

Hikurangi Swamp Floodway Riparian and Ox-Bow/Cut Off Channel Management Plan

March 2017

Hikurangi Swamp Floodway Riparian and Ox-Bow/Cut Off Channel Management
Plan

Whangarei District Council

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Management Plan status

1 Overall responsibility for the co-ordination of all matters in this plan		
Date	Name	Designation
May 2011	Conal Summers	Stormwater Asset Engineer
March 2017	Adam Twose	Operations Engineer

2 Prepared/reviewed/updated by		
Date	Name	Designation
May 2011 – Version 1 -Draft	V Kloosterman & Warren King	VK Consulting Environmental Engineers Ltd
March 2017 – Version 2 - Draft	Adam Twose & David Wright	WDC & Ecology North (respectively)

1 Executive summary

1.1 Introduction

This document has been prepared in accordance with resource consent 20031137501 issued by Northland Regional Council for the activities associated with the Hikurangi Swamp Scheme. These consents required WDC as consent holder to prepare a Floodway Riparian Management Plan by 27 May 2011 and an Oxbow/Cut-Off Channel Management Plan by 27 May 2012. The management of the riparian margins and the enhancement of the oxbow/cut-off channels are closely interlinked and so WDC has combined these two management plans into this one document called the Floodway Riparian and Ox-Bow/Cut-off Channel Management Plan (ROBMP).

This document forms part of, and should be read in conjunction with, the Hikurangi Swamp - initial Scheme Management Plan (i.e. iSMP) which also contains the full resource consent and register of scheme plans.

1.2 Process

During the original development of this ROBMP, WDC involved representatives of the Northland Fish and Game Council and Department of Conservation. This included identifying current good practice carried out by DOC and NFGC in the Scheme area. Furthermore, consultation was also undertaken with Northland Regional Council staff and regards to relevant Northland Regional Council documents. Subsequently in this second draft, input has been received from Living Water (a 10 year Fonterra / DoC partnership) and Ecology North. The advice and input from all these groups and individuals is gratefully acknowledged.

WDC also proposes to make this draft ROBMP available on Council's website so that it is accessible to the general public and stakeholders. WDC will also be consulting directly with grazing license holders to discuss and agree the changes which need to be put in place to allow for implementation of riparian margin and oxbow enhancement within the grazed floodway areas.

This process identified the following key issues

- Plant suitability.
- Planting methodology
- Stock exclusion.
- Compatibility with grazing licences.
- Stakeholder coordination.
- Ongoing maintenance.
- Affordability.

1.3 Goal

The goal of this ROBMP is to:

Revegetate the areas (referred to in the resource consent) in a manner which creates environmental benefits and ensures the design basis and flood carrying capacity of the Scheme is not compromised; and at a rate that has regard to practicality, benefit and affordability.

1.4 Methodology

1.4.1 Planting, fencing and stock exclusion

A range of plants have been identified which are able to withstand ponding and flooding, survive intermittent wetting and drying, require minimal maintenance, do not have significant die-back periods nor contribute large volumes of dead plant material, and do not adversely affect the flood carrying capacity of the scheme. Suitable plant species identified include: Phormium tenax (New Zealand Flax) Carex secta (Pukio) Bolboschenus fluviatilis (River bulrush), native Hebe already endemic in the area, Juncus species (leafless rushes). This is not an exclusive list and other plants could also be used.

It is intended to fence the riparian zones, exclude stock and allow for natural regeneration to occur. Riparian margin width will be variable depending on the cross-sectional shape of the channel and the slope of the side banks. In general it is proposed to locate the fencing 1 to 2 m back from the top of the main river channel on flat land. For oxbow/cut-off channels a riparian margin of up to a maximum of 5 metres is proposed.

Responsibility for fencing and provision of alternative water supply still needs to be discussed and agreed between WDC and grazing licence holders.

1.4.2 Water level control in Oxbow/cut-off channels

NFGC has indicated that some water level control is desirable in the oxbow/cut-off channels and simple earthen embankments of up to 2 m in height are proposed between the cut-off channel and the main river channel to retain greater water depths.

1.4.3 Maintenance

Ongoing maintenance is likely to be a joint responsibility with contribution from a range of stakeholders. Final details still need to be discussed and agreed. Maintenance will include mechanical cleaning and clearing of sediments, vegetation and detritus from oxbow and cut-off channels. Control of plant pests and inappropriate plant species also needs to be carried out. It is proposed this will be in general accordance with Table 3 of the NRC document "*Clean Streams-A Guide to Riparian Management in Northland*".

Control of animal pests in the floodway areas is likely to remain the responsibility of grazing licence holders.

1.4.4 Timeline

The timeline for this riparian revegetation will depend on a number of factors including:

- the renegotiation of the grazing licences
- the allocation of tasks and management responsibilities between the various stakeholders
- the revegetation method adopted.
- the need for consents from NRC to carry out works within the riparian zone or in the oxbow/cut-off channels
- the cost and availability of funding, which is also influenced by the factors identified above.

1.5 Proposed Restoration Sites

Annotated photographs are included in section 6 which show the proposed work along the main river banks and oxbow/cut-off channels between the southern end of the floodway at Matarau Road and the Tanekaha pump station (Borrow-Cut Area). There are a total of 18 sites which have been photographed and it is proposed to restore these areas first and then based on the experience gained to move on to the northern part of the floodway.

Annotated oblique photographs are supplied for each oxbow/cut-off channel site indicating where fencing, weed removal, alterations to the banks and the formation of a low embankment may be required.

Annotated oblique photographs of the riparian zones along the main river show the proposed location of fencing and existing vegetation.

In this second draft, opportunities to restoration sites outside of the berm land and on the protected side of the stop banks have been investigated and subsequently developed. To date these have included sites within the Okarika, Mountain and Tanekaha Pockets.

2 Introduction

2.1 Background and Purpose

This Floodway Riparian and Ox-Bow/Cut-off Channel Management Plan (ROBMP) is prepared in accordance with the resource consents issued by Northland Regional Council (NRC) for the Hikurangi Swamp Drainage Scheme.

The consents require Whangarei District Council (WDC) to prepare a Floodway Riparian Management Plan to address the riparian margins within the Scheme floodway up to 10 metres either side of the low flow river channel banks. This Management Plan must be forwarded to NRC's Monitoring Manager by 27 May 2011.

