnership Group will bring wider perspectives to the table for the purpose of providing leadership and decision making on the Ahuriri Plan. The Steering Group will focus on the details, compiling input and information and recommending actions based on this. • There was some discussion about the Environment Canterbury representation on the Partnership Group. The proposed Terms of Reference suggest including reps from engineering, reserves management and ecology/biodiversity. It was noted that these sections of Environment Canterbury are also likely to be represented on the Steering Group, and may be the same people. However, it was agreed that the roles of the reps would be different for each group. There is value in having engineering and reserves management reps on the Partnership Group as they will be familiar with policies and legal constraints which apply. By having a role in making decisions it will avoid any possibility of engineers/reserve managers being asked by the Partnership Group to do something contrary to policy/legal requirements.

	• It was also agreed that the Project Leader should represent Environment Canterbury on the Partnership Group, with ecological/biodiversity expertise called on as required for the Steering Group. • It was agreed that the Department of Conservation should be invited to be part of the Partnership Group in addition to the Steering Group. It was also agreed to invite Te Rūnanga o Ngāi Tahu to be represented on the Partnership Group, and also the Steering Group as appropriate. • Steering Group – it was noted that the composition will depend on availability and there will be some flexibility. • Forming the Steering Group – it was suggested that one or two public meetings be held to explain the process, with all stakeholders invited to attend. People attending the meeting(s) will be asked to volunteer for the Steering Group.
14 May 2014	Public meeting regarding a Restoration Plan for Ahuriri Reserves and establishment of an Ahuriri Steering Group. Invited: Clive Appleton (Christchurch City Council), Elise Arnst (Banks Peninsula Conservation Trust), the office of the Arowhenua Rūnanga, Herewini Banks (Te Hapū o Ngāti Wheke), Alison Bower (Environment Canterbury), Stephen Bragg (Environment Canterbury), Helen Brown (Te Rūnanga o Ngāi Tahu), Ian Brown (Environment Canterbury), Annabel Butler (Whakaora Te Waihora), Donald Couch (Environment Canterbury Commissioner), James Caygill (Te Rūnanga o Ngāi Tahu), Sandra Cook, Meri Crofts, Andrew Crossland (Christchurch City Council), Matt Cullen (Fonterra), Brian Dimbleby (Environment Canterbury), Kim Drummond (Environment Canterbury), Murray England (Selwyn District Council), Leonie Fechney (Department of Conservation), John Gebler (Environment Canterbury), the office of the Kaikōura Rūnanga, Katherine Glasgow (Environment Canterbury), Anake Goodall, Philip Grove (Environment Canterbury), Wendy Groves (Environment Canterbury), Dan Harrison (Environment Canterbury), David Hewson (Opus), Wendy Hoddinott, Kay Holder (Christchurch City Council), Wayne Holton-Jeffreys (Environment Canterbury), Phil Keene (Landcare), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Maire Kipa (CERA/Te Rūnanga o Wairewa), the office of the Koukourārata Rūnanga, Donna Lill (Environment Canterbury), Adrienne Lomax (Waihora Ellesmere Trust), Andrew MacTier (Selwyn District Council), Simon Manson (Local resident /Halswell River Rating District Committee), Ruth Markham-Short (Waihora Ellesmere Trust), Ross McFarlane, Angus McLeod (Environment Canterbury), Grant Miller, P.R. Miller, Stewart Miller (Local resident/Selwyn Waihora Zone Committee), Ross Millichamp (Fish and Game), the office of the Moeraki Rūnanga, Riki Nicholas (Te Rūnanga o Wairewa), the office of the Onuku Rūnanga, the office of the Ōraka-Aparima Rūnanga, the office of the Ōtākou Rūnanga, David Owen (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Kirsty Percasky (Department of Conservation), David Perenara-O'Connell (Environment Canterbury), Hayden Preece (Local resident), Rachel Puentener (Environment Canterbury), Peter Ramsden (Environment Canterbury), the office of the Rāpaki Rūnanga, Hamish Rennie (Lincoln University), Adrienne Rewi (Te Rūnanga o Ngāi Tahu), Julie Robilliard (Te Taumutu Rūnanga), Glenys Russell, Frances Schmechel (Environment Canterbury), Rei Simon (Te Rūnanga o Wairewa), Lisa Smith, Robin Smith (Department of Conservation), Terrianna Smith (Te Waihora Management Board), Steve Sonya, Andy Spanton (Te Rūnanga o Ngāi Tahu), June Swindell, D. Tainui, the office of the Taumutu Rūnanga, Ken Taylor (Environment Canterbury), the office of Te Ara Kākāriki, Steve Terry (Fish and Game), Debbie Tikao (Te Rūnanga o Ōnuku), George Tikao (Te Rūnanga o Ōnuku), the office of the Tuahiwi Rūnanga, the office of the Wairewa Rūnanga, Amanda Ward (Whakaora Te Waihora), Shelley Washington (Environment Canterbury), and Chrissie Williams (Environment Canterbury). The purpose of this meeting was: 1. To give stakeholders the opportunity to provide input in regards to (1) their vision and (2) desired restoration actions for Ahuriri Reserves. 2. To establish an Ahuriri Steering Group to lead the development and drafting of a 20 year plan for Ahuriri Reserves. • Sent with the meeting invitation was a draft vision, based on previous work and engagement, and a draft terms of Reference for an Ahuriri Steering Group. Attended (30 people attended, there were two others who attended who's names are not recorded below):

	• "Community members" [term used in the notes of the meeting]: Donald Brown, Annabel Butler (Whakaora Te Waihora), Andrew Crossland (Christchurch City Council), Peter Graham, Rima Herber, Lucette Hogg, Maree Kidd, Peter Kidd, Arron Johnson-Stark, Adrienne Lomax (Waihora Ellesmere Trust), Simon Manson, Fay Miller, Stewart Miller, Alfred Preece, Hayden Preece, Ralph Stark, and Selwyn Turpin. • "Partnership group members" [term used in the notes of the meeting]: Herewini Banks (Te Hapū o Ngāti Wheke), Stephen Bragg (Environment Canterbury), Donald Couch (Environment Canterbury Commissioner), Brian Dimbleby (Environment Canterbury), Philip Grove (Environment Canterbury), Dan Harrison (Environment Canterbury), Wayne Holton-Jeffreys (Environment Canterbury), Donna Lill (Environment Canterbury), David Perenara-O'Connell (Environment Canterbury), Robin Smith (Department of Conservation), and Andy Spanton (Te Rūnanga o Ngāi Tahu). Apologies: Clive Appleton (Christchurch City Council), Alison Bower (Environment Canterbury), James Caygill (Te Rūnanga o Ngāi Tahu), Sandra Cook, Kim Drummond (Environment Canterbury), Leonie Fechney (Department of Conservation), Anake Goodall, Wendy Groves (Environment Canterbury), Phil Keene (Landcare), Angus McLeod (Environment Canterbury), Ross Millichamp (Fish and Game), Craig Pauling (Te Taumutu Rūnanga), Adrienne Rewi (Te Rūnanga o Ngāi Tahu), Julie Robilliard, Terrianna Smith (Te Waihora Management Board), D. Tainui, the office of Te Ara Kākāriki, Steve Terry (Fish and Game), Amanda Ward (Whakaora Te Waihora), Shelley Washington (Environment Canterbury), Chrissie Williams (Environment Canterbury), and Clare Williams. Meeting facilitator: Donna Lill (Environment Canterbury). Key points from the meeting notes: • Short presentations were given on, o Ahuriri Reserves Restoration Plan (by Donna Lill), o Ngāi Tahu associations with Te Ahuriri (by David Perenara-O'Connell), o Current management objectives for Halswell drainage (by Dan Harrison), o Governing legislations (by Brian Dimbleby), and, o Ecological values of Ahuriri Lagoon. • There was discussion in small groups regarding, o A 20-year vision covering drainage management, mahinga kai, wetland communities, water quality, and education and recreation, and o Possible actions for drainage management, mahinga kai, wetland communities, water quality, and education and recreation • The following volunteered, or were nominated, for the Ahuriri Steering Group: Lucette Hogg, Maree Kidd (nominated by Peter Graham), Simon Manson, and Stewart Miller. o Donna Lill to contact these members, rūnanga, and Department of Conservation and Environment Canterbury, to arrange the first meeting of the Ahuriri Steering Group.
2014	Monthly meetings of the Ahuriri Steering Group. Members: Herewini Banks (Te Hapū o Ngāti Wheke), Brian Dimbleby (Environment Canterbury), Dan Harrison (Environment Canterbury), Lucette Hogg (local resident), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Donna Lill (Environment Canterbury), Simon Manson (Local resident /Halswell River Rating District Committee), Stewart Miller (Local resident/Selwyn Waihora Zone Committee), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Iaean Cranwell and/or Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), Debbie Tikao (Te Rūnanga o Ōnuku). Meetings facilitated by Donna Lill (Environment Canterbury). During this time the work of the Ahuriri Steering Group was focussed on the information gathering needed to develop a long term restoration plan. Topics introduced included the history of land use changes, the cultural and ecological significance of the area, water quality and flooding and drainage limitations. There was discussion on the development of restoration scenarios and learning from similar projects such as Travis Wetland and the Selwyn District Council storm-water ponds.

11 June 2014	Meeting of the Ahuriri Steering Group. Attended: Herewini Banks (Te Hapū o Ngāti Wheke), Brian Dimbleby (Environment Canterbury, Phillip Grove (Environment Canterbury), Lucette Hogg (local resident), Donna Lill (Environment Canterbury), Simon Manson (Local resident /Halswell River Rating District Committee), Stewart Miller (Local resident/Selwyn Waihora Zone Committee), Craig Pauling (Te Taumutu Rūnanga), Robin Smith (Department of Conservation), Matt Surman (Environment Canterbury), and Debbie Tikao (Te Rūnanga o Ōnuku). Guest attendance: John Skilton (Travis Wetland Park Ranger, Christchurch City Council). Apologies: Dan Harrison (Environment Canterbury). Key points from the meeting minutes: • There was a presentation by John Skilton on the restoration and management of Travis Wetland, with questions from the Group on community involvement, budget, decisions made for restoration actions, flooding and neighbours, and land ownership/protection. • There was a discussion on what background information exists for Ahuriri Reserves. • There was a discussion on the terms of Reference for the Ahuriri Steering Group. • There was a discussion on current Environment Canterbury work relating to Ahuriri Reserves.
9 July 2014	Meeting of the Ahuriri Steering Group. Attended: Donna Lill (Environment Canterbury), Simon Manson (Local resident /Halswell River Rating District Committee), Stewart Miller (Local resident/Selwyn Waihora Zone Committee), Craig Pauling (Te Taumutu Rūnanga), and Matt Surman (Environment Canterbury). Guest attendance: Scott Allen and Bob Bower (Golder Associates). Apologies: Herewini Banks (Te Hapū o Ngāti Wheke), Brian Dimbleby (Environment Canterbury), Iaean Cranwell (Te Rūnanga o Wairewa), Phillip Grove (Environment Canterbury), Dan Harrison (Environment Canterbury), Lucette Hogg (local resident), Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), and Debbie Tikao (Te Rūnanga o Ōnuku). Key points from the meeting minutes: • There was a presentation on water level assessment to support restoration planning (by Golder Associates). • There was a general discussion about restoration options. • There was a discussion on the required background work for the development of the restoration plan. • There was a discussion on engaging other stakeholders.
10 September 2014	Meeting of the Ahuriri Steering Group. Attended: Herewini Banks (Te Hapū o Ngāti Wheke), Colin Brookland (Environment Canterbury), Dan Harrison (Environment Canterbury), Lucette Hogg (local resident), Donna Lill (Environment Canterbury), Simon Manson (Local resident /Halswell River Rating District Committee), Stewart Miller (Local resident/Selwyn Waihora Zone Committee), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Matt Surman (Environment Canterbury), Guest attendance: Helen Brown (Te Rūnanga o Ngāi Tahu), Dan Clark (Environment Canterbury), Michael Greer (Environment Canterbury), David Perenara-O'Connell (Environment Canterbury) Apologies: Brian Dimbleby (Environment Canterbury), Phillip Grove (Environment Canterbury), Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), and Debbie Tikao (Te Rūnanga o Ōnuku). Key points from the meeting minutes: • There was a presentation on the Ngāi Tahu history of the name 'Ahuriri' (by Helen Brown

	and David Perenara-O'Connell). • There was an update on compiling background information for the restoration plan. • There was a presentation on water quantity (by Dan Clark). • There was a presentation on water quality (by Michael Greer).
2014	Bi-annual meetings of the Ahuriri Reserves Partnerships Group (representing Papatipu Rūnanga, Te Waihora Management Board, Te Rūnanga o Ngāi Tahu, Environment Canterbury, and the Department of Conservation) to update on progress of the restoration plan.
7 October 2014	Meeting of the Ahuriri Reserves Partnerships Group. Invited: Herewini Banks (Te Hapū o Ngāti Wheke), James Caygill (Te Rūnanga o Ngāi Tahu), Donald Couch (Environment Canterbury), Charles Crofts (Te Rūnanga o Koukourārata), Dan Harrison (Environment Canterbury), Donna Lill (Environment Canterbury), Ross Millichamp (Department of Conservation), Craig Pauling (Te Taumutu Rūnanga), Peter Ramsden (Te Rūnanga o Koukourārata), Rei Simon (Te Rūnanga o Wairewa), Terriana Smith (Te Taumutu Rūnanga/Te Waihora Management Board), Debbie Tikao (Te Rūnanga o Ōnuku), George Tikao (Te Rūnanga o Ōnuku), and Clare Williams (Te Rūnanga o Ngāi Tūāhuriri). The purpose of the meeting was an update on the Restoration Plan development progress, including a public meeting, Ahuriri Steering Group membership, background information received, ongoing studies, and upcoming activities.
8 October 2014	Ahuriri Steering Group Field-trip. During this field-trip members: visited Selwyn District Council's Lincoln Wetlands, where they heard a talk from Murray England (Selwyn District Council); visited the Te Whāriki development, where they heard a talk from Scott Allen (Golder Associates) on storm-water management; and, visited Awatea Basin, where they heard a talk from Kevin Williams (Christchurch City Council).
12 November 2014	Meeting of the Ahuriri Steering Group. Invited: Herewini Banks (Te Hapū o Ngāti Wheke), Debbie Tikao (Te Rūnanga o Ōnuku), Craig Pauling (Te Taumutu Rūnanga), Rei Simon (Te Rūnanga o Wairewa), Simon Manson (Local resident /Halswell River Rating District Committee), Lucette Hogg (local resident), Stewart Miller (Local resident/Selwyn Waihora Zone Committee), Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Robin Smith (Department of Conservation), Dan Harrison (Environment Canterbury), Brian Dimbleby (Environment Canterbury), Philip Grove (Environment Canterbury), Matt Surman (Environment Canterbury). Apologies: Debbie Tikao (Te Rūnanga o Ōnuku), Robin Smith (Department of Conservation), Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Philip Grove (Environment Canterbury). Meeting facilitator: Jodi Rees (Environment Canterbury). Key points from the meeting minutes: • Environment Canterbury meeting to be arranged to discuss draft process for ensuring endowment income (based on Donna Lill's proposal). • There was some discussion around the objectives but everyone was happy with them as they stand. • There was some discussion around the draft document "Development of Restoration Scenarios for Ahuriri Reserves – Request for Proposal': o More detail needed; concerns about available budget; definition of scope, o It was decided that timeframes would need to be shifted back to allow proper assessment by the Ahuriri Steering Group of the Request for Proposal • Brief update on work done for freshwater survey, groundwater monitoring, vegetation survey.
10 December 2014	Proposed meeting of the Ahuriri Steering Group (group 5) cancelled due to Environment Canterbury facilitator injury.
January – April 2015	Environment Canterbury arrange for City Care to provide project management and facilitation services for the Ahuriri Steering Group.