The consents also require WDC to prepare an Ox-Bow/Cut-Off Channel Management Plan which identifies the ox-bow/cut-off channels within the floodway which can be enhanced having regard to practicality and benefit and which outlines the methods to achieve this enhancement. This Management Plan must be forwarded to NRC's Monitoring Manager by 27 May 2012.

As the management of the riparian margins and the enhancement of the ox-bow/cut-off channels is interlinked, these two Management Plans have been combined into this one document resulting in the Ox-bow/Cut-off Channel Management Plan being submitted one year ahead of schedule.

The ROBMP also needs to be read in conjunction with the Hikurangi Swamp initial Scheme Management Plan (iSMP) which was submitted to NRC in November 2010 in accordance with resource consent requirements. The iSMP sets out operating and management procedures for the Hikurangi Swamp Scheme and a timetable for achieving all consent requirements by 27 May 2012, by which time a full Scheme Management Plan (SMP) needs to be submitted to NRC.

The overall purpose of the full Scheme Management Plan will be to incorporate best practice, the requirements of the consents and any other associated documents in a comprehensive guide for the management of the Scheme. The full Scheme Management Plan includes the ROBMP and a Fisheries Management Plan. The latter needs to be submitted by 27 May 2012.

These Management Plans must be read in light of the terms and conditions of the resource consents granted by NRC. In the event of any conflict in meaning, or ambiguity, between the terms and conditions of the resource consents and the provisions in the Management Plans, the resource consents take precedence.

In this second draft, considering feedback received from the Hikurangi Swamp Working Group and the practicalities of developing areas within the flood-prone bermland (i.e. fencing), restoration opportunities in the protected pocket side have been sought. Three areas have been identified to date and are presently being developed, located within the Okarika, Mountain and Tanekaha Pockets.

2.2 Document Control and Review

2.2.1 Document Control

The ROBMP and any subsequent updates to any part of the document are issued to those listed on the Document Register. A record of changes will be listed on the Status page with the version and release date.

Each of the individual sections and attachments may be independently issued.

In addition, WDC as part of its standard best practice makes Management Plans for the Hikurangi Scheme accessible on its website: www.wdc.govt.nz.

2.2.2 Document Register

Copy No.	Holder	Organisation and (Function)	No. of Copies
1	Stormwater Asset Engineer (SAE)	Whangarei District Council (Owner/Manager/Consent Holder/General overview)	1
2	Waste and Drainage Operations Supervisor	Whangarei District Council (Supervision of Scheme Operators)	1
3	Scheme Operator	HydroTech Ltd. (Scheme Operators)	1

Copy No.	Holder	Organisation and (Function)	No. of Copies
4	Monitoring Manager	Northland Regional Council (Consent Authority)	1

2.3 Consents

The Consent Holder and contracted Scheme Operators are responsible for taking such measures as are required to ensure that the scheme is operated in accordance with all resource consents. CON20031137501 has been issued by the Northland Regional Council for the following activities associated with the Hikurangi Swamp Scheme:

- (1) Water Permit: To divert and dam floodwaters within the Hikurangi Swamp Scheme ("Scheme") control-banks (=stopbanks), canals, drains and floodgates.
- (2) Discharge Permit: To discharge floodwaters over Scheme control-banks on to land and to water courses and rivers via flood control mechanisms within the Scheme.
- (3) Land Use Consent: To use restore, manage and maintain existing dams, culverts, control banks and floodgates, and placement and use additional structures on the bed of the watercourses within the Scheme.
- (4) Land Use Consent: To carry out excavation or disturbance of the bed of the water courses for the purpose of the free flow of water.
- (5) Water Permit: To divert water from repaired control-banks.
- (6) Discharge Permit: To discharge water from repaired control-banks.
- (7) Land Use Consent: To undertake earthworks on the control-banks and berms adjacent to watercourses within the Scheme, including modifications to spillways.

The full resource consent is included in Appendix A of the iSMP.

2.4 Related Documents

The following are related documents required by the resource consent issued by NRC.

- *Hikurangi Swamp-Initial Scheme Management Plan Version 001-3* dated March 2011. This document should be referred to for information on: scheme description, scheme purpose and design basis, roles and responsibilities, programme of works, monitoring programme, scheme maintenance and contingency and emergency planning. This document also contains the full resource consent and register of scheme plans.
- *Hikurangi Swamp Full Scheme Management Plan* (to be prepared by 27 May 2012) - will supersede initial scheme Management plan above
- *Fisheries Management Plan* (to be prepared by 27 May 2012)

2.5 Resource Consent Reference Documents

- *Hikurangi Swamp Major Scheme Volumes 1 and 2*. Northland Catchment Commission, 1968. (TRIM Record Numbers 07/40129 and 07/40130 respectively)
- *Hikurangi Swamp Scheme - Application for Resource Consents and Assessment of Effects on the Environment* MWH, May 2004. (TRIM Reference 09/114427)
- *Pump Station Operation and Maintenance Manuals*.
 - *Otonga, May 2008*: (Trim Record Number 08/48584)
 - *Ngararatunua, May 2008*: (Trim Record Number 08/46639)
 - *Okarika, May 2008*: (Trim Record Number 08/46612)

- *Mountain, May 2008:* (Trim Record Number 08/46598)
- *Junction, May 2008:* (Trim Record Number 08/46600)
- *Te Mata, May 2008:* (Trim Record Number 08/46583)
- *Tanekaha, May 2008:* (Trim Record Number 08/46574)
- *As-Built Plans.* (refer Appendix B of the iSMP)
- *Assessment of Effects on the Environment of the Hikurangi Swamp Scheme.* Hawthorn and Geddes, August 2009. (TRIM Record Number 09/72187)
- *Stormwater Business Continuity Plan.* Whangarei District Council, June 2008. (TRIM Record Number 08/48584)
- *Whangarei District Council's Health and Safety Procedures* (TRIM Record Number 10/102860)

3 Process

3.1 Background

Whangarei District Council's application for the consents for the Hikurangi Swamp Drainage Scheme went through a consent process which included a number of stakeholders (refer section 3.2) and resulted in the consent being issued by Northland Regional Council on 27 May 2010. The relevant consent conditions, 3 and 4, from this consent are given below.

3. *"The Consent Holder shall prepare a Floodway Riparian Management Plan . . . to address the riparian margin of the rivers within the Scheme up to 10 metres either side of the low-flow river channel bank. The provisions of this Management Plan relating to riparian margins within a floodway shall include, as a minimum, the following:*

(a) *the requirements for the types and the maintenance of riparian vegetation that are to be established along the banks of the main channels of the Whakapara, Waiotu and Wairua rivers.*

Advice note: It is recommended to take into account the following when preparing 3(a): the Northland Regional Council document "Clean Streams: a Guide to Riparian Management in Northland", advice from the Northland Regional Council staff and current good practice in the Scheme area or in similar areas.

(b) *A description of appropriate methods to be implemented for exclusion of stock from the riparian margins within the floodway. . . ."*

4 *The Consent Holder shall prepare a description of oxbows and cut off channels within the floodway channels of the Waiotu, Whakapara and Wairua Rivers that can be enhanced with respect to riparian function, such to be included in the Scheme Management Plan as the Oxbow/Cut-Off Channel Management Plan.*

The description shall include the procedures, methodology and funding mechanisms to achieve the enhancement and shall be prepared in conjunction with the Northland Regional Council and representatives of the Northland Fish and Game Council and the Department of Conservation and in consultation with persons farming the land in question. The plan shall identify which oxbows/cut off channels can be enhanced having regard to practicality and benefit. . . ."

WDC has followed the process of taking into account the specified Northland Regional Council documents, taking advice from Northland Regional Council staff, identifying current good practice carried out by DoC and NFGC in the scheme area, and involving representatives of the NFGC and DoC in the development of this ROBMP as set out in conditions 3 and 4.

It is also proposed that this draft ROBMP will be made available to all farmers in the Scheme for their input and comments by making it available on WDC's website. WDC will also be consulting directly with those "persons farming the land in question"(ie: grazing licence holders) to determine and agree the modifications needed to the grazing licences and the new mechanisms which need to be put in place to allow for implementation of riparian margin and oxbow enhancement within the grazed floodway areas.

Two of these ox-bow have been environmentally restored through this document, namely sites 13 & 14 as identified below. However, based on feedback from the Hikurangi Swamp Working Group and Environmental River Patrol, these endeavors have not been particularly successfully. This is due to both the practicalities and perceptions. In terms of practicality, being very flood-prone results in difficulties in managing the fence lines, which results in stock being quite frequently able to access the restored sites. The subsequent grazing coupled with the harsh ground conditions results in significant native plant loss and dominance of weeds. In terms of perception, anything which grows in the bermland is deemed (but not proven) as having the ability to slow the flow of water and contribute to potential flooding. To have a better success rate for establishing and securing (fencing) environmental restoration projects, the present strategy is to environmentally enhance areas on the protect pocket part of the Scheme.

3.2 Stakeholders

There is a combination of stakeholders with an interest and role in maintaining and enhancing riparian function and managing the outcomes. These include:

Stakeholder	Role and Interest
Northland Regional Council (NRC)	<p>NRC is the consent authority responsible for issuing the consent and monitoring compliance. NRC also made a submission in general support of WDC's application noting that the integrity of the Scheme and its stated objectives should be maintained.</p> <p>Condition 3 recommends that NRC's document "<i>Clean Streams: A Guide to Riparian Management in Northland</i>" and advice from NRC Council staff be taken into account when preparing Floodway Riparian Management Plan.</p>
Northland Fish and Game Council (NFGC)	<p>NFGC made a submission on WDC's application about the lack of planting in the riparian zone of the main river and old oxbows.</p>
	<p>Work is currently underway, lead by NFGC, to restore the "Borrow-Cut" Oxbow within the floodway near the Tanekaha Pump Station. This involves enhancement for both aquatic and terrestrial habitat. NFGC initiatives include installing water level control and fencing to exclude and/or limit and control stock access. This restoration has provided guidance for future work proposed in this ROBMP.</p> <p>NFGC is also partnering with DOC via a formal Management Agreement for joint management of the Wairua River Wildlife Management Reserve immediately adjacent to the floodway.</p>
Department of Conservation (DoC)	<p>DoC made a submission on WDC's application expressing concern about potential adverse effects on indigenous freshwater fish and seeking mitigation to address any adverse effects on natural and habitat values and processes.</p> <p>DoC administers the marginal strips adjacent to the river banks which have been vested in the Crown as Reserve. (Refer section 3.3) and is also responsible for jointly managing the Wairua River Wildlife Management Reserve with NFGC.</p>
Local land owners and those farming the land in question	<p>The floodway land is vested in WDC as a reserve for soil conservation and river control purposes as part of the Scheme. It is grazed under lease to the local landowners. The lease includes a number of conditions including to farm and manage the land in good and husband-like manner, at all times maintain the land in good grass, no greater than 150 mm in height on average, and clear the land of all noxious weeds as well as controlling animal pests.</p>
Iwi (Ngati Hau Trust Board)	<p>The Trust Board made a submission on WDC's application expressing concern about habitat degradation and its adverse effects on freshwater fish and their habitat. They sought input and participation into the effective management of the waterways including the freshwater fishery. (These aspects are being dealt with by a separate body of work currently underway to form the basis of the Fisheries Management Plan).</p>

3.3 Reserves and Marginal Strips vested in the Crown

Marginal strips within the Scheme area were created along the Whakapara and Wairua Rivers where crown land was sold adjacent to the river. This occurred long before the Scheme was constructed and typically a 20 metre strip adjacent to each bank of the rivers was vested in the crown as Reserve. These reserves are known as marginal strips and are administered by the Department of Conservation (DoC) for the purposes of:

- a reserve for public access;
- protection of the conservation values present;
- their inherent species values; and
- the improvement of the water quality.

The location of these marginal strips is shown in Figure 5.1 of the iSMP (provided by DoC). Where these marginal strips are located within the Scheme floodway they come under the umbrella of conditions 3 and 4 of the Scheme consent, which requires WDC to prepare a Management Plan to address riparian and oxbow/cut-off channel enhancement. Accordingly, the provisions for the enhancement of these areas with respect to riparian function are addressed in this ROBMP.