13 May 2015	Meeting of the Ahuriri Steering Group. Meeting facilitated by City Care, and focussed on progressing the restoration plan.
15 July 2015	Meeting of the Ahuriri Steering Group. Meeting facilitated by City Care, and focussed on progressing the restoration plan.
9 March 2016	City Care is contracted by Environment Canterbury to develop a management plan for the rehabilitation of Ahuriri Lagoon. Richard Berry from City Care is the Project Manager.
March 2016	Richard Berry (City Care) develops a draft management/restoration plan for Ahuriri Lagoon.
30 March 2016	Meeting of the Ahuriri Steering Group. Invited: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Colin Brookland (Environment Canterbury), Brian Dimbleby (Environment Canterbury), Michael Greer (Environment Canterbury), Philip Grove (Environment Canterbury), Lucette Hogg (Local resident), Ian Isaac (City Care), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Verity Kirstein (Environment Canterbury), Simon Manson (Local resident/Halswell River Rating District Committee), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), Matt Surman (Environment Canterbury), and Debbie Tikao (Te Rūnanga o Ōnuku). Apologies: Debbie Tikao. Attended: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Donald Brown, Brian Dimbleby (Environment Canterbury), Lucette Hogg (Local resident), Peter Kidd and Maree Kidd (Local residents/Ahuriri Grazing Licence holders, Simon Manson (Local resident/Halswell River Rating District Committee), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), and Matt Surman (Environment Canterbury). Meeting facilitator: David Murphy (Environment Canterbury). Key points from the meeting minutes: • Matt Surman delivered a PowerPoint presentation covering the ground and water levels of the site, and options for water level control. • Options presented by Matt Surman were possibilities to enhance water at the site (to achieve the desire to have permanent water to increase the ecological and cultural values), and still minimizing the risk of flooding of neighbouring land. These options were: 1. One-way gates (culverts with flat-gates) to allow water from the canal into the lower lying areas. This option would be cheap, but would have minimal capacity to hold water and there would probably be long periods without water. 2. A weir, with stop logs that can be removed to prevent flooding. Moderately expensive, but it could hold enough water to achieve a depth of 1.65m. 3. Diverting water from the top end of the site through the wetland by using excavated channels. Expensive. Probably limited ability to hold water unless water levels are raised and/or pools are dug. 4. Reduce the weed maintenance. Would result in water levels higher for longer. But probably not that effective. 5. Two-way channels allowing water into excavated ponds on both sides of the canal. Expensive. 6. Divert Burke's Creek above the site. Expensive. Unsure what water level could be achieved. This would also help reduce sediment in Te Waihora / Lake Ellesmere, as there could be a sediment trap before the water reaches the Ahuriri Lagoon site. The diversion would need to be approx. one kilometre up the creek. 7. Use of bores to deeper artesian aquifer to supply water. • There was consensus from the Group that the best option would be a combination of the options that would: Excavate scrapes with one-way gates to hold water; Put in some artesian wells; Perhaps construct a weir to hold water in a pool at the centre of the site; And have a diversion from Burke's Creek that would flow into a sediment trap, before the water flowed into a central pool in the Ahuriri Lagoon site. This combination would create an open water-

	body in the middle of the site, with ephemeral wetlands at the edges. This option will be incorporated by Richard Berry in the revised draft of the Restoration Plan. • In regards to the structure and Terms of Reference for the Ahuriri Steering Group, Craig Pauling suggested that given the current stage of the draft plan, it would be wiser for the plan to specify the role and functions of the Ahuriri Steering Group going forward. This was agreed by the Ahuriri Steering Group, so any comments on the future role/function of the Ahuriri Steering Group, and on the Restoration Plan, to be provided to Richard Berry by Friday 8 April.
April 2016	Richard Berry (City Care) progressed the draft of the Ahuriri Lagoon Restoration Plan, and incorporates the combination of options discussed at the 30 March meeting of the Ahuriri Steering Group in a concept plan/map.
27 April 2016	Ahuriri Steering Group Field-trip. Invited: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Brian Dimbleby (Environment Canterbury), Michael Greer (Environment Canterbury), Philip Grove (Environment Canterbury), Lucette Hogg (Local resident), Ian Isaac (City Care), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Verity Kirstein (Environment Canterbury), Simon Manson (Local resident/Halswell River Rating District Committee), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), Matt Surman (Environment Canterbury), and Debbie Tikao (Te Rūnanga o Ōnuku). Apologies: Michael Greer, and Craig Pauling. Attended: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Brian Dimbleby (Environment Canterbury), Philip Grove (Environment Canterbury), Lucette Hogg (Local resident), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Simon Manson (Local resident/Halswell River Rating District Committee), David Murphy (Environment Canterbury), and Matt Surman (Environment Canterbury). Key points from the field-trip: • The Group walked the Ahuriri Lagoon site, during which Richard Berry presented the concept plan/map, and the Group talked about the features in the concept plan/map in relation to the existing site. • Matt Surman commented that the large water-body proposed on the south-western side of the canal in the concept plan/map could only be filled from the canal if either the water-level in the canal was raised (such as with a weir), or the ground where the proposed water-body is located was lowered (such as by excavation). Matt asked what the suggested option was. o Richard Berry responded saying that investigations into what water-level was possible, and the best method(s) to achieve this, would be among the first required works in the management/restoration plan. Richard reiterated that the concept plan/map was the vision – the “Rolls Royce” of what could possibly be achieved – and the investigations to come will determine what will be possible. • Philip Grove asked about capturing the existing biodiversity/ecological values (such as the sedgeland to the east of the canal), and David Murphy asked about capturing the existing values of plantings by Whakaora Te Waihora. o Richard Berry responded saying that existing values could be captured in the management/restoration plan. By identifying existing values, the actions in the management/restoration plan can then be focused on the other areas of the site where work is required to reach the vision in the concept map • There was general consensus from the Group with the concept plan/map, and the value of discussing this on-site.
April-May 2016	Richard Berry (City Care) progressed the draft of the Ahuriri Lagoon Restoration Plan, incorporating background information and comments received from members of the Ahuriri Steering Group.
8 June 2016	Meeting of the Ahuriri Steering Group. Invited: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Colin Brookland (Environment Canterbury), Brian Dimbleby (Environment Canterbury), Michael Greer

	(Environment Canterbury), Philip Grove (Environment Canterbury), Lucette Hogg (Local resident), Ian Isaac (City Care), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Verity Kirstein (Environment Canterbury), Simon Manson (Local resident/Halswell River Rating District Committee), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), Matt Surman (Environment Canterbury), and Debbie Tikao (Te Rūnanga o Ōnuku). Apologies: Brian Dimbleby, Philip Grove, Lucette Hogg, Verity Kirstein, Rei Simon, and Debbie Tikao. Attended: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Colin Brookland (Environment Canterbury), Philip Grove (Environment Canterbury), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), and Matt Surman (Environment Canterbury). Meeting facilitator: David Murphy (Environment Canterbury). Key points from the meeting minutes: • Richard Berry presented the revised draft of the Ahuriri Lagoon Restoration Plan. • Herewini Bank's raised Lucette Hogg's email (sent with her apologies prior to the meeting), which said "…*I'd like this document to spell out and justify the planning journey to date. This is in order directly manage the risk that some entity can overturn this document on the basis of not enough consultation, whatever. We need to spell out the community WAS consulted, iwi WERE consulted, we followed all the due processes etc…. As I've mentioned previously, my biggest bug bear is the lack of traction that has been inherent in this project. We need to safeguard ourselves against this and make sure this document is built upon, not discarded*…". Herewini supported Lucette's comment, and wants to see in the plan a history of how the plan was developed and the consultation. • There were suggestions from the Group on additions/edits required in the final draft. • There was consensus from the Group that, once Richard Berry has incorporated these additions/edits in a final draft, this final draft can then be presented for approval at the next meeting of the Ahuriri Steering Group.
June 2016	Richard Berry (City Care) completed the final draft of the Ahuriri Lagoon Restoration Plan, incorporating comments received from members of the Ahuriri Steering Group.
13 July 2016	Meeting of the Ahuriri Steering Group. Invited: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Colin Brookland (Environment Canterbury), Brian Dimbleby (Environment Canterbury), Michael Greer (Environment Canterbury), Philip Grove (Environment Canterbury), Lucette Hogg (Local resident), Ian Isaac (City Care), Peter and Maree Kidd (Local residents/Ahuriri Grazing Licence holders), Verity Kirstein (Environment Canterbury), Simon Manson (Local resident/Halswell River Rating District Committee), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Rei Simon (Te Rūnanga o Wairewa), Robin Smith (Department of Conservation), Matt Surman (Environment Canterbury), and Debbie Tikao (Te Rūnanga o Ōnuku). Apologies: Philip Grove, Maree and Peter Kidd, Verity Kirstein, Rei Simon, and Debbie Tikao. Attended: Herewini Banks (Te Hapū o Ngāti Wheke), Richard Berry (City Care), Donald Couch (private citizen, supporting Herewini Banks of Te Hapū o Ngāti Wheke), Brian Dimbleby (Environment Canterbury), Lucette Hogg (Local resident), Stewart Miller (Local resident), David Murphy (Environment Canterbury), Craig Pauling (Te Taumutu Rūnanga), Jodi Rees (Environment Canterbury), Robin Smith (Department of Conservation), and Matt Surman (Environment Canterbury). Meeting facilitator: David Murphy (Environment Canterbury). Key points from the meeting minutes: • Richard presented the final draft of the Ahuriri Lagoon Restoration Plan.

	• The final draft was discussed, and minor changes were suggested. • With the changes noted, the Steering Group approved the final draft of the Ahuriri Lagoon Restoration Plan in principal. Craig Pauling moved that the final draft of the Ahuriri Lagoon Restoration Plan be approved, which was seconded by Stewart Miller. • David Murphy discussed the next steps in the approval process. He noted, from Appendix A of the Plan (Ahuriri Lagoon restoration Plan Development Process), the process started with a presentation at the Te Waihora Co-Governance Group, which led to the formation of the Ahuriri Partnerships Group, which approved a community meeting where members of a Steering Group were put forward. Therefore, the next steps for the approval of the Plan will be to reconvene the Ahuriri Partnerships Group and present the Plan to them for approval, before taking it back to the Te Waihora Co-Governance Group. • The Steering Group nominated Herewini Banks, Craig Pauling, Lucette Hogg, Stewart Miller, and Simon Manson to be community representatives who could, alongside Richard Berry, support the Plan when it is presented to the Ahuriri Partnerships Group and Te Waihora Co-Governance Group. • Donald Couch noted that in the development process for the Plan there was as wider representation as possible, and that the Plan has been a good investment that Environment Canterbury could pick-up and run with.
July 2016	• City Care contract to develop a restoration plan approved by the Ahuriri Steering Group was completed. Richard Berry (City Care) provided the final draft of the Ahuriri Lagoon Restoration Plan to Environment Canterbury. • David Murphy (Environment Canterbury) edited the final draft of the Ahuriri Lagoon Restoration Plan, incorporating the changes suggested at the 13 July meeting of the Ahuriri Steering Group.

9. APPENDIX B: SIGNIFICANCE AND VALUES

Ahuriri, or Ahuriri Lagoon, is a significant mahinga kai resource located on the Huritini/Halswell River between Taitapu and Motukarara. This Lagoon was an important influence in the location of the Ngāti Koraha pā (village) complex located on the spurs directly above the Lagoon and extending toward Motukarara.

Pre-drainage, this area was a large lagoon/wetland area surrounded by “koraha” or mudflats created by the pre-European lake levels of Te Waihora. Between 3-4 metres above sea level, Ahuriri would become fully integrated with the larger waterbody of Te Waihora. In particular, this wetland area supported a large harakeke (flax) wetland that gave rise to a large flax mill that operated during the mid to late 19th century.

Because of the productivity of this lagoon the area was extensively occupied by the Ngāti Koraha people. Pā and kāinga (fortifications and living sites) are located on the spurs directly above the Lagoon and extend toward Motukarara. A small warm (geothermal) waipuna (spring) is also a valued and unique resource for this area.

A western-most tip of the spur (Te Mokopeke) that runs down from Gebbies Pass, juts out into the side of Ahuriri Lagoon. This site has important occupation and spiritual associations for Ngāi Tahu. There is also some small remnant dryland vegetation on this site that enhances its special link to past occupation.

As a result of mid-19th century claims by Ngāi Tahu to the Government regarding inadequate mahinga kai areas, Judge Fenton set aside a number of fishing easements for the various hapū in Canterbury. One such reserve, Te Koraha, was set aside adjacent to Ahuriri. The owners of this reserve are the hapū from Ngāi Tūāhuriri in the north to Ngāi Te Ruahikihiki in the south and includes the hapū of Te Pātaka a Rākaihautū/Banks Peninsula.

Unfortunately, due to the drainage of Te Waihora and construction of drainage channels throughout the Halswell catchment, Ahuriri was completely drained and the fishing easement rendered useless. The bed of the historic lagoon is now predominately pasture (with some remnant wetland sites) and is administered by Environment Canterbury. SH 75, the main road from Christchurch to Akaroa, passes through the area.

Ahuriri Reserves (also known as Ahuriri Lagoon) comprises 250ha and the area was first gazetted as a sanctuary for game birds in 1897. It provides protected breeding habitats for birds and fish, and a sanctuary for birds during hunting season.

Despite extensive drainage and pastoral development, Ahuriri Reserves are still by far the most significant wetland habitat in the Greenpark-Taitapu-Halswell-Christchurch Lowlands (outside of Te Waihora itself). Winter ponding provides extensive shallow margins, which attract thousands of wetland birds, both waders and waterfowl. These include black cormorant, black swan (kakī anu), Canada geese, paradise shelduck (pūtakitaki), mallard/grey duck (pārera), grey teal (tete), New Zealand shoveller.

Environment Canterbury land at Ahuriri is managed to Best Management Practice Standard and includes riparian planting and the managing of grazing and license conditions.

Whakaora Te Waihora already has a restoration planting programme underway and a cultural monitoring programme for Te Waihora as a whole is being developed and will be implemented by Ngāi Tahu. Some aspects of this programme will be relevant to the Ahuriri area.

9.1. Flora

To complement the species already present within areas of the Ahuriri Reserves various planting have been conducted. Along the bank edges tussock sedges/grasses with forest plant community plantings in areas where the land is drier than what the natural restoration processes of a wetland could achieve.

While many of the plantings do not match historically records described by Andrew Crossland's 'Ahuriri Lagoon: Wildlife Values and Habitat Restoration Potential (2008)', the conditions of the landscape have changed significantly that to restore the local environment back to conditions suitable for raupo to be the dominant species throughout the reserve significant changes would be required to the water table and potentially result in an increased chance of flooding for the surrounding properties.