3.4 Significant indigenous wetlands.

The final Scheme Management Plan is required to include "*provisions for the protection of significant indigenous wetlands within the main floodway (washway) channels ie. between the control banks.*" (Condition 2 (f)).

The NRC staff report for the consent application¹ identified four separate remaining significant areas of remnant swamp or forest as follows:

¹ Northland Regional Council, April 2007. "*Northland Regional Council staff report on application: CON20031137501*"

- Forsythe meander
- Otakairanga Peat Bog
- Wairua wildlife Management reserve
- Jordan Valley Shrubland.

All of these areas are outside the floodway channel, but three of them, the Forsythe Meander, the Wairua River Wildlife Management Reserve and the Jordan Valley Shrubland have remnant cut-off channels within the floodway, although these are no longer hydraulically linked to the wetland areas due to the construction of the stop banks. The enhancement of these cut-off channels within the floodway is addressed in this ROBMP.

3.5 The approach to developing the ROBMP

This section outlines the approach taken by WDC in developing this ROBMP including meetings, discussions, liaison and site visits with various stakeholders and review of relevant documents.

Description - Date	Present	Outcomes/Discussion
Meeting 8 December 2010	Bob Cathcart (NRC) Conal Summers (WDC) Viv Kloosterman (VKCEE for WDC)	<p>Plants need to be able to withstand ponding, cope with intermittent wetting and drying, require minimal management and not adversely affect the hydraulic capacity of the Scheme. Suggested rushes, sedges, flaxes and hebes. If flaxes are planted first then the rest of the species tend to follow naturally.</p> <p>From the junction of the Waiotu and Whakapara rivers and upstream, it is important not to trap sediment and riparian planting is probably not required in this area. Willows were planted in this area because the banks were slumping but they do need to be managed. Bob Cathcart (NRC) to go out with Andy Keith (WDC) to decide which willows should be trimmed, removed.</p> <p>Need to select which oxbows should be managed and revisit grazing licences for these oxbows so that restoration can be implemented over a period of time to fit in with these licenses.</p> <p>Potentially creating significant wetlands over time so need a good photographic record of the "before" photos and be clear that these wetlands which will develop over time need to be managed within the constraints of the Scheme and in a way that does not compromise the Drainage Scheme objectives.</p>
Meeting 10 February 2011	Ian Hogarth (DoC) Rudy Hoetjes (NFGC) Conal Summers (WDC) Viv Kloosterman (VKCEE for WDC)	<p>DoC and NFGC agreed to help identify oxbows/cut-off channels for enhancement and offered to send aerial photograph identifying oxbows/cut-off channels.</p> <p>NFGC and DoC were working on Management Plan for the Wairua Wetland Reserve and agreed to provide a copy of this for background information.</p> <p>Photographic record of the oxbows/cut-off channels was important to provide a baseline record. Protocols need to be agreed now so that restoration and ongoing management can be carried out without the need for further consents.</p> <p>Necessary to increase the water levels in oxbows/cut-off channels for longer periods to get increased area of habitat, so earthworks are first step. Depths of 1 to 1.5 m maximum are desirable.</p> <p>Access is required for machinery to control sedimentation, remove dead plant materials and detritus and provide access for spraying.</p> <p>Stock exclusion is crucial to achieving successful riparian revegetation. Suggested options of solar powered electric fencing.</p> <p>Discussion on who was responsible for management of behalf of WDC. In regard to funding mechanism NFGC suggested work in</p>

Description - Date	Present	Outcomes/Discussion
		kind and that they were available to act in an advisory capacity. Suggested a meeting once per year between iwi, DoC, NFGC, WDC and landowners.
Aerial photographs showing location of oxbow/cut-off channels March 2011		Provided by NFGC to assist with identifying oxbows/cut-off channels for restoration
Wairua Wetland Reserve Management Plan Management Plan for the Borrow-Cut area adjacent to Tanekaha pumping station 6 April 2011		Provided by NFGC and used by WDC as guidance and for consistency with this ROBMP
Telephone discussion 19 April 2011	Viv Kloosterman (VKCEE for WDC) Rudy Hoetjes (NFGC)	Sought NFGC views on how to prioritise the rehabilitation of the ox bows. NFGC suggested starting from the south end and working north. Also suggested working on ox bows in the area where WDC may already have machinery working to keep costs down. The ability to carry out restoration and riparian planting would also be dependent on reaching agreements with the farmers who currently graze the floodway and modifying grazing licences. These discussions could also impact on timing and prioritisation. Revegetation in the Borrow-Cut area has been achieved by excluding/controlling stock access, and with minimal actual replanting. The area has mainly been colonised by species native to the area. This approach to revegetation could be an affordable option for the Scheme.
Site visit to Scheme 27 April 2011	Ian Hogarth (DoC) Rudy Hoetjes (NFGC) Warren King (VKCEE for WDC)	Visit to Borrow-Cut restoration area adjacent to Tanekaha pump station. Site visit to inspect oxbows/cut-off channels and riparian margins (refer section 6))
Establish restoration opportunities on pocket side – 2015/16	Adam Twose (WDC) David Wright (Ecology North) Living Water (DoC/Fonterra Partnership)	Identified three areas on the protected pocket side of the Scheme (as opposed to the flood prone bermland) which could be environmentally restored. Three areas were identified; <ul style="list-style-type: none"> • Wairau Ox-Bows in the Okarika Pocket • Tanekaha Ox-bow in the Tanekaha Pocket • Jordan Valley Rd Reserve in Mountain Pocket

3.5.1 Issues Identified

This process identified the following key issues:

- Plant suitability: Plants are required to withstand the conditions within the riparian margins while at the same time maintaining the integrity of scheme capacity and design.
- Planting methodology: What is the most efficient and effective method of revegetation?
- Stock exclusion. How is stock exclusion from the riparian margins best achieved?
- Compatibility with grazing licences. These licenses will need to be renegotiated to deal with aspects

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relating to water supply, fencing and plant and animal pest control

- Stakeholder coordination. How is stakeholder coordination carried out so that each party can make a meaningful contribution towards restoration in a way that maximises the different capabilities and inputs from each of the stakeholders?
- Ongoing maintenance: What is the most efficient way of carrying out long-term maintenance for riparian areas and newly created oxbow channel restorations (e.g. sediment, weed, plant and detritus removal)?
- Affordability: How can restoration of riparian margins and oxbows/cut-off channels be carried out so that it is cost-effective and works are undertaken at a rate that is both financially and environmentally sustainable.

4 Goal of Riparian and Ox-Bow/Cut-off Channel Enhancement

4.1 Goal

The goal of the riparian and oxbow cut-off channel improvement within the floodway is to:

Revegetate these areas in a manner which creates environmental benefits and ensures the design basis and flood carrying capacity of the Scheme is not compromised; and at a rate that has regard to practicality, benefit and affordability.

Environmental benefits of this revegetation include: •

Improved water quality

- Enhanced aquatic and fisheries habitat leading to greater diversity and abundance of freshwater life
- Enhanced terrestrial habitat for flora (native plants) and fauna (eg: wildfowl) leading to greater diversity and abundance of these species.
- Improved bank stability and reduced erosion
- Contributing towards restoration of the historical use of the swamp by Maori.

5 Methodology

5.1 Plants

The choice of appropriate plant species is central to the success of riparian revegetation and restoration. The plants selected need the following attributes:

- able to withstand ponding and flooding;
- able to survive intermittent wetting and drying;
- require minimal maintenance
- do not have significant dormant/die off periods nor contribute large volumes of detritus during die-off periods
- do not adversely affect the flood carrying capacity of the Scheme.

5.1.1 Plant Selection

The features of suitable plants which meet the above criteria are given in the table below. These plants are suitable for marginal shallow-water, embankments and areas surrounding open water. They are reasonably easy to grow and able to tolerate wet soils and periodic flooding. They are able to bend with the flow and are low growing (generally no higher than 1-2 m) so as not to inhibit flood flows and trap debris.

Smaller native sedges, grasses and rushes are the most effective filter for removing sediment, bacteria and nutrients from surface run-off on relatively level ground.² The list below is not exclusive and other plants may also be suitable.

Plant species	Common names	General growth characteristics	Depth range (m)	Recommended plant spacings	Comments
Phormium tenax	Harakeke, New Zealand flax	1-3 m tall. Robust clumps of tough fibrous leaves. Tall dark brown to black flowerheads.	0**-0.05	1-1.2 m	Suitable for embankments. Does not generally grow well in continuously flooded conditions. A very important plant for Maori, traditionally providing fibre for weaving and rope making, as well as nectar and buoyant flower stalks. Also an important nectar source and cover plant for wildlife
Carex secta ⁽¹⁾	Pukio	1-1.5 m tall. Drooping harsh tussocks forming trunk like base when mature. Green year round.	0*-0.05	0.4-0.6 m	Classic plant of New Zealand wetland and stream margins. Suitable for margins and embankments.
Bolboschenus fluviatilis, etc	Ririwaka, River bulrush, Marsh club rush	1-1.8 m tall. Leafy sedges with stems, (triangular in cross section).	Shallow water to 0.3 m.		Fast-growing in spring and early summer, there is some die back overwinter, but can provide seasonal diversity.
Hebe (native hebe endemic to area)					(obtain info from NFGC)
Juncus spp.; especially J pallidus J effusus	Leafless rushes	Generally range in height from around 0.4 to 1.5 m, but J. Pallidus will grow to 2 m or more. Form clumps of green cylindrical stems with seedheads emerging from just below the tip	0*-0.25		Rush species commonly found in wet pastures and swampy areas. Suitable for stabilising margins and embankments. Tend to grow in periodically wet conditions, and once established, will tolerate periods of dryness.

(1) also Carex flagellifera which NFGC have reported growing in Zone 2 of the Wairua Wildlife management Reserve.

"0*" refers to tolerance of periodically wet soils and conditions where the water table generally remains within 200 mm of the soil surface.

"0**" refers to tolerance of relatively dry conditions, approaching those of normal temperate terrestrial plants. Some embankment species are likely to require supplementary water supply during establishments under dry conditions.

² Northland Regional Council, 2005. "Clean Streams-A Guide to Riparian Management in Northland".

5.1.2 Planting Method

The revegetation of riparian margins will involve re-establishing native grasses, sedges and rushes for long-term protection. This may involve protecting riparian areas to allow natural regeneration, replanting, or a combination of the two. Natural regeneration has the advantage of the areas being colonised by species that are endemic to the area and naturally able to withstand the conditions.

Successful revegetation will require the exclusion of stock from the riparian areas (refer section 5.3) and the removal of weeds and inappropriate plant species (refer section 5.5.2).

5.2 Riparian Margin Width

5.2.1 Riparian Width – Main River

Recent New Zealand research recommends that for gently rolling land, widths of one to three metres per 100 m of slope feeding into waterways are ideal.⁽²⁾ Run on slopes between the stop banks and the riverbanks are generally in the order of 100 m along the floodway indicating that a riparian width of one to three metres would be appropriate.

Given the cross sectional shape of the river channel, if this was strictly applied the fencing would be located on the side slopes of the riverbank. A practical alternative is to locate the fencing 1 to 2 m back from the top of the river channel on flat land. This is shown in the typical cross section and annotated photographs in section 6.

5.2.2 Riparian Width - Oxbow/cut-off channels

The cut-off channels have varying cross sections. Some banks are gently sloping, with one in four gradients or flatter while other banks are steep with a marked change to a flat gradient at the top of the bank.

NFGC indicated a preference to have a platform for machinery access to allow for long-term maintenance and also to have side slopes of one in three or flatter as this gradient allows waterbirds to walk up the bank. The soil which is removed during this bank regrading could be used to construct the earthen embankments referred to in section 5.4.

Overall this results in a fence location and riparian width of up to 2 m from the top of the channel bank on flat land, or a maximum of 5 m from normal water level. These details are shown in the typical cross section and annotated photographs in section 6.

5.3 Stock Exclusion

Condition 3 of the resource consent requires WDC to describe the methods that will be implemented to exclude stock from the riparian margins within the floodway. In order for this to occur changes will need to be negotiated to the grazing licences between WDC and the farmers who graze the floodway land. This raises the issues of fencing and alternative water supply which will need to be negotiated in consultation with the farmers grazing the land. Some proposals are outlined below.