Instead the forest plant communities consist of totara, cabbage tree, karamu, manuka, kanuka, broadleaf, flax, toetoe, kahikatea, and matai etc.. The result of these diverse plantings will be an overall increase in biodiversity within Ahuriri Reserve, which would not have been able to be achieved through natural wetland regeneration processes.

9.2. Birds

Contemporary bird populations within the Ahuriri Lagoon area comprise a mix of native and introduced species that favour riverine, wetland, lowland wet grassland and farmland habitats. At least 50 species are known to occur.

Although the area has lost many of its original bird species, it is still of local importance to at least Black Swan (a notable flocking area); New Zealand Scaup (breeding site); Grey Teal (breeding site and flocking area); New Zealand Shoveler (breeding site and flocking area); Australasian Bittern (wintering site and probable breeding area), Marsh Crake (wintering site and probable breeding area); Pied Stilt (nesting·area); and, Australasian Harrier (night roost site).

Over the past few years the Waihora Ellesmere Trust have conducted bird counts on Lake Ellesmere and its surrounding areas. The 2016 counts numbered just under 48,000 with the previous two years in the 55,000 range. With the overall classifications broken down into shags, herons, waterfowl, New Zealand waders, Arctic waders, and gulls and terns, waterfowl were the most populous representing over 75% of the count data, and New Zealand waders representing 15% of the count data.

9.3. Fish

Along the Huritini/Halswell River a range of fish species can be seen. Among the upper reaches with faster flowing water over gravel beds species include lamprey, eels, bullies, trout and several species of Galaxid including īnanga. However, over time the habitat for these species has degraded from high silt loads especially since the earthquakes. Through the degradation of the upper reaches of the Huritini/Halswell River locations of trout spawning zones has decreased, reducing the number of trout present in the waterway. Through the lower reaches (including the Halswell Canal) and into the mouth of Te Waihora the dominant species changes to eels with a significant proportion of the population consisting of the long finned eel over the short finned species. It is the lower reaches in which Ahuriri Lagoon is situated making improved fish habitat for the dominant species, eels, a priority.

9.4. Invertebrates

EOS Ecology (2015) have undertaken baseline surveys of four streams and four wetland ponds in and around Ahuriri. Thirty seven (37) invertebrate taxa were found in the sampled streams while 26 were present in the wetland ponds. The best-represented taxa groups which were present were Diptera, Crustaceans, Caddisflies, Molluscs, Hemiptera, Coleoptera, and Odonata. However, when you look at the abundance of each of the taxa within both of the wetland pond and stream sub-habitats, it is the non-insect taxa which dominate the environments. By comparing the five most abundant taxa in each of the sub-habitats, three taxa were common between them, *P. antipodarum* (Snail), Ostracod Crustaceans and *C. zealandicus* (midge larvae). The captured invertebrates are consistent with those present in other similar small spring-fed waterways within the area, as these streams generally consist of slow water velocities, sediment laden beds, significant macrophyte growth and limited shading.

While these species do not hold high ecological significance, they still hold a significant role to play in the greater system providing a valuable food source.

9.5. Pest Species

Animal grazing, namely from cattle in and around the waterways, provides the greatest risk to the waterways and rehabilitation of the wetland. Stock increase sedimentation and nutrient levels and graze or damage plantings. In addition to cattle, small populations of feral cats, rodents, possums and mustelids have been noted.

Willows are a common terrestrial weed species dominating the riparian canopy within the site. Pasture grasses also encroach on the riparian edge and outcompete smaller native shrubs, grasses and groundcovers.

The submerged macrophyte commonly found in the canal is a pest species, as it requires significant management by way of removal to provide adequate conveyance within the canal.

10. APPENDIX C: SUMMARISED HISTORY OF AHURIRI LAGOON FROM 1850 ONWARDS

- 1851: Rhodes Brothers secure lease to the run named Ahuriri, after Ahuriri Lagoon (Acland, 1946, p335).
- 1850s: Large farming runs were taken up around Te Waihora / Lake Ellesmere.
- 1868: Native Land Court sitting, Ahuriri Lagoon claimed by Ngāi Tahu amongst other areas as a significant mahinga kai.
- 1888: Ellesmere Lake Act was passed which made provision for the construction of works to protect lands surrounding the Lake from flooding. Under this act, the Halswell Canal was constructed in 1879.
- 1893: The Halswell River Drainage Act was passed to provide for the raising of money to maintain flood works and also allowed land to be endowed to the Selwyn County Council "to provide funds for the purpose of removing any obstruction to the flow of the Halswell River through Lake Ellesmere to the sea." The endowment land was initially on Kaitorete Spit.
- 1895: Native Land Court sitting, Ahuriri Lagoon claimed by Ngāi Tahu amongst other areas as a significant mahinga kai.
- 1895: Te Koraha Māori Reserve 959 gazetted (Taylor, 1944).
- 1897: Ahuriri Lagoon made a reserve for native game (Anderson, 1927, p38).
- 1901: Te Koraha Māori Reserve vested in the Public Trustee (Taylor, 1944).
- 1905: The Ellesmere Land Drainage Act transferred the responsibility for the Halswell River Drainage District and its endowment lands from Selwyn County to the Ellesmere Land Drainage Board. The Ahuriri Lagoon area was added to these endowment reserves.
- 1912: An amendment to the Ellesmere Land Drainage Act endowed a further area of Ahuriri land to the Board. All the endowment land was leased out to neighbouring farmers to provide income by way of rents for the Board to be able to finance river works.
- 1913: Native Land Court confirmed fishing rights at Ahuriri Lagoon to various Ngāi Tahu hapū (Taylor, 1944).
- 1947: The North Canterbury Catchment Board (NCCB) was established and the powers, functions and assets of the Ellesmere Drainage Board (along with many other local drainage boards) was transferred to the NCCB. Endowment land income helped meet the cost of lake openings and maintaining the Huritini/Halswell River system. During NCCB administration some wetter land areas were first retired or had grazing restrictions over them. The existing rushland and remnant water area was protected.
- 1986: The Canterbury Regional Council was established and the functions, powers and assets of the NCCB were transferred to the new council. Since then the Canterbury Regional Council, known as Environment Canterbury, has continued to administer this land as endowment land under its original 1905 legislated purpose. All rents are still used to maintain the Huritini/Halswell River.

11. APPENDIX D: CATCHMENT CHARACTERISTICS

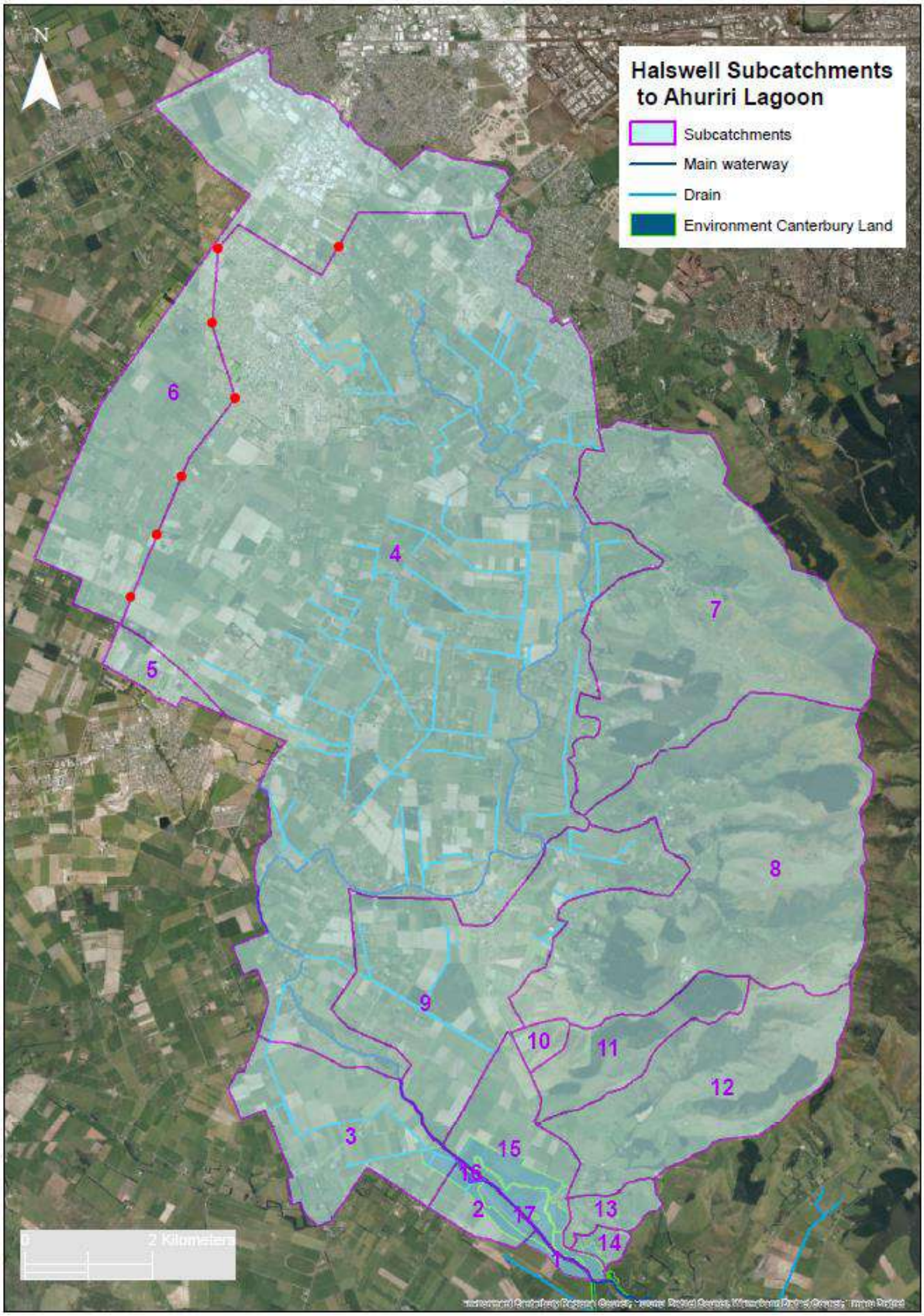

Figure 6. The surface water catchment for Ahuriri Lagoon.
(Red circles denote where the main stockwater races join the main part of the catchment)

The Hurutini/Halswell River catchment upstream of the Ahuriri Lagoon includes an area of about 132km^2 (13,200ha). About one third of this is steep hill catchments of the Port Hills, with the remaining two thirds on the relatively flat Canterbury Plains. About 5% of the catchment is urbanised.

The western boundary of the surface water catchment is difficult to define. A note below explains this further, but for the purposes of this report, the western boundary has been taken as Springs Road plus Prebbleton.

The catchment has been divided into 17 parts and/or sub-catchments, shown on Figure 6 above and Table 4 below. The catchments have been numbered and labelled starting at the southernmost area west of Ahuriri Lagoon, generally in a clockwise direction.

Table 4. Sub-catchment areas for Ahuriri Lagoon.

Sub-catchment number	Sub-catchment	Catchment areas (ha) Flat	Hill	
1	Environment Canterbury land south	20		
2	Matthews Drain	108		
3	Murrays Drain	567		
4	Halswell River flat areas	6517		
5	*Halswell River peripheral - Lincoln*	*97*		
6	*Halswell River peripheral - Shands Rd*	*1608*		
7	Halswell River hill catchments		1579	
8	Burkes Creek hill catchments		1791	
9	Burkes Creek flat catchments	1016		
10	Ahuriri 1		47	
11	Rifle range drain		290	
12	Ahuriri stream/drain		802	
13	Ahuriri 4		86	
14	Ahuriri 5		36	
15	Ahuriri flat	355		
16	Peninsula	4		
17	Halswell Canal	8		
	Total (excluding “peripheral” areas)	8593	4632	13225

Of most relevance to the Ahuriri Lagoon are the following generalised sub-catchments:

- Discrete areas west of the Halswell River – a combined area about 700ha (sub-catchments *1-3*).
- The Halswell River catchment upstream of Burkes Creek of about 8100ha, about 20% of which is hill catchment and 80% relatively flat (*4,7*). There are a large number of springs in the catchment.
- The Burkes Creek catchment of about 2,800ha, 65% hill, 35% flat (*8, 9*). Environment Canterbury mapping shows two springs in the catchment.
- The eastern catchments that flow directly to the main part of the Lagoon – a combined area 1,580ha (80% hill, 20% flat, sub-catchments *10, 11, 12, 13, 15*). The Ahuriri Stream/drain, at a little over half the area, is the largest of these sub-catchments - Environment Canterbury mapping shows one spring in this catchment.
- Other small areas include a 36ha catchment that drains to a small waterway south of the main lagoon (*14*), the 4ha “peninsula” between an old course of the Huritini/Halswell River (that Murrays and Matthews Drains drain to) and the straightened part of the Huritini/Halswell River (*16)*, and the banks and surface of the Huritini/Halswell River between Burkes Creek and the Old Course of the river (approximately 8ha, *17*).

<u>A note on the western catchment boundary</u>

In small rainfall events, with the exception of some stormwater from Prebbleton, there is little or no run-off from areas west of about Springs Road. In larger events, there is occasionally runoff from further west, perhaps generally to Shands Road. This includes an area of industrial Hornby, which discharges to a stormwater pond at Halswell Junction Road. This pond discharges only occasionally in prolonged storm

events. Christchurch City Council have indicated an intention to build additional soakage facilities for this stormwater, which will further reduce the incidences of discharge (to almost zero). Similarly, an area known as Carrs Road basin has high infiltration rates and discharge is expected to be nil or rare. Combined, these areas are mapped as the "peripheral – Shands Road" area.

There are nine places where the stockwater races from the Paparua water race network can discharge to the catchment, to a consented maximum of 90L/s. In practice, in large storm events, these water races may discharge more than is consented since the network upstream of the discharge points covers an area of about 120km^2, there are few natural watercourses in this area and developments (roads, farm activities etc.) sometimes alter natural overland flow routes. The network has a large number of races that terminate in soakpits, but could nonetheless act as conduits for more than the consented 90L/s. Figure 5 includes red circles where the main stockwater races join the main part of the catchment (the nine races combine to seven watercourses by this boundary).

The catchment boundaries around Lincoln have been altered as subdivisions have progressed and stormwater systems have been built. The "peripheral –Lincoln" area is included in the Halswell Drainage rating district but parts of this may now drain towards the LII – the boundary is not carefully mapped in this area, but the exact area is not critical to this study.

While in some (extreme) situations, any or all of these areas may drain to the Huritini/Halswell River system, with the exception of the stockwater inflows, their usual rate of runoff is so low that they have been assumed not to be part of the catchment for the purposes of this report. The stockwater inflows may be somewhat relevant.

11.1. Rainfall, Flow and Water Level Records

Table 5. Data from rainfall, flow, and water level sites.