5.3.1 Grazing Licenses – Current Situation

It is necessary, as part of Scheme operation, to maintain low vegetation on the current river banks in order to maximise the flood carrying capacity of the rivers. This is facilitated in a cost-effective manner by grazing the full extent of the floodway. Stock access to the river edge is generally provided to allow stock to drink, as there is no reticulated water supply in the floodway. Currently the banks of the river are generally maintained in short grass, rather than allowing dense riparian vegetation to grow.

The grazing and management of this floodway area is covered by a grazing licence between WDC and the farmers grazing the floodway land.

The grazing licences require the farmers to:

- maintain, clean, keep open and in proper working order and free from obstruction, all water courses
- comply with any direction of WDC regarding the conservation of water-fowl, fish life and other wildlife;
- clear the land of noxious weeds and plants
- keep the land free and clear from all rabbits and noxious vermin
- top dress the pasture

- farm and manage the area in a good and husband like manner in accordance with the Scheme operational requirements
- keep all fences, bridges, gates, culverts etc in a good state of repair and condition
- not erect fences on the land without the prior written consent of the WDC.

WDC is not liable to provide or maintain a supply of water on this land either to stock or for any other purpose.

5.3.2 Fencing

A single wire electric fence along the riparian margins of the river and the oxbow/cut-off channels is proposed. Fence posts could be either permanent or temporary. These details, including who will be responsible for erecting and maintaining the electric fences, still need to be agreed and confirmed between WDC and the licence holders.

5.3.3 Water Supply

When stock are excluded from the riparian margins, an alternative reticulated water supply will need to be provided. Responsibility for constructing and maintaining this alternative water supply will need to be agreed and confirmed between WDC and the licence holders.

5.4 Water Level Control in Ox-Bow/Cut-off Channels

NFGC and DoC have indicated the importance of water level control and active management to preserve open water areas and improve habitat.

They report that in the Wairua Reserve some species have already disappeared due to a reduction in the shallow margins on the ponds and wetlands. The creation of open water areas is a requirement for species which live in and under the water. The loss of open water areas limits invertebrate species such as dragonfly, damselfly, midges, water boatmen and back swimmers which are an essential part of providing a high protein food source for both fish and birds in wetlands. These open water areas also provide habitat for native fish species, such as eels. It can also be beneficial to manipulate water levels to simulate natural ecosystems and allow for drying out of areas to provide a healthy environment.^{3,4}

One option to increase water levels in the oxbow and cut off channels is by constructing simple earthen embankments of up to 2 m in height between the cut-off channel and the main river channel. A number of these cut-off channels already have earthen embankments in this location. Refer section 6 for further details.

It is considered that these activities would be covered by the consents already granted for the Scheme, but this still needs to be confirmed with NRC.

5.5 Maintenance

It is envisaged that ongoing maintenance will be a joint responsibility with contribution from a range of stakeholders. Discussions still need to take place to confirm and agree long-term arrangements. The following section describes the maintenance work which will be required to be allocated between the parties.

5.5.1 Mechanical Cleaning and Clearing

Oxbow and cut-off channel restoration and deepening of water levels creates additional requirements for ongoing maintenance. Access needs to be provided for machinery to clear and remove sediments, vegetation, including water weeds, dead plant materials and detritus. Weeds such as privet also need to be removed around some of the cut-off channels and this may need to be carried out mechanically.

Any mechanical clearing which takes place in the oxbow/cut-off channels will ensure that:

- weed fragments are not distributed downstream
- any work will not take place during peak fish spawning and migration and bird nesting periods.

The proposed machinery access platform is shown on the typical cross-section in section 6.

³ Northland Fish and Game Council and Department of Conservation, 2011. "Wairua Wildlife Management Reserve Strategy"

⁴ Northland Fish and Game Council, 1999. "Management Plan for the Borrow-Cut Area Adjacent to Tanekaha Pumping Station."

5.5.2 Control of plant pests and unsuitable plants

Chemical control of weeds in oxbow's/cut-off channels will be carried out using only chemicals that are licensed for application over water. In general, contact herbicides, which act directly on plant tissue, will be used.

Weeds in revegetating riparian zones will be controlled in general accordance with Table 3: Methods and Herbicides for Controlling Weeds in "*Clean Streams-A Guide to Riparian Management in Northland*" NRC 2005.

It will also be necessary to remove plants which have colonised the riparian areas but are unsuitable, due to their size, for example. Removal of larger shrubs and trees will probably be by hand or by spraying.

5.5.3 Control of Animal Pests

Under the current grazing licences, control of animal pests is the responsibility of the licence holders and this is likely to continue unchanged.

5.5.4 Fence Line Maintenance

Fence lines along the riparian boundaries will need to be inspected after flood events and maintained, repaired or reinstated as required prior to any grazing on floodway areas.

5.6 Timeline

Section 6 includes annotated photographs showing the proposed work along the main river banks and oxbow/cut-off channels between the southern end of the floodway at Matarau Road and the Tanekaha pump station (Borrow-Cut Area). It is proposed to restore these areas first and then based on the experience gained to move on to the northern part of the floodway.

The timeline for this riparian revegetation will depend on a number of factors including:

- the renegotiation of the grazing licences
- the allocation of tasks and management responsibilities between the various stakeholders
- the revegetation method adopted. It is proposed to commence with fencing and allow revegetation to occur naturally, but experience may show that some replanting is required.
- the need for consents from NRC to carry out any revegetation or earthworks within the riparian zone or in the oxbow/cut-off channels
- the cost and availability of funding, which is also influenced by the factors identified above.

5.7 Pocket-side Restoration

The proposed methodology for the environmental restorations on the 'Pocket-side' of the Scheme is more difficult than the ox-bow restorations in the berm land. This is due to different pressures and opportunities. To ensure these identified areas are restored in the more productive and efficient manner, David Wright of Ecology North has been commissioned to undertake restoration plans for the three initial sites. These restoration plans have been included as Appendices B, C & D. The proposed methodology is to follow the establishment and maintenance regime detailed in these plans.

6 Proposed Restoration Sites

Typical cross-sections and photographs of proposed sites for restoration and riparian enhancement are included in this section.

6.1 Typical Cross Sections

Figures 6.1 and 6.2 show a typical cross-section along the main river bank, and a typical cross-section along an oxbow/cut-off channel respectively.