Rainfall sites	Location	Easting	Northing	Start Date[1]	Interval
Ryans Bridge	Tai Tapu			28/5/1996	Daily[2]
Coopers Knob				27/4/1990	Daily[2]
Greenpark	Clarks Rd			13/9/1956	Daily[2]
Others?					
Flow sites					
Ryans Bridge	Tai Tapu			16/4/1996	15 mins
Water level sites					
Halswell at Burkes Creek	Neills Rd			4/1/1990	Weekly
Halswell at Hodgens Bridge	Motukarara			4/1/1990	Weekly

[1]All datasets ongoing. Data summarised to 31/12/2015.
[2]shorter intervals available for some periods especially more recent data

The data records are summarised briefly in Tables 5-7 and Figures 8-10 below. Where rainfall data was missing from the record, if information was available from adjacent sites, this was used to fill in the missing information using the following assumptions: Greenpark rainfall = Ryans Bridge rainfall = (Coopers Knob rainfall)/1.8.

Table 6. Rainfall, flow and level summaries.

Rainfall sites (mm)	Average annual	Max	Min
Ryans Bridge	621	886	383
Coopers Knob	*TBA*	*TBA*	*TBA*
Greenpark	632	907	344
Flow sites (m^3/s)			
Ryans Bridge	0.77*	13.98	0.17
Ryans Bridge – average annual		6.10	0.39
Ryans Bridge – mean annual 7 day low flow	0.51*		
Water level (metres above mean sea level)			
Average of Halswell at Burkes Creek and at Hodgens Bridge	1.13	0.59	2.40

**Estimate for 1984-2010 from "The surface water resources of the Lake Ellesmere/Te Waihora catchment", Clark (2011)*

In a report entitled "Water quality and quantity limit setting in Selwyn Waihora Catchment, Predicting the consequences of future scenarios", Clark (2014) estimated the mean flow in the Huritini/Halswell River at MacCartneys Bridge to be 0.90m^3/s, under a no abstraction (natural) scenario to be 1.15m^3/s and in the "Zone Committee Solution package" (including replacement of 30,000ha of groundwater abstraction as part of development of irrigation on 60,000ha by Central Plains Water, managed aquifer recharge and other measures), a mean flow of 1.29m^3/s. In addition, urbanisation in the upper part of the catchment is likely to be adding modest volumes to the total flow, especially during and after rainstorm events (although proposals for increased infiltration within the Christchurch City boundary may reduce surface water flows from some sub-catchments). So unless additional water takes are authorised, influences from both within and outside the Halswell River catchment are likely to increase the mean flow in the Huritini/Halswell River in the future. The 7DMALF (7 day mean annual low flow) estimate for the Huritini/Halswell River at MacCartneys Bridge is 0.68m^3/s (Clark, 2014).

The degree of variability will be of importance to the water quality and health of the Ahuriri Lagoon. For instance, the five yearly average annual rainfall at Greenpark varies from about 500mm to about 800mm. Regardless of the method chosen to introduce and/or retain water into the Lagoon, the annual, decadal and seasonal variability of rainfall and/or flow inputs will influence the various lagoon habitats.

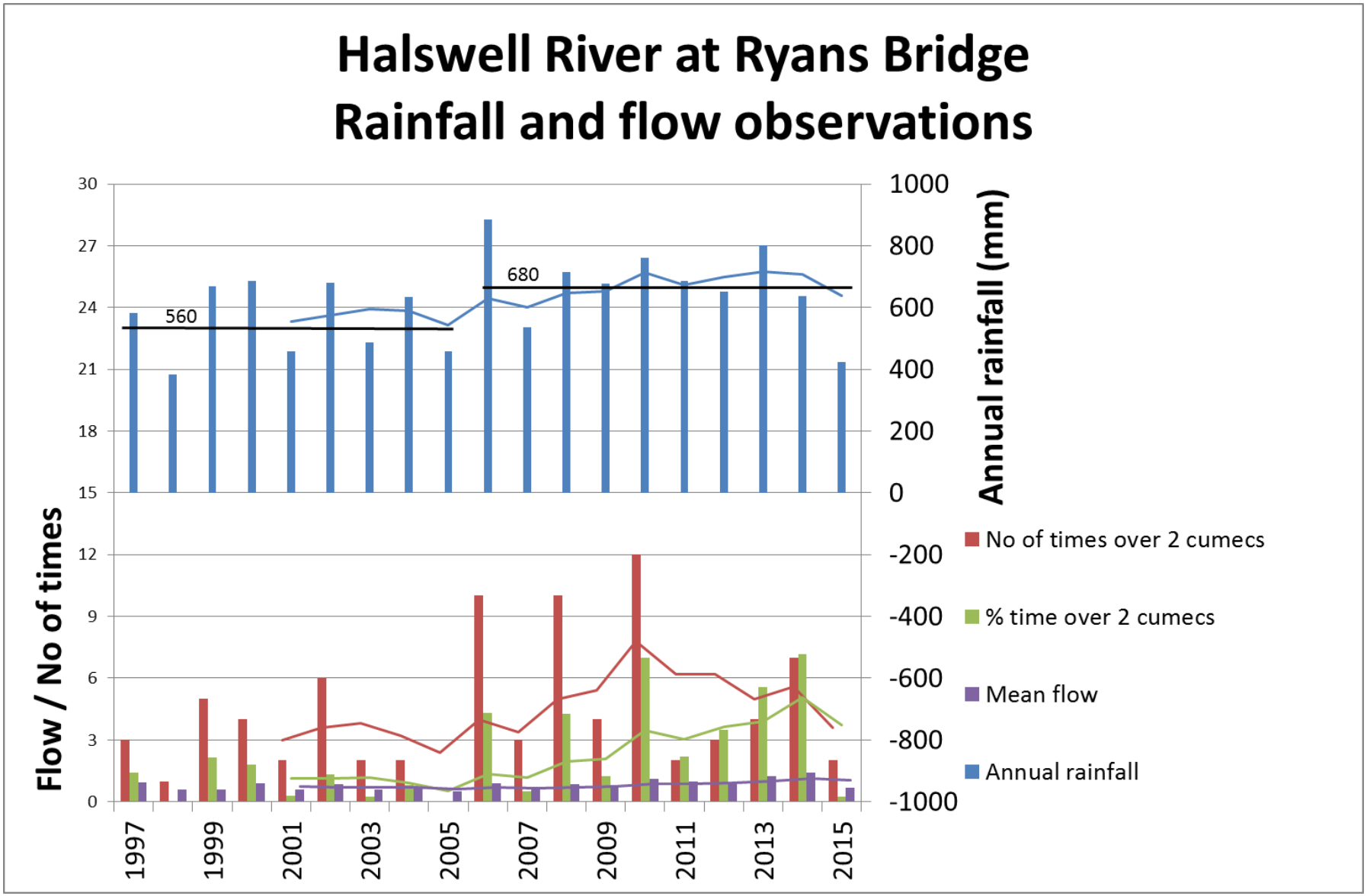

Figure 8. Annual rainfall and flow observations in the Huritini/Halswell River at Ryans Bridge between 1997 and 2015.

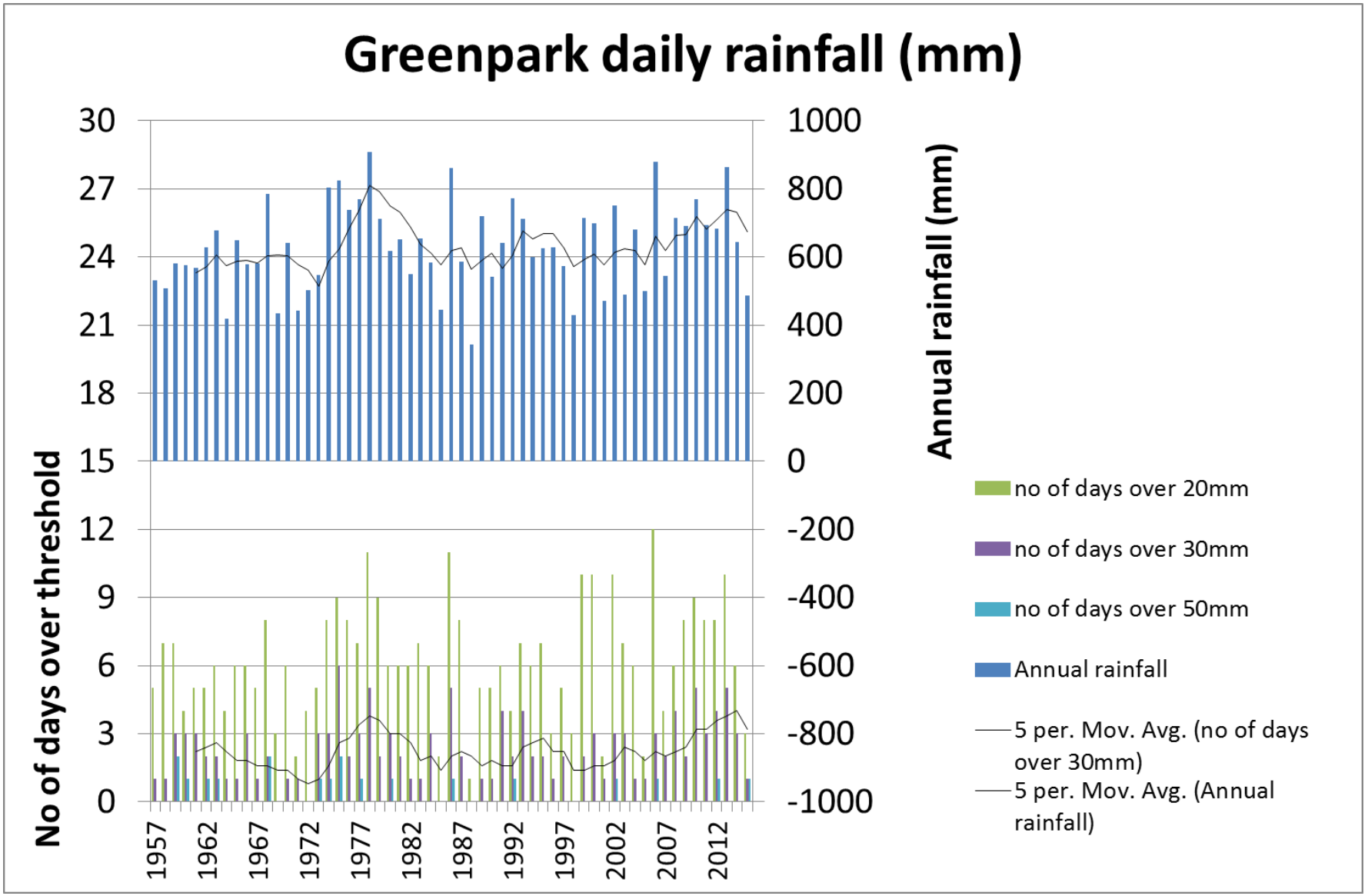

Figure 9. Annual rainfall at Greenpark between 1957 and 2016.

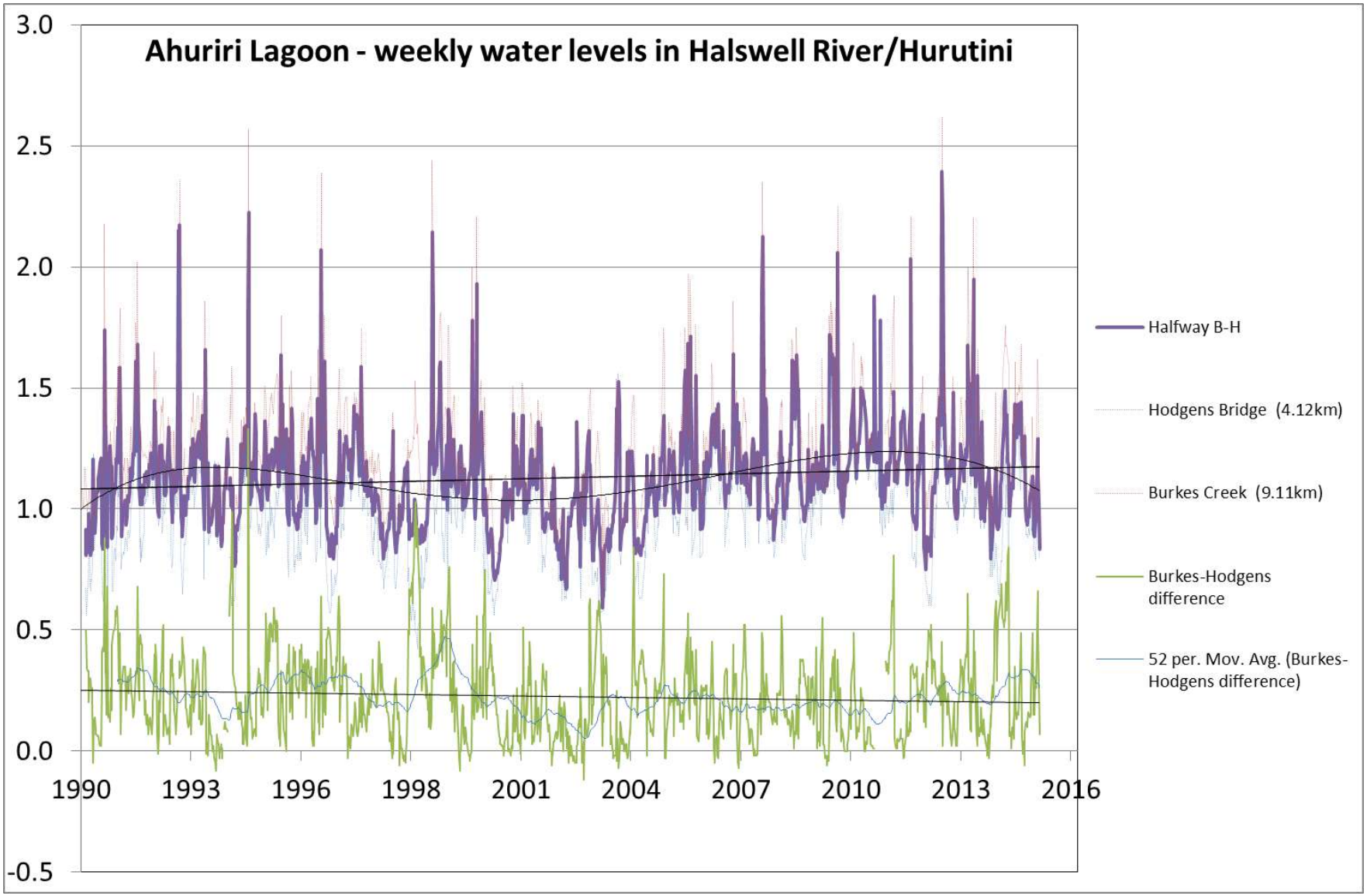

Figure 10. Weekly water levels in the Huritini/Halswell River at Ahuriri Lagoon between 1990 and 2016.

Table 7. Summary of weekly water level information (average of gauges in the Huritini/Halswell River at Burkes Creek and Hodgens Bridge), between 1990 and 2015.