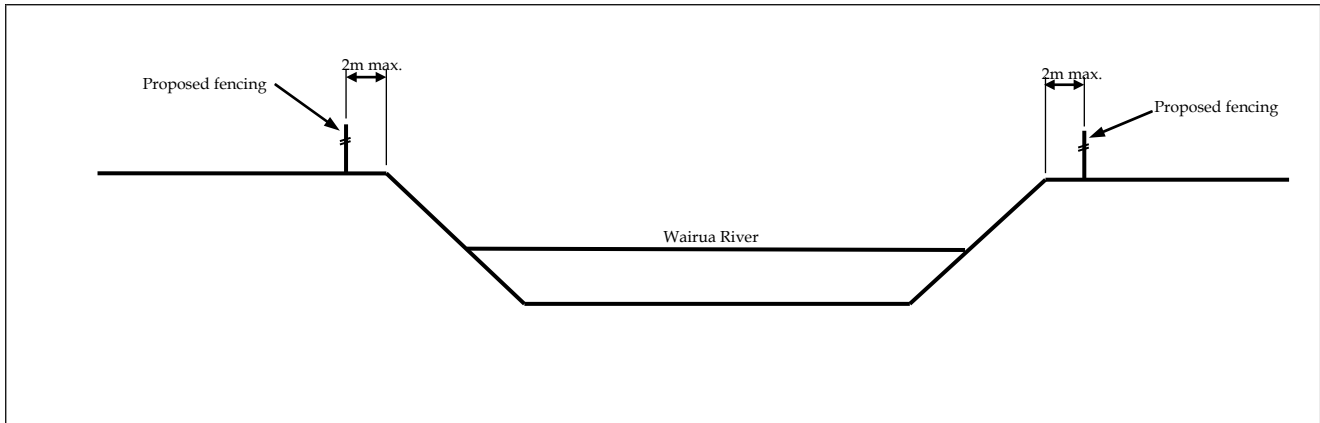


Figure 6.1: Typical Cross-section along main river bank

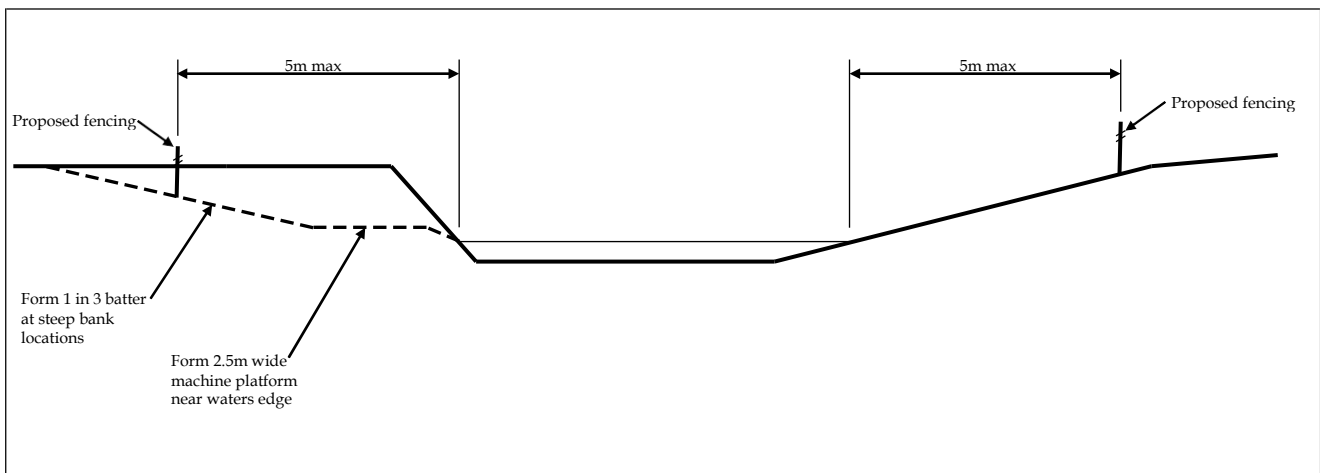


Figure 6.2: Typical cross-section – Oxbow-Cut-off channel

6.2 Photographs of individual sites

The main index plan shows the location of the restoration sites labelled 1 to 18 starting at Matarau Road at the southern end of the floodway. The following information is supplied for each oxbow/cut-off channel site:

- an aerial photograph of the site showing the location and direction from which oblique photographs were taken. These aerial photographs are all aligned with a north point up the page.
- annotated oblique photographs of each oxbow/cut-off channel indicating where fencing, weed removal, alterations to the banks and the formation of a low embankment would be required
- annotated oblique photographs of the riparian zones along the main river showing the proposed location of fencing and existing vegetation.

The location of fences is indicative only and would be subject to agreement between stakeholders.



Figure 6.3: Index Plan Showing sites 1 to 12



Figure 6.4: Index Plan showing sites 12 to 18

Glossary of terms

Abbreviation	Description
iSMP	Hikurangi Scheme- initial Scheme Management Plan
ROBMP	Floodway <u>R</u> iparian and <u>O</u> x- <u>B</u> ow/ <u>C</u> ut- <u>O</u> ff Channels <u>M</u> anagement <u>P</u> lan
NRC	Northland Regional Council
NFGC	Northland Fish and Game Council
DoC	Department of Conservation
WDC	Whangarei District Council