Year	Weekly record c 1.50m	No times	Max	Average	Min	Comments
1990	1	1	1.74	1.04	0.81	
1991	4	3	1.68	1.16	0.89	
1992	3	1	2.18	1.18	0.89	
1993	1	1	1.66	1.11	0.85	
1994	1	1	1.83	1.11	0.77	
1995	1	1	1.64	1.15	0.92	
1996	2	2	2.07	1.11	0.80	
1997	1	1	1.59	1.19	0.98	
1998	0	0	**1.33**	**0.98**	0.80	
1999	4	4	2.15	1.11	0.86	
2000	2	2	1.93	1.18	0.96	
2001	0	0	**1.40**	**0.97**	0.71	Period 13/10/2000 to 27/8/2004: nothing over 1.50m, over 1.30m 10 times (12 weeks), average level 1.00
2002	0	0	**1.39**	1.08	0.83	
2003	0	0	**1.36**	**0.97**	**0.67**	
2004	1	1	**1.53**	**0.98**	**0.59**	
2005	0	0	**1.39**	1.04	0.81	
2006	6	4	1.72	1.16	0.92	
2007	1	1	1.64	1.23	1.01	
2008	3	1	2.13	1.15	0.87	
2009	5	2	1.64	1.17	0.95	
2010	9	3	2.06	1.24	0.97	
2011	3	2	1.88	1.29	1.00	
2012	1	1	2.04	1.21	0.84	
2013	3	1	2.40	1.16	0.75	
2014	6	4	1.95	1.17	0.80	
2015	0	0	1.49	1.17	0.89	
Average	2.2	1.4	1.76	1.13	0.85	
Max	9	4	2.40	1.29	1.01	**Time over 1.5m: 4%**
Min	0	0	1.33	0.97	0.59	

12. APPENDIX E: WETLANDS

12.1. How Do Wetlands Work?

Wetlands are complex systems where biological, chemical and physical processes combined to reduce stormwater pollutant loads:

- Biological processes include direct uptake of nutrients by wetland plants, as well as nutrient removal aided by microorganisms found in root-zones and soil.
- Some chemicals such as hydrocarbons, metals and organic compounds are broken down or converted into non-harmful forms through chemical processes such as precipitation, volatilization and oxidation/reduction.
- Physical processes include reducing follow velocity. This is achieved by running stormwater through a densely vegetated area or a deep sedimentation zone, which allows sufficient time for the suspended solids to filter or settle out of the water column.

12.2. Key Wetland Components

Constructed wetlands are comprised of four primary components: the inlet zone, macrophyte zone, open water zone, and outlet zone. The macrophyte zone is generally at least 50%- 80% of the entire surface area of a wetland planted with appropriate wetland plant species.

Inlet and outlet structures distribute the flow into and through the wetland controlling flow path and water depth. The inlet and outlet at either end of the wetland are essential to ensure uniform influent distribution into and through the wetland. These structures help to prevent “dead zones” where exchange of water is poor, resulting in standing water.

Water level control is the most important tool for effective wetland management and ensuring long-term wetland health. This is achieved by mechanical or physical means of raising or lowering a control structure dictating the water level and thus depth through the system.

12.3. Plants (Macrophytes)

Macrophytes in constructed wetlands fall into one of three categories: emergent, free floating, and submerged (Brix and Schierup 1989). Macrophytes within wetlands have a number of attributes that make them essential to a functioning treatment system. Most obvious of all is the direct uptake of nutrients by the macrophytes themselves. Actual nutrient uptake rates for macrophyte species within wetlands is highly variable, ranging between 200-2500 kg ha-1 year-1 and 30-350 kg ha-1 year-1 for nitrogen and phosphorus respectively (Brix 1994; Kadlec and Knight 1996; Tanner 1996; Kadlec et al. 2000). Macrophytes are capable of transpiring substantial quantities of water into the atmosphere, potentially reducing the hydraulic load on a receiving environment. Again, at what degree this process occurs is directly dependant on which species of macrophyte you look at (and the productivity of that species) and the local weather conditions.

Stems of submerged macrophytes (both emergent, free floating and submerged) provide sites for periphytic growth that can assimilate nutrients directly from the water column (Korner and Vermaat 1998). Little published data is available that reports nutrient loss within wetlands via periphyton, with the factors governing periphyton growth/accumulation and co-existence with macrophytes also not well reported.

Many emergent macrophytes have the ability to transport gases from the atmosphere to their rhizomes, where it then diffuses through into the surrounding sediment. This physiological adaptation (known as aerenchyma tubes found within the plants stem) increases redox potential surrounding the root zone of the plant to counteract the normally reducing environment of wetland sediments (Armstrong et al. 1992). This adaptation by certain emergent macrophytes detoxifies potentially harmful reducing substances to the plant root system within an anaerobic sediment. (Brix 1990; Grosse et al. 1996). The subsequent aeration of the wetland sediment surrounding the rhizome is often termed ‘rhizosphere aeration’ and effectively creates an oxygenated environment that provides sites where aerobic bacteria can colonize, stimulating the decomposition of organic matter and the growth of nitrifying bacteria (Gersberg et al. 1986).

Roots and rhizomes of macrophytes have also been reported to release compounds that act like antibiotics, killing a range of bacteria (Coliforms, Salmonella and Enterococci) (Copper et al. 1996; Decamp et al. 1999). A variety of organic compounds are also released from the roots and rhizomes of macrophytes. Such organic compounds have been suggested to act as a carbon source for de-nitrifiers and thus increase nitrate removal in certain types of wetland treatment systems (Brix 1997).

12.4. Microorganisms

The role of microorganisms within wetlands is complex. It is beyond the scope of this Plan to outline their role in wetland ecosystems in detail, so only the important processes are discussed in terms of their role in wetlands. The dominant removal process for nitrogen in constructed wetlands is via microbial metabolism, involving the processes of ammonification, nitrification (Equation 1) and denitrification (Equation 2) (Reddy et al. 1989; Kadlec and Knight 1996).

$$NH_4^+ + 2\,O_2 \rightarrow NO_3^- + 2\,H^+ + H_2O \quad \text{(Equation 1)}$$

$$5(CH_2O) + 4NO_3 + 4\,H^+ \rightarrow 5\,CO_2 + 2N_2 + 7\,H_2O \quad \text{(Equation 2)}$$

Ammonification occurs in both aerobic and anaerobic environments, occurring at a more rapid rate under aerobic conditions (Kadlec and Knight 1996). Once organic nitrogen compounds are converted to NH4+ via ammonification, they are then oxidised to NO3- via nitrification. Nitrification occurs only under aerobic conditions and is reported to decrease with a decrease in water temperature (Williams et al. 1994; Reed et al. 1995). The final step in the process of microbial nitrogen removal is the conversion of NO3- to N2. This process occurs under anaerobic or anoxic conditions providing there is a sufficient source of carbon to fuel the process (Copper et al. 1996; Ingersoll and L.A. 1998).

Microorganisms are also responsible for the degradation of organic matter, under both aerobic and anaerobic conditions. Aerobic degradation of organic matter produces CO2 and H2O (Equation 3), while anaerobic degradation involves the fermentation of organic matter into fatty acids (Equation 4 and 5) and alcohol's (Equation 6).

$$(CH_2O) + O_2 \rightarrow CO_2 + H_2O \quad \text{(Equation 3)}$$

$$C_6H_{12}O_6 \rightarrow 3CH_3COOH + H_2 \quad \text{(Equation 4)}$$

$$C_6H_{12}O_6 \rightarrow 3CH_3CHOHCOOH(\text{lactic acid}) \quad \text{(Equation 5)}$$

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2CH_3CH_2OH\ (\text{ethanol}) \quad \text{(Equation 6)}$$

These fermentation products are then utilised by methane forming and sulphate reducing bacteria, further cycling carbon within the wetland (Equations 7 and 8) (Kadlec et al. 2000).

$$CH_3COOH + H_2SO_4 \rightarrow 2CO_2 + 2H_2O + H_2S \quad \text{(Equation 7)}$$

$$CH_3COOH + 4H_2 \rightarrow 2CH_4 + 2H_2O \quad \text{(Equation 8)}$$

Microorganisms do not play a large direct role in the removal of phosphorus from wetlands. Bacteria within wetland sediments readily oxidise most phosphorus species to orthophosphate (soluble) form (H2PO4-, HPO42-, PO33-), and have been shown to store phosphorus as polyphosphates, and indirectly control numerous chemical processes responsible for phosphorus release/storage (Copper et al. 1996; Khoshmanesh et al. 1999). Bacteria within a wetland sediment can affect the release of adsorbed phosphorus by (i) lowering redox potential by consuming oxygen, enhancing loss of phosphorus from iron-P bonds, (ii) reducing Fe (III) to Fe(II) when iron reducing bacteria are present, concurrently releasing phosphorus previously adsorbed to the iron oxide, and (iii) reducing sulfate to sulfide, when sulfate reducing bacteria are present, causing a reduction in redox potential that facilitates iron reduction (as stated above) (Richardson and Craft 1993).

12.5. Phytoplankton and Periphyton

Phytoplankton are free floating photosynthetic organisms that lack the capability of substantial self-locomotion. Phytoplankton communities are one of the most productive communities in the world, capable of utilising large quantities of nutrients for growth and reproduction (Nybakken 1997). It is difficult to obtain data that directly measures nutrient uptake by phytoplankton communities in a storm water treatment wetland, or even a fresh water ecosystem. However, Harris (1986) reports that rapidly growing phytoplankton communities can exhibit an uptake ratio of 106 C: 16 N : 1 P.

Periphyton refers to photosynthetic organisms that permanently attach themselves to substrate within wetlands. This substrate is commonly macrophyte tissue (stem, leaves or roots) exposed within the water column and sediment at the base of the wetland. Korner and Vermaat (1998) reported that periphyton attached to macrophyte stems and sediment particles can remove significant amounts of nutrients from the water stream, while additionally filtering small suspended particulate matter. Periphyton communities also release oxygen into the water column via photosynthesis.

12.6. Macrophyte Zone Re-Suspension Cross-Check

In times of high flow through the wetland, it is important that biofilms attached to the macrophytes' stems don't get scoured, and sediment from the base of the wetland does not get re-suspended. Equation 4.1 (Equation 6.3 of the WSUD Technical Design Guidelines for SEQ, 2006), has been used to ensure the velocity of water moving through the narrowest part of the wetland does not exceed 0.05 m/s.

$$V = \frac{Q_{maxriser}}{A_{section}} \qquad \text{(Equation 9)}$$

where;

$Q_{max\ riser}$ = maximum discharge flow rate

$A_{section}$ = wetland cross section area at the narrowest point, measured from the top of the extended detention depth (mAHD)

At the narrowest point at full extended detention depth, the designed wetland has a cross section area of approximately 39m^2 (at 60m width and 0.65m deep). With the maximum discharge rate of 2.65l/s for the 3 month ARI (25% of the 2 year ARI), the maximum velocity of water moving through the wetland has been calculated at 0.098m/s, which is close to the 0.05m/s recommended threshold. We suggest that this velocity is acceptable given more recent research on growth rates of biofilms within wetlands reporting recovery of biofilms in two to three weeks following scour.

13. APPENDIX F: THE RIPARIAN ZONE

13.1. Role of Vegetation

The role of riparian vegetation in ecological and environmental restoration is well documented. A well developed and structured riparian zone is critical in providing physical assistance to restoration in the form of providing and enhancing bank stability and protection (Abernathy and Rutherfurd 1999; Lovett and Price 1999). Riparian vegetation also aids in reducing solar heating of a waterway and in the case of a forested riparian zone will also aid in the cooling of soil water and shallow groundwater through evapo-transpiration (Tabacchi et al. 1998). Other benefits that are developed over the longer term include an increase in the carbon supplies and enhanced nutrient cycling in the riverine zone (Marsh et al. 2005).

A detailed design of the wetland and associated riparian planting will serve to achieve the desirable outcomes of enhanced riparian vegetation. A planted riparian zone should integrate with existing, desirable riparian species and further protect species of significance. In all instances the riparian enhancement will be best achieved by a multi-tiered approach, with species composition, complexity and density reflecting, where possible species indigenous to the area and reflective of the local structure and density.

13.2. Riparian Buffer Zones

A Buffer Zone is an area of the riparian vegetation parallel to the waterway that is planted with the aim of improving water quality by removing sediment and sequestering nutrients and other pollutants from overland flow, while increasing the stability of the creek banks and maximizing connectivity away from the canal or wetland. Three types of buffers are discussed further in this Plan; pioneer species planting, structural reconstruction and designed landscape response.

Areas classified as ‘Low’ recovery potential are generally not likely to be prioritised for restoration due to the poor quality of the vegetation and significant investment required; however these areas can be maintained as a buffer which will provide direct improvements to water quality while increasing the area of riparian vegetation at less cost than full ecological restoration. In general, buffers protect a system component from the effects of change within another part of the same or an adjoining system. Riparian buffer zones are very important for a number of reasons:

- They often contain diverse vegetation communities which provide a habitat heterogeneity for terrestrial and semi-aquatic organisms;
- They can influence water flow, both surface and subsurface, thereby improving water quality; they provide shade, which in turn helps control water temperature, algal growth and provides cover for aquatic species;
- They are a source of leaf matter as a source of food, and woody debris for habitat;
- They increase bank stability; and,
- They provide corridors for movement of native fauna and flora between geographically separate areas. Riparian zones can also act as a buffer to noise and light pollution from nearby roads or urbanised regions.

The effectiveness of a riparian buffer at achieving each of the abovementioned functions varies depending on several key factors, namely bank slope, vegetation species composition and age, and sediment type (Parkyn, 2004). Slope gradient appears to be the most important variable in removal of sediment or particulate pollutants, whereas buffer width is most important for the effective removal of dissolved nutrients (Parkyn, 2004).

Riparian buffers comprising grassed or pasture grasses (referred to as vegetated filter strips) are effective at trapping sediments and nutrients adsorbed to sediments (such as phosphorus), but tend to be relatively poor at trapping dissolved nutrients, or for the provision of shade, food sources, in-stream structure or corridors for many species (Parkyn, 2004). Riparian buffers comprising taller, woody vegetation are typically good at providing shade, as a source of food and woody habitats, as a screen for light and noise, as corridors for terrestrial fauna (to a varying extent depending on species composition), and as a means for reducing soluble nutrient inputs. Designed riparian buffers often incorporate multi-tiered systems of both native woody vegetation to enhance

ecological function, and vegetated filter strip for the management of water quality. In essence, this approach seeks to mimic the complexity and effectiveness of a natural riparian buffer system, and often the best approach is to provide the required buffer width to enable a self-sustaining buffer of native vegetation (Parkyn, 2004).

It is difficult to derive a general 'rule of thumb' regarding buffer width, as this will vary depending on the desired functions of the buffer, volume of water, sediment being transported, and vegetation composition. Whilst a 5-10m vegetated filter strip buffer may be adequate for removing the majority of sediment and adsorbed nutrients, it has been shown to be insufficient for removing soluble nutrients (Parkyn, 2004), and would likely serve limited ecological value. A combination of 10m of grass buffer and 10m of natural vegetation adjacent to canal and wetland margins has been recommended as effective in many situations from a water quality perspective, (Land and Water, 2004). When the consideration is in relation to the protection and enhancement of bank stability, riparian buffer width should be determined by the height and steepness of the eroding banks profile; the higher and steeper the bank the greater the width of the protective buffer (Abernathy and Rutherfurd, 1999). However the minimum width requirement to achieve some level of enhanced bank stability and protection is five metres (Abernathy and Rutherfurd, 1999).

All of these factors must be balanced by existing and potential site constraints at the location of the restoration activities. Due to a number of site constraints, ideal widths of the riparian revegetation zone will not always be achievable, however, the five meter minimum width will be achieved in the majority of cases.

13.3. Managing Vegetation – Weeds and Natives

Native vegetation will be managed by enhancing the existing desirable species on-site and identified in previous studies. To the greatest extent practical, preference should be given to the use of local provenance plant material, which in this context would mean as close to site as possible, or at least from the Ahuriri Lagoon catchment.
Vegetation plays an integral role in the sites long-term stability, by binding soils and limiting erosion; enabling succession in large trees to mature then fall into the water; and to provide food sources and shelter for aquatic and terrestrial fauna.
Weeds have a variety of significant impacts, affecting not only the environment but also the economy and social values. They are an important factor that needs to be controlled during the restoration and stabilisation process.
The success of one technique over another for control can vary significantly depending on a variety of factors, including:

- the size of the standing population or level of infestation;
- time constraints imposed on the management regime;
- the constraints of the surrounding environment or the site; and
- the proximity of populations that can re-establish a site.

On-going success in weed management requires a detailed understanding of the target species, with a focus on factors such as:

- life history;
- fecundity or size of seed bank; and
- dispersal mechanisms.

There is a need to undertake weed control in a staged manner. Whilst undesirable, many of the weed species provide shelter and food, and contribute to corridors for wildlife. Care must be taken to ensure that the environmental benefits provided by adult trees are retained until the native revegetation is able to replace these functions. A detailed weed assessment is needed to ascertain if native fauna are using weed species as habitat and if so careful consideration of a staged weed removal and replacement will have to be considered.

The planting densities should be focussed on providing a dense ground cover layer at all revegetation layers. A dense ground cover layer is a useful, passive strategy for crowding out and preventing the establishment weed species (BCC, 2003).

13.4. Restoration of Native Vegetation

Management responses for the rehabilitation of native vegetation will vary according to the condition of the subject site, types of weeds and other pressures being managed. For the purpose of this plan two primary types of rehabilitation are proposed – assisted regeneration and restoration.

Assisted regeneration of riparian buffers assumes appropriately qualified bushland regenerators or restoration practitioners employing recognised strategic weed control methods within remnant native vegetation with a high recovery potential. The purpose is to guide a site's ecological trajectory to recovery via strategic weed control methods and stimulating seed banks. Planting is generally not a part of assisted natural regeneration and would only be in response to observations made around vegetation structure and species representation over time.

The assumed weed control management within assisted regeneration areas would involve works being undertaken over a 12 month to 36 month period with a sequence of works likely to include:

0 – 6 months – preliminary/primary weed control
6 – 12 months – follow up weed control
12 – 36 months – maintenance weed control

Maintenance does not necessarily end after 36 months. The aim is to get the site to a level of minimal maintenance. Some sites will require maintenance in perpetuity, perhaps being treated once or twice per annum.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed with the aim of restoring to the extent possible, the structure, function, dynamics and the integrity of the pre-existing vegetation and the sustaining habitat that is provided. Restoration is to be conducted in accordance with the following definitions:

- Natural regeneration – this applies to relatively intact plant communities where recovery is automatic with the removal of the cause of the damage/disturbance e.g. after cyclonic events, bushfires etc. Usually no human intervention is required.
- Assisted Natural Regeneration – this approach is appropriate in relatively intact native plant communities where limited intervention such as weed control, track closure, erection of fencing etc. is sufficient to restore the native vegetation through natural regeneration and successional processes.
- Rehabilitation – the reparation of ecosystem processes, productivity and services alone, but not necessarily re-instating the pre-existing vegetation community. Rehabilitation can be part of a restoration program.
- Reconstruction (Revegetation) – this approach is required in highly disturbed, modified and degraded areas where the potential for native plant regeneration is considered to be limited. In these situations, native species are unlikely to return to the site without greater intervention, such as replanting, large-scale weed control, rehabilitation of drains, importation of soil etc.
- Fabrication – this approach is required where conditions are permanently changed and better adapted local systems can be constructed to restore integrity to the landscape.

13.5. Structural Weeds

The most commonly encountered weeds within the site are willow and pastural grasses. Each of these weeds impacts on riparian rehabilitation as they form a structural component of the terrestrial riparian vegetation.

Vines

Vines are particularly invasive plants. They are destructive, prolific and persistent, often able to adapt to a vast range of soils and conditions and difficult to control. Control of invasive vine weed species is recommended throughout the remnant vegetation of the riparian zone as part of a coordinated approach to weed management between landowners.

Canopy Weeds
Planning for removal of canopy weed trees requires consideration of the role of the tree in riparian stabilisation framework. The riparian canopy consists of trees between 5m and 30m. Root systems of riparian trees are a central dense root mass about five times the diameter of the trunk. The root system provides the framework for the physical strength of the bank. The tree roots hold the bank together, facilitate drainage through the bank and prevent water logging and slumping.

The major canopy weed of riparian zone is willow. These weedy trees are dominant species often forming monocultures on creek banks. Where no other species are assisting in bank stabilisation and the vegetation zone is narrow, the bank can eventually become unstable from deep undercutting and the tree falls into the water. Although serious degradation is caused, the trees still provide riparian function which needs to be considered in weed control programs. They provide shade on the waterway, reducing water temperature and provides limited canopy habitat for fauna. A program of staged removal and replacement is the best approach to management.

Midstorey
Although midstorey weeds provide shelter and shade on the waterway and may provide bank stabilisation functions, they also compete with less vigorous native seedlings and block their regeneration.

Understorey
Pasture grasses are dominant in the riparian understorey. Understorey weeds in riparian zones block regeneration of native seedlings through competition but they also contain bank sediments during flood events. Understorey weeds also inhibit natural littler cycling and reduce habitat for reptiles and amphibians. Removal of understorey weeds is essential to reinstate riparian function, but consideration of the erosion potential following weed removal is required.

Aquatic weeds / Macrophytes
Aquatic weeds are reducing the hydraulic capacity of the canal, effectively damming large sections of the canal. It is however providing a water quality function trapping nutrients and sediments. The return of a functional riparian canopy will reduce the cover of these weeds through shading of the water way in certain locations.

Weed specific programs on a catchment basis are required to deal with more serious aquatic weeds.

13.6. Riparian Buffer Options

Riparian Buffer options could include one or a combination of many treatments ranging from fencing an ephemeral margin and undertaking seasonal weed control to full ecological restoration. Options include:

- Fencing and weed management;
- Fencing, grass buffer strip, and weed management;
- Fencing, pioneer planting, and weed management;
- Fencing, and ecological restoration; and,
- Natural assisted regeneration.

14. APPENDIX G: RIPARIAN PLANTING AND ESTABLISHMENT

Plant list
Species recommended for planting in podocarp forest restoration sites, from Williams (2005). *Native plant communities of the Canterbury Plains.* Department of Conservation, Christchurch)

Tall trees

kahikatea	*Dacrycarpus dacrydioides*
hinau	*Elaeocarpus dentatus*
pōkākā	*Elaeocarpus hookerianus*
mātai	*Prumnopitys taxifolia*

Trees and large shrubs

wineberry/makomako	*Aristotelia serrata*
marbleleaf/putaputaweta	*Carpodetus serratus*
karamū	*Coprosma lucida, C. robusta*
cabbage tree/ti kōuka	*Cordyline australis*
tree fuchsia/kōtukutuku	*Fuchsia excorticate*
broadleaf	*Griselinia littoralis*
pigeon wood	*Hedycarya arborea*
narrow-leaved lacebark	*Hoheria angustifolia*
mānuka	*Leptospermum scoparium*
rōhutu	*Lophomyrtus obcordata*
poataniwha	*Melicope simplex*
kaikōmako	*Pennantia corymbosa*
lemonwood/tarata	*Pittosporum eugenioides*
kōhūhū	*Pittosporum tenuifolium*
lowland ribbonwood	*Plagianthus regius*
lancewood/horoeka	*Pseudopanax crassifolius*
milk tree/tūrepo	*Streblus heterophyllus*

Shrubs, flax, grasses

mikimiki	*Coprosma propinqua*
red-stemmed coprosma	*C. rubra*
round-leaved coprosma	*C. rotundifolia*
koromiko	*Hebe salicifolia*
weeping matipo/māpou	*Myrsine divaricata*
harakeke/swamp flax	*Phormium tenax*
toetoe	*Austroderia richardii*

The planting strategy and list draws upon species naturally occurring in the catchment of Ahuriri and those species readily available from wholesale nurseries.

The majority of species are to be sourced as 50mm tubestock, while some species require collection as rhizomes or root stock.

Planting densities are recommended at six plants per metre square for wetlands and eight for ephemeral areas. Planting is to occur in bands or clumps of single species. A diversity of macrophytes species have been specified, however it is likely that two to three species will dominate over time, which is natural and appropriate.

14.1. Fencing

Uncontrolled use of riparian lands around the Halswell Canal and ephemeral lateral margins by stock can contribute greatly to the amount of sediment, nutrients and animal wastes moving into the creek. In addition, uncontrolled access can lead to excessive run-off, bank erosion, loss of productive land, decline in important wildlife habitat and damage to in-stream and wetland

ecosystems. As domestic stock favour riparian frontages and low-lying gullies, these areas can become over-grazed, eroding the soils allowing weed invasion and eroding stock tracks which result in increased sediment, nutrients and animal wastes being washed into the canal and ephemeral wetland system.

The simplest way of regulating stock access to riparian land is to fence the area between the riparian or ephemeral land from the remainder of the property, limiting access.

14.2. Weed Management

Once an area is fenced off, it will require maintenance to prevent weed invasion. The maintenance of these buffers will be required several times each year. Weed control may range from slashing periodically or allowing seasonal grazing within a grass buffer, through to routine assisted regeneration of reconstructed areas such as spot spraying and hand weeding. Although some of these options are not consistent with best practice management bushland regeneration, we recommend this as a compromise, if necessary, that upholds the principle that some vegetation cover is more beneficial to the health of the riparian zone than none, particularly as the buffer could be viewed as Stage 1 of further ecological restoration.

While undertaking weed control, erosion needs to be managed by maintaining some vegetation cover to avoid exposed soils along ephemeral drainage lines and on the banks of the creek. Retaining some vegetation cover should also prevent an increase in weed species.

Follow up maintenance is an integral part of regeneration and needs to be funded as part of the initial planning for each site. Any follow up works requiring more highly skilled regenerators will require funding for professional contractors.

It is important to keep livestock out and to maintain the buffer to ensure there is almost complete ground cover and a good height of vegetation (grasses should be at least 10-15 cm) to maximise the capacity for sediment and nutrient entrapment. The ideal width and management practice for grass buffer strips depends on the volumes of water and sediment being transported and the nature of the adjacent landscape, however it is generally recommended that an ideal combination of 10m of grass buffer and 10m of natural vegetation adjacent to a riparian margin will be effective in most situations (Prosser and Karssies, 2001), however between 10m and 20m is recommended.

14.3. Pioneer Planting

Pioneer planting is a thick density of fast-establishing pioneer riparian species that will quickly encourage soil binding and canopy shade to deter weed infestation. This is likely to include bird attracting canopy tree species but may not be particularly structurally complex or have high species richness.

The primary aim of the planting is to improve and establish habitat quickly providing a micro-climate for the establishment of an understorey. Similar to grass buffers, it is recommended that this planting type be at least 5m wide and be situated to ensure that ephemeral and overland flow paths are intercepted (Figure 11).

Establishment of this buffer would involve fencing to exclude livestock, slashing and spraying of pasture grass, planting of appropriate native species at a density of between one and two tubestock per square metre, initial watering and periodic follow up weeding until the native plants are sufficiently established to suppress weed growth.

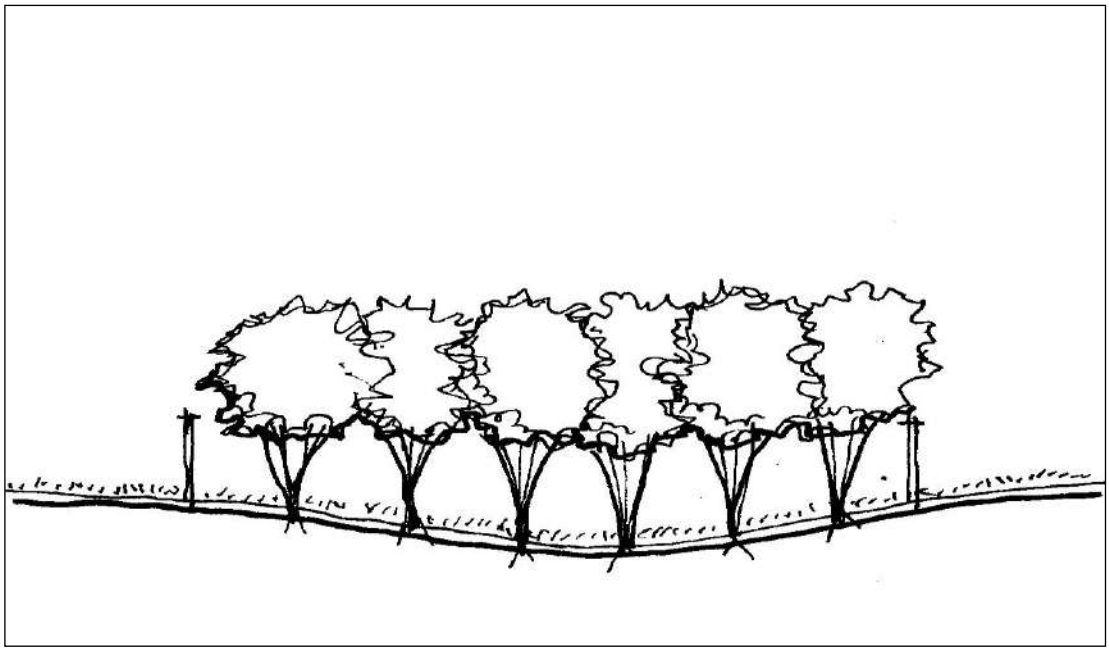

Figure 11. Conceptual image of pioneer planting.

14.4. Structural Planting / Reconstruction

In areas where native vegetation is so degraded that assisted natural regeneration or rehabilitation alone is unlikely to be successful, reconstruction of native vegetation will be required. This would apply where weed cover is greater than 70% of a site, native seed banks are poor, species diversity is very low and vegetation community structure is poor to non-existent.

Consistent with the definition of reconstruction, this option involves a wholesale reinstatement of the original vegetation community. The aim of reconstruction will be to recreate the system that would occur naturally onsite by planting a range of species such as native grasses, reeds, and shrubs on the margins and shrubs and small trees higher up the bank to recreate a more natural vegetation structure (Figure 12). Local native plant species, i.e. plants that are indigenous or commonly found, occurring naturally within the Ahuriri catchment (including trees, shrubs, herbs and grasses) are to be used.

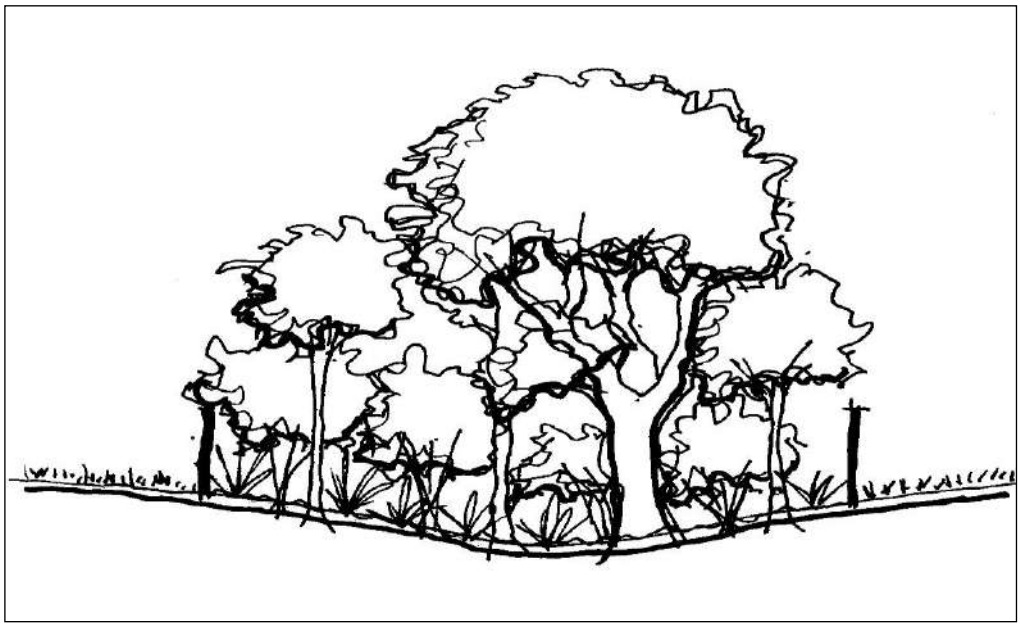

Figure 12. Conceptual image of structural reconstruction.

This type of reconstruction could be seen as a progressive goal on suitable riparian land. The initial fencing and planting of a grass buffer strip could be seen as the first stage of improving water quality buffers (Figure 13).

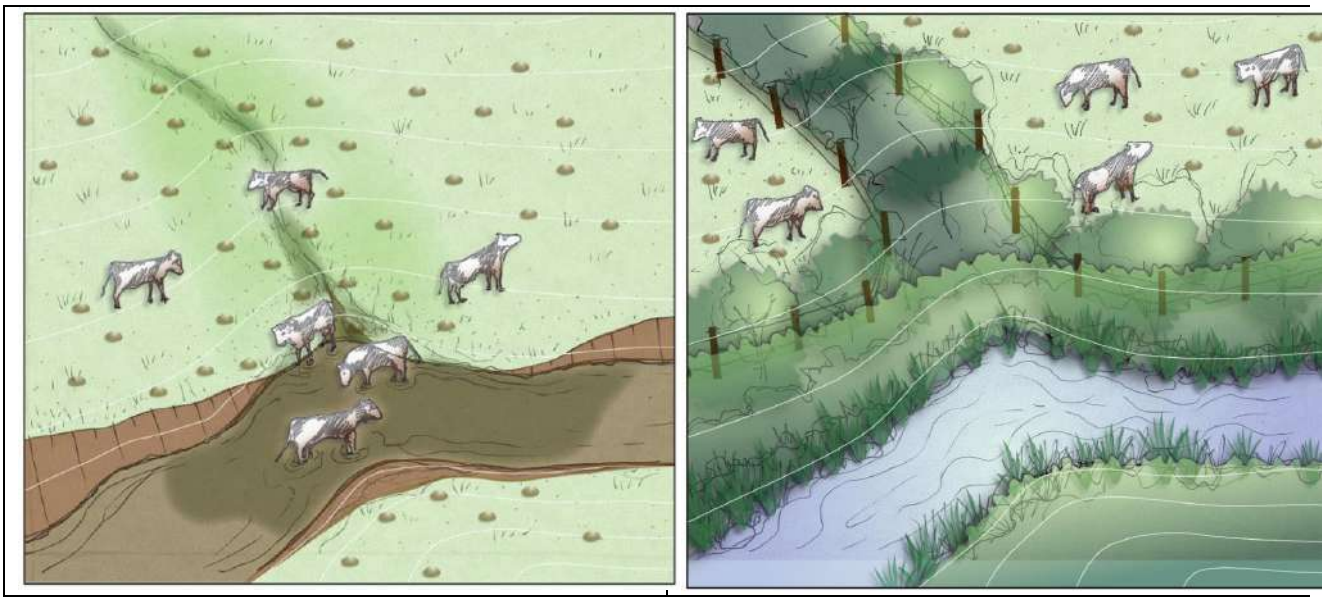

Figure 13. Conceptual image of riparian water quality buffer indicating existing degraded condition (left) and revegetated riparian water quality buffer (right).

Restoration in this context would involve primary weeding using techniques such as cutting and painting or drilling and injecting woody weeds, spraying of herbicides and scraping and painting canopy weeds such as vines. Beyond this primary weeding phase, secondary weeding will be required, possibly in combination with mulching or geotextile matting of exposed soils.

Planting of appropriate native species is required to recreate the site's original vegetation community with respect to species and composition. Follow up weed control and then maintenance weed control over a two to three year period is assumed to be required.

15. APPENDIX H: THREATENING PROCESSES

The major threats are to riparian rehabilitation vary throughout different parts of the Ahuriri Lagoon site. The major threats were: weed encroachment, grazing and water availability, upstream urban catchments and water quality, limited riparian buffer vegetation and connectivity.

An important part of successful rehabilitation is the management of threatening processes. Management actions need to address the threats at each site as they may affect the capacity of a site to regenerate.

The degradation of riparian vegetation has resulted largely from agricultural and indirectly, urban development. The major impacts of this are summarised below (with reference to the *Principles for Riparian Lands Management* by Lovett & Price 2007).

- Isolation of the wider flood plain from the Huritini/Halswell River / Halswell Canal through realignment of the canal from its original flowpath and current maintenance practices of depositing excavated material from the Canal onto embankments for improved conveyance.
- Draining of the wider environment for improved farming practices.
- Removing riparian trees increase the amount of light and heat reaching waterways. This favours the growth of nuisance algae and weeds.
- Clearing native riparian plants removes the natural sources of leaves, twigs, fruit and insects that underpin the aquatic food web.
- Removing riparian vegetation takes away the source of large branches and trunks, which would provide important habitat for aquatic organisms.
- Unrestricted stock access to the top of stream banks increases the delivery of sediments and nutrients to streams. Large volumes of fine-grained sediment smother aquatic habitat, while increase nutrients stimulate weed and algal growth.
- Removing riparian vegetation destabilises stream banks, often resulting in massive increases in channel width, channel incision and gully erosion.
- Removing vegetation along channels, and large wood in channels, can allow water to travel downstream at a faster rate, contributing to increased flooding and erosion.
- Removing vegetation throughout the catchment can lead to raised water tables and possible salinisation of land.

15.1. Weeds

Plants that are out of place or unwanted due to their invasive nature are considered weeds. They are mostly introduced species, but can include native plants from a different geographic area. Weeds are spread by animals, wind, water, humans and vehicles. They characteristically produce large amounts of seed compared to native endemic species and are the first to invade disturbed areas. Thus, places such as roadsides, urban areas and cleared landscapes generally have a greater abundance of weeds. In addition, riparian zones are at threat of weed invasion due to:

- The concentrated use by animals and humans;
- The more favourable conditions for weed production (e.g. moisture and flood disturbance);
- They are often the only remnant components of urban areas; and,
- Riparian zones often have a narrow longitudinal shape, so there is a greater proportion of patch-edge that is exposed to adjacent land uses and associated weeds.

Weeds have the potential to out-compete native plants for resources (soil, water, nutrients and light). They often form dense stands, smother native plants and provide refuge to feral animals. The rural land uses of the subject site are susceptible to weed invasion and pose a threat to the ongoing health of riparian native vegetation communities and ecosystems. Field observations indicate that many of these weeds grow around waterways, often dominating one or more vegetation layers.

15.2. Sedimentation and Erosion

Sedimentation is the process in which particulate matter carried from its point of origin by either natural or human-enhanced processes is deposited elsewhere on land surfaces or in water bodies. Sediment is a natural product of stream erosion; however, the sediment load may be increased by human practices. Such enhanced sources of sediment in a catchment include unvegetated streambanks and uncovered soil regions, including construction sites, deforested areas, and croplands.

In the context of stream hydrology, sediment is inorganic and organic material that is transported by, suspended in, or deposited by streams. Sediment load, which is the quantity of sediment transported by a stream, is a function of stream discharge, soil and land-cover features, weather conditions, land-use activities, and many other factors. Sediment load carried by streams and rivers can be composed either of fine materials, mostly silts and clays, or larger materials such as sand.

Solid sediment load can be divided into two components on the basis of the mode of sediment transport: suspended sediment, and bedload sediment. Suspended sediment consists of silt-sized and clay-sized particles held in suspension by turbulence in flowing water. Bedload sediment consists of larger particles which slide, roll, or bounce along the streambed by the force of moving water. Dissolved load consists of inconspicuous material in solution moving downstream. It is produced by chemical weathering processes, and does not settle out of water.

Additional erosion damages in both rural and urban areas include reduced property values, deteriorated water quality, and increased costs of removing sediment from roadways, roadside ditches, and surface-water supplies.

One of the principal causes of degraded water quality and aquatic habitat is the depositing of eroded soil sediment in waterbodies. Excessive amounts of sediment resulting from natural or human-induced causes can result in the destruction of aquatic habitat and a reduction in the diversity and abundance of aquatic life.

If the river cross-section is sufficiently reduced by sediment build-up, sedimentation can increase flooding. In addition, some metal ions, pesticides, and nutrients may adhere to sediment particles and be transported downstream.

Erosion is simply the opposite of sedimentation. Erosion is the removal of material/sediments out of the system. Although erosion is a natural process human land use practices also have an effect on erosion, especially when associated with agriculture, deforestation, and urban sprawl. Land use for these purposes generally experiences a significantly greater rate of erosion than that of land under natural vegetation.

Erosion is natural and, in fact, healthy for the ecosystem. For example, gravels continuously move downstream in watercourses. Excessive erosion, however, causes serious problems, such as receiving water sedimentation, ecosystem damage and outright loss of soil.

15.3. Flooding

- To remove exotic plant species from the creek corridor to improve the hydraulic function of the creek;
- To provide for the rehabilitation of the creek with endemic plant species which are tolerant of riverine conditions;
- To create an environment which is sympathetic to the ecology of the creek, and in particular, fauna habitat;
- To create a rehabilitated creek corridor which allows for access by the general community for recreation and education;
- To ensure that the potential for soil erosion and destabilisation of the creek banks is addressed by providing for the management and staged rehabilitation of the creek.

16. APPENDIX I: CLIMATE CHANGE

Global warming of around three degrees Celsius this century would translate to a mean warming over New Zealand of around 2.1 degrees C (Mullan et al. 2008), a warming rate of about 70% of the global mean. A consistent signal from global climate model projections is for an increase in the westerly wind circulation over New Zealand, especially in winter and spring. During summer, there may be a tendency for reduced westerly winds over New Zealand, but this is less certain (Mullan et al. 2008). Hence, evaporation may increase more (at least in relative terms) in winder than in summer.

As a result of expected wind changes, there is likely to be an increase in annual mean precipitation in western regions of New Zealand, and a decrease in rainfall in the east of the country. Such changes are likely to be most pronounced in winter and spring. During summer, there may be a reversal of this trend, with somewhat increased rainfall in the east of the country, and decreases in the west (Mullan et al. 2008).

Such changes in the mean climate would result in many changes in extremes of climate: reduced frost frequency and increased risk of heat waves over the whole country, reduced soil moisture and increased risk of drought in the east of the country, increased risk of forest fires in many eastern and northern regions, and increased risk of heavy rainfalls in most places.

A substantial increase is projected for the number of warm days (days with maximum temperatures over 25 degrees Celsius), particularly at already warm sites. For the current climate, Christchurch has around 31 warm days per year. Projected changes for the region near Te Waihora/Lake Ellesmere indicate an increase of around 25 to 40 more warm days, approximately a doubling in frequency compared to the current climate (Mullan et al. 2008).

Projections for Canterbury show rainfall increases in the west of the region and decreases in the east. In coastal Canterbury, rainfall is projected to decrease, but large alpine-fed rivers could have increased flows on average because of greater rainfall in the headwaters. The annual average rainfall change has a pattern of increases in the west (up to 5% by 2040 and 10% by 2090) and decrease in the east and north (exceeding 5% in places by 2090) (Mullan et al. 2008). The annual pattern of being wetter in the west and drier in the east is driven by that pattern occurring in the winter and spring seasons, when westerly winds are likely to be stronger than at present across New Zealand. In summer and autumn, the pattern is quite different, especially for the North Island where the pattern is reversed (although winter/spring changes dominate in the annual mean). There is still a lot of variability between models, although most models agree on the sign of the projected precipitation change across Canterbury.

For the Canterbury region, and for the area around Te Waihora/Lake Ellesmere, there is relatively good agreement between models that winter rainfall is likely to decrease by the late 21st century, while summer rainfall is likely to stay near present levels or to increase (Mullan et al. (2008). In the annual mean, the majority of models project a rainfall decrease for the Canterbury region.

For a mean sea-level rise of the order of 0.5-0.8m over 100 years (and 0.2-0.3 m over 50 years) the simplest expectation is that the beach system along Kaitorete barrier will rise, more or less in pace with sea level. This will occur as swell and storm waves ride in on progressively higher sea-levels. The likely outcome is for a higher, narrower, landward-migrating beach ridge spanning the outlet zone. Left unmanaged, the lake level would rise to match sea-level and the higher beach ridge.

In relatively shallow and productive lakes like Te Waihora/Lake Ellesmere (Verburg et al. 2010) reduced vertical mixing tends to reduce the replenishment of oxygen in bottom water and anoxia may occur or become more frequent in bottom water. Furthermore, increased runoff and external nutrient loading will compound such problems by increasing productivity with resulting increased oxygen consumption in bottom water.

Oxygen depletion in bottom water generally results in a higher trophic state and the potential for blooms of algae, in particular of blue-green algae.

17. APPENDIX J: RAMS ASSESSMENT

17.1. Site Assessment and Ranking of Sites

Previous catagorisation of the site by Environment Canterbury delineated 11 geographical areas within the extents of the site boundary. Using these areas as a starting point an assessment was made to determine the rehabilitation potential of each site. The assessment of vegetation health and the prioritisation of sites is based upon the Rapid Assessment Method (RAM). The assessment has been used successfully for numerous studies by the project team, and provides an informed and detailed assessment of the current character and issues of the riparian zone without undertaking a detailed geomorphic assessment. Details of the RAM methodology are as follows; two parameter types will be recorded for the assessment, non-ranking and ranking:

Non-ranking assessment parameters
These parameters are recorded to provide descriptive, qualitative information about the sites and include:

- Site number – Sites are numbered progressively from upstream to downstream;
- GPS waypoints – Waypoints are marked using a handheld GPS using map datum WGS84;
- Photo numbers – The photo numbers are recorded in the Riparian Assessment Matrix to ensure correct allocation of photographs to sites for reporting;
- Section length – The approximate length/ size of each site is indicated in metres based on changes in vegetation or obvious landmarks as identified on maps;
- Vegetation community code – endangered ecological community mapping codes (if available);
- Vegetation community ground-truthed – Ground-truthing of each mapped vegetation community is undertaken. Landscaped sites and remnant communities too small to be picked up by mapping or aerial photographs were also noted;
- Dominant terrestrial weeds – The dominant terrestrial weed species for each site are recorded;
- Dominant threat type – The dominant perceived threat was recorded for each site (e.g. grazing, weed invasion, stormwater pollution, erosion, sedimentation etc.);
- Current adjoining land use – The current adjoining land use was recorded based on field observations; and,
- Significant species/habitat – The presence of any listed threatened species was noted.

Ranking assessment parameters

The following parameters are scored to provide a quantitative assessment at each site. This assessment enables the calculation of the regeneration potential of each site based on each site's sum of scores. Each ranking assessment parameter is rated using a Likert scale where a score between 1 and 10 is assigned to each parameter. A score of 10 indicates excellent conditions and a score of 1 indicates the poorest conditions.

Parameters include:

- Weed cover – The proportion of weed cover to native cover is estimated where: 1 = all weed species and no natives; 10 = no weeds present at the site;
- Density (vegetation) – The density of native vegetation (including riparian trees, shrubs and forbs) is estimated where: 1 = no vegetation; 10 = maximum riparian vegetation density that could be expected at that site relative to the vegetation communities present;
- Diversity – The diversity of vegetation (including trees, shrubs and ground covers) is estimated where: 1 = no native species; 10 = the maximum diversity which could be expected at that site relative to the vegetation communities present;
- Vegetation community age – The relative age of riparian vegetation community establishment is scored for each site. The scores are based on the following:

Score	Community Age
1	Yet to regenerate (recently cleared or disturbed), no old growth trees.
3	Seedlings actively regenerating in a cleared/disturbed area, few to no old growth trees.
5	Saplings, indication of a young vegetation community, older disturbed area with few old growth trees
8	Established regenerated community – no obvious recent disturbance, some old growth trees.
10	Old growth community – no disturbance.

- Threats – This score indicates the likelihood of each site to ecologically degrade due to an active process or a combination of processes. Threats will likely include grazing, erosion, sedimentation, and weed invasion. Scores: 1 = very high threat likely to heavily impact on the ecological value of the site; 10 = no apparent threat and,
- Width (of riparian vegetation) – The width of the riparian vegetation zone is estimated for each site. The score describes the range of the extent of riparian vegetation from the edge of the canal or wetland margin. Score allocation is described in the table below:

Score	Width of Riparian Zone Vegetation (m)
1	1 – 5
2	5 – 10
3	10 – 15
4	15 – 20
5	20 – 25
6	25 – 30
7	30 – 35
8	35 – 40
9	40 – 45
10	> 45

- Connectivity (riparian) – Connectivity with other riparian areas up and down stream and laterally is estimated where: 1 = no connectivity to other riparian forest areas; 5 = either one side of creek has good riparian connection, or both banks have intermittent connection; 10 = unbroken connectivity with adjoining riparian forest on both banks;
- Connectivity (adjacent) – Connectivity with adjacent vegetated (Native plantings either natural or reconstructed) areas is estimated where: 1 = no connectivity to adjacent vegetated areas; 10 = continuous connectivity with adjacent vegetated areas of > 250m width; and,
- Access for rehabilitation – The availability of access for rehabilitation is estimated where: 1 = no access possible; 10 = unrestricted access for rehabilitation available.

Riparian rehabilitation prioritisation
Following assessment of riparian zone, the project requires prioritisation of riparian rehabilitation works and protection to:

- Address geomorphic processes,
- Address weed issues,
- Protect and enhance the riparian zone, and
- Protect and enhance the ecological health of the canal and the wider flood plain.

The following methods are proposed for the achieving these requirements. Rehabilitation sites were prioritised based on the calculation of each site's regeneration potential and threat score derived from the results of the site assessment. The regeneration potential is the score designed to reflect an area's resilience or ability to recover to a stable self-sustaining state from a degraded state given that active threatening processes are controlled. This can be expressed as:
Regeneration Potential (%) = (Bed Condition + Bank Stability + Weed Cover + Density + Diversity + Vegetation Community Age + Threats + Width + Connectivity Riparian + Connectivity Adjacent + Access for Rehabilitation) / 90 x 100.
Regeneration potential is derived using the sum of the eleven scores given for the ranking assessment parameters, expressed as a percentage. The lowest percentages reflect sites with the lowest regeneration potential, and the highest percentages reflect sites with the highest regeneration potential.

Threats may inhibit a site's ability to regenerate. If a site's regeneration score exceeds the threat score it is more likely to require less effort to regenerate than a site where the threat score greatly exceeds the regeneration potential.

The individual sites have been scored using the methods described above, and the results tabulated below 16.1. The results divide the site into high to low priority areas with respect to rehabilitation works based on a percentage score. The % score indicates the regeneration potential but this can be interpreted in a number of ways. A low percentage score or regeneration potential may in fact be a priority site as the need to implement rehabilitation at these locations is obviously needed. Whereas high regeneration potential scores are either more intact or have some degree of existing management. Access for Rehabilitation can also skew results, elevating rehabilitation potential scores. Access scores can be easily assessed on site and do not really influence a sites ecological rehabilitation potential.

Facilitators will need to assess each site on its merit with the above in mind to determine where funds are best spent. They also need to look at the site as whole as certain management activities need to be undertaken along the entire length of the canal and within the catchment. As an example, although several sites have low recovery potential scores there are high priority management activities that need to occur within them. The removal of Willows will be noted as a priority action regardless of a sites recovery potential. These priority actions to occur along the whole of the subject site are listed in Table 16-1.

Environment Canterbury will need to reconcile these points when implementing the actions to follow in this report and firmly establish and document a protocol for decisions around riparian management and expenditure.

17.2. Ecological Communities

The Ahuriri Lagoon has been broken down into 11 sites, which are illustrated in the concept masterplan (see page 14).

Site 1 – Old Course of the Huritini/Halswell RIver
Located at the top of the Ahuriri Reserve the old course of the Huritini/Halswell River extends in a short ox-bow on the true left of the canal. This section of the original flow path of the river is currently blocked from the main canal at the upstream end, however aquatic life can access the pools created from downstream. With no direct flow entering the old course from the Huritini/Halswell River this area of the reserve is dependent on an artesian well, backflow from the Huritini/Halswell River and groundwater levels to maintain suitable low-flow habitat for species

within the area, most notably tuna/eels. Providing shelter from above there are mature willows and the variability in the natural bed which assist with creating a stabilised aquatic environment.

Up until 2013 this area of the reserve was used for grazing acted as a stock camp. Since then stock access has been removed and along the riparian zone of the old course 500 plants were established as part of the restoration process.

Site 2 – Murrays Drain

Downstream on the true right of the canal we reach a second section of the old course of the Halswell River. Like Area 1 the top end has been cut off from the river with the downstream connection intact. With well-established crack willows and aquatic vegetation this area would be ideal habitat for eels and native fish which prefer low-flow habitat.

Running adjacent to this area and area 5 is the Little River Trail Route. This scenic route has been used to provide a measure of flood prevention by being located higher than the surrounding landscape.

In addition, 4,300 plants were established in this zone to assist with Ahuriri's restoration potential.

Site 3 – Extension of Rushland

An area of approximately 5.6ha on the true left of the Halswell River located mostly within the footprint of the old lagoon. Due to this areas low-lying nature heavy grazing has not occurred recently and the land has since been retired. Without the heavy grazing the native rushes are regenerating well and is extending since the area has been retired from grazing. Through the extension of the rushland increased feeding areas will be created for native waders and waterfowl. Along with the natural regeneration of this area there are plans to undertake excavations of shallow scraps to lengthen the persistence of shallow ponds into later months providing a more stable habitat.

Site 4 – Old Course Island

Approximately 4ha on the true right of the Halswell River located between area 2 and the Halswell River. Currently this is an area dominated by pasture grasses and contains mature pine trees, however there have been approximately 15,000 natives planted within this area to establish this section of Ahuriri Reserve into a Kahikatea-Matai-Totara forest habitat. With the majority of the ground level in this area being slightly higher than the surrounding area and therefore drier, native regeneration of wetland species in this area was deemed unlikely. Instead by planting between two thirds and three quarters of the area with forest plant species, restoration of the region will progress quicker while providing a more diverse series of habitats to birdlife.

Site 5 – Grazed Paddock Inside Rail Trail

The development of the rail trail through the reserve isolated an area of farmland approximately 15ha which is now between the rail trail and the Halswell River. Consisting of a low-lying pasture grasses area 5 floods during the wet winters and during periods of heavy rainfall. Through regularly flooding the area has been retired from grazing with potential option of using the space to gathering hay/silage as a means to keep the grasses maintained. It is expected that if the area was to be left alone the pasture grasses would out compete the natural wetland regeneration process as with the exception of the times in flood the 15ha will generally not be wet enough to allow for appropriate regeneration. Instead by cutting the grass leading into winter they will exist a greater capacity for ponding areas suitable for wildlife.

Site 6 - Wetland Margin Planting

An already retired section of land occupying adjacent to the core rushland area (site 7). This was an area dominated by exotic grasses due to the ground being drier preventing the rushes from expanding into it. In order to restore this particular area to a native state over 12,000 plants matching the Kahikatea-Matai-Totara forest habitat were planted in the areas deemed slightly higher and drier than what the rushland would be able to penetrate into.

Site 7 – Rushland

As one of the first areas to be retired this area forms the core marsh native rushland area within the reserve. Among the rushland area occupies willow forest areas which under most

circumstances provide valuable habitat especially within area's 1 and 2, however among the rushland if they are left unchecked they would dominate the sub-habitat. Currently removing the willows would have a negative influence of the ecosystem within the reserves so instead and monitoring and control approach has been taken on and will be later reviewed at a later date.

Site 8 – Seasonally Flooded Grazing Land

Similar to area 5 during the wet winters and heavy rainfall periods this low-lying grazed paddock will flood. Creating temporary ponds and extensive shallow margins, a prime habitat for wetland birds. In comparison to area 5 this section of the reserve will provide a more open habitat for wetland birds and is located on the other side of the Huritini/Halswell River from the Rail Trail reducing the levels of disturbance caused by the public. In order to maintain the current environment within area 8, grazing could be maintained during the drier parts of the year to ensure the vegetation stays relatively low-saturated further keeping this area open. The wetland species already present within area 8 have shown resilience to the current grazing regime, however more intensive farming techniques would likely cause substantial damage.

Site 9 – Puke Rapiti

A small rock outcrop currently on private land adjacent to area 8. The majority of this rocky outcrop is currently grazed and dominated by pasture. What is of interest with this parcel of land is that contained on the geologically interesting outcrop is a remnant dryland shrub consisting of plants rare in this area of the plains. The species contained within the remnant include matagori, pohuehue, and mingimingi. In order to bring this unique habitat into the overall management of the Ahuriri reserve a land swap has been proposed for the long term protection of the remnant while transferring across developed pasture of lower ecological value.

Site 10 – Halswell River Riparian Planting

The true left bank of the Huritini/Halswell River running parallel to the rail trail on the other side of the river consisted of exotic grasses consistent with pasture, crack willow and a native nettle as known as Ongaonga. To increase the diversity of species along this area approximately 8,000 natives were planted along this patch of the reserve. Care was taken during the planting and maintenance stages to prevent damage through spraying to the Ongaonga present at the water's edge, primarily through ensuring all plantings were conducted at least two metres away from the nettles. The species along this patch of reserve were also selected to provide screening for birds occupying areas on the true left of the bank which may be otherwise disturbed by individuals travelling along the rail trail or spending time at the reserve.

Site 11 – Marshall Block Restoration Planting

At the southern end section of the reserve this approximately 12ha area of land was retired mid-2012. Within area 11 the plant species consist of a variety of species consist with reedland, pasture grassland and native plantings of species present in a Kahikatea-Matai-Totara forest. The diversity of plant species present within this area stems from culverts feeding spring water into the land while drier areas as is consistent with plantings within other areas of the reserve are a collection of forest species which will have an easier time of establishing against exotic grasses than the wetland species.

Table 8. Ranking of Sites – Section 1.

Ranking Assessment* Parameters Scores (1 – 10)																	
						Total											
Site	**Location**	**Photo numbers**	**Approx. section length (m)/Area m²**	**Dominant terrestrial weed**	**Dominant threat type**	**Current adjacent land use**	**Weed cover**	**Density (vegetation)**	**Diversity (trees, shrubs, forbs)**	**Vegetation community age**	**Threats**	**Width (riparian vegetation)**	**Connectivity riparian**	**Connectivity adjacent**	**Access for rehabilitation**		**% Regeneration potential**
1	Old Course	1-3		Pasture grasses	Grazing, Pasture grasses	Grazing, canal	2	2	2	1	3	1	2	2	3	18	20.0
2	Murrays Drain	4-5		Pasture grasses, hen, thistle	Maintenance, weeds	Isolated canal and drain	5	5	7	3	4	9	7	6	9	55	61.1
3	Extension of rushland	6-9		Pasture grasses, Willow	Pasture grasses, grazing	Grazing, canal	2	1	2	1	2	2	4	4	3	21	23.3
4	Old Course Island	10-13		Pasture grasses	Weeds	Isolated canal and drain	2	2	2	1	3	9	7	7	8	41	45.5
5	Grazed paddock inside Rail Trail	14-15		Pasture grasses	Grazing, Pasture grasses	Grazing, canal	1	1	1	1	1	1	2	2	7	17	18.8
6	Wetland margin planting	16-20		Pasture grasses, willow	Grazing, pasture grasses	Grazing, rushland	1	1	1	1	2	2	5	6	6	25	27.7

Ranking Assessment* Parameters Scores (1 – 10)							Total									
Site	**Location**	**Photo numbers**	**Approx. section length (m)/Area m²**	**Dominant terrestrial weed**	**Dominant threat type**	**Current adjacent land use**	**Weed cover**	**Density (vegetation)**	**Diversity (trees, shrubs, forbs)**	**Vegetation community age**	**Threats**	**Width (riparian vegetation)**	**Connectivity riparian**	**Connectivity adjacent**	**Access for rehabilitation**		**% Regeneration potential**
7	Rushland			Pasture grasses to margins, willow	Weed encroachment	Grazing, canal	7	8	7	5	6	9	8	8	5	63	70.0
8	Seasonally flooded grazing land	21		Pasture grasses	Grazing, pasture grasses	Grazing, canal	1	1	1	1	1	1	2	2	9	19	21.1
9	Puke Rapiti	22-25		Pasture grasses	Weed encroachment, maintenance	Grazing	6	1	2	1	2	2	2	2	9	25	27.7
10	Halswell River riparian planting	26-28		Pasture grasses, willow	Willows, maintenance, weed encroachment	Canal, grazing, rushland	5	6	6	3	4	4	7	6	7	48	53.3
11	Marshall Block restoration planting	29-32		Pasture grasses	Willows, maintenance, weed encroachment	Canal, grazing	6	7	7	6	6	7	6	7	8	60	66.6