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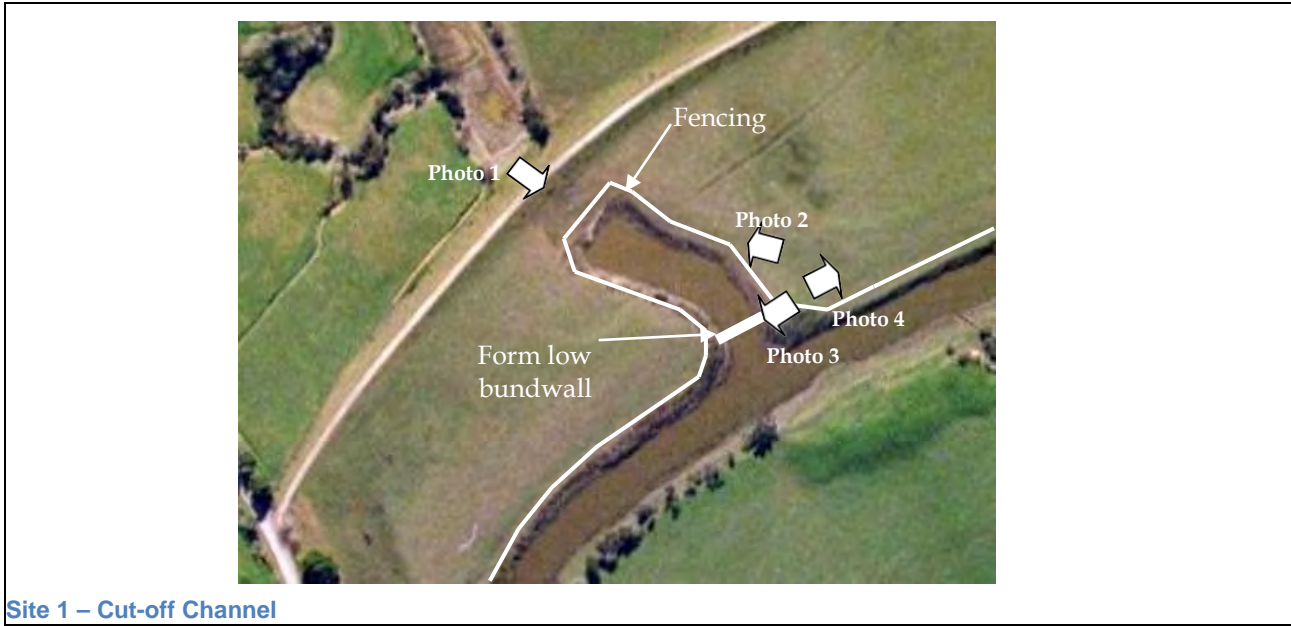
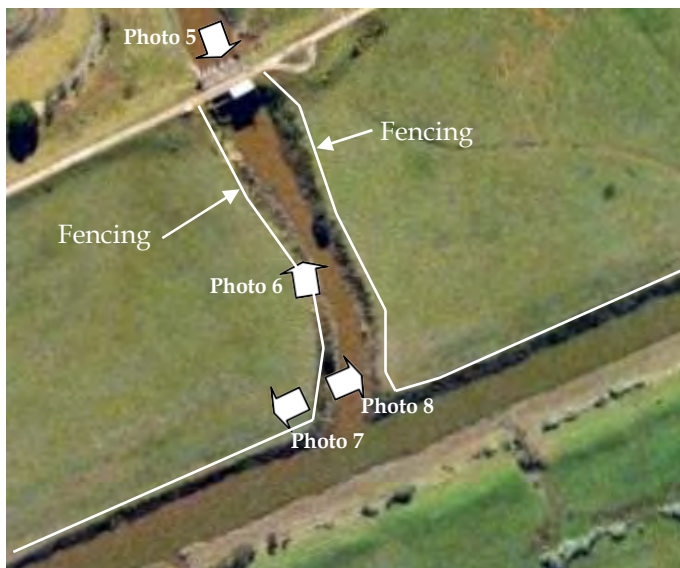




Photo 3: Site 1 – Riparian Margins of Wairua River Channel Looking Downstream



Photo 4: Site 1 – Riparian Margins of Wairua River Channel Looking Upstream



Site 2 – Man-made Pumping Channel – Okarika Pump Station



Photo 5: Site 2 - Man-made Pumping Channel Looking Downstream



Photo 6: Site 2- Man-made Pumping Channel Looking Upstream



Fencing

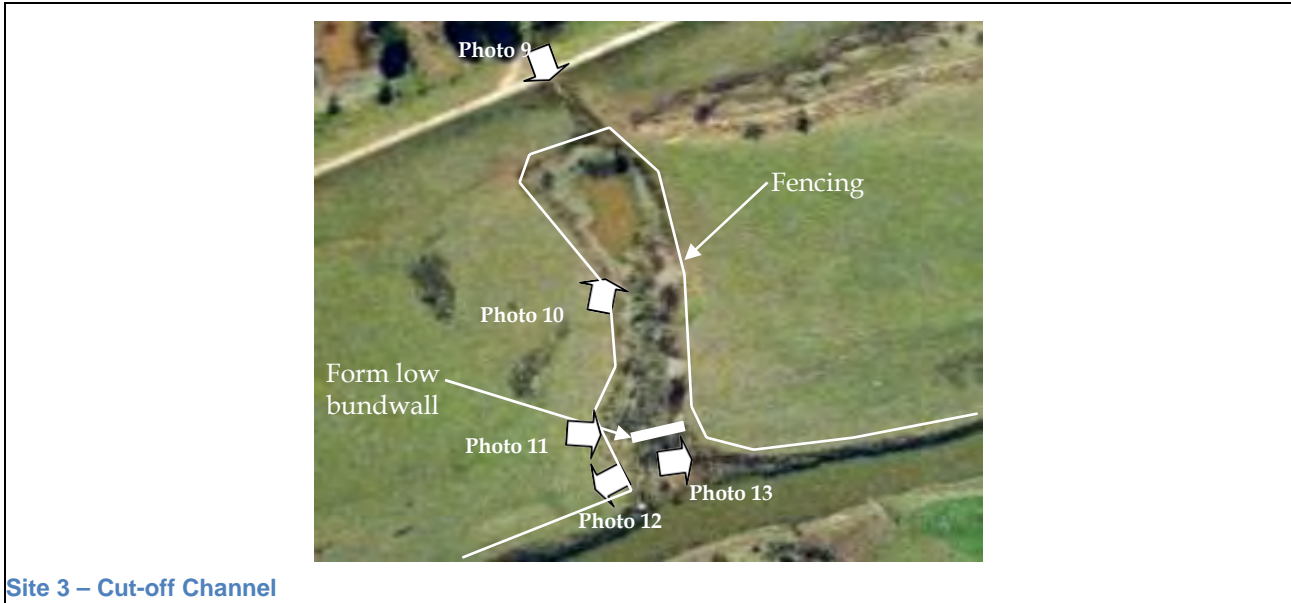
Photo 7: Site 2 – Riparian Margins of Wairua River Channel Looking Downstream



Wairua
River
fencing

Cut-off
channel
fencing

Photo 8: Site 2 – Riparian Margins of Wairua River Channel Looking Upstream



Site 3 – Cut-off Channel



Photo 9: Site 3 - Cut-off Channel Looking Downstream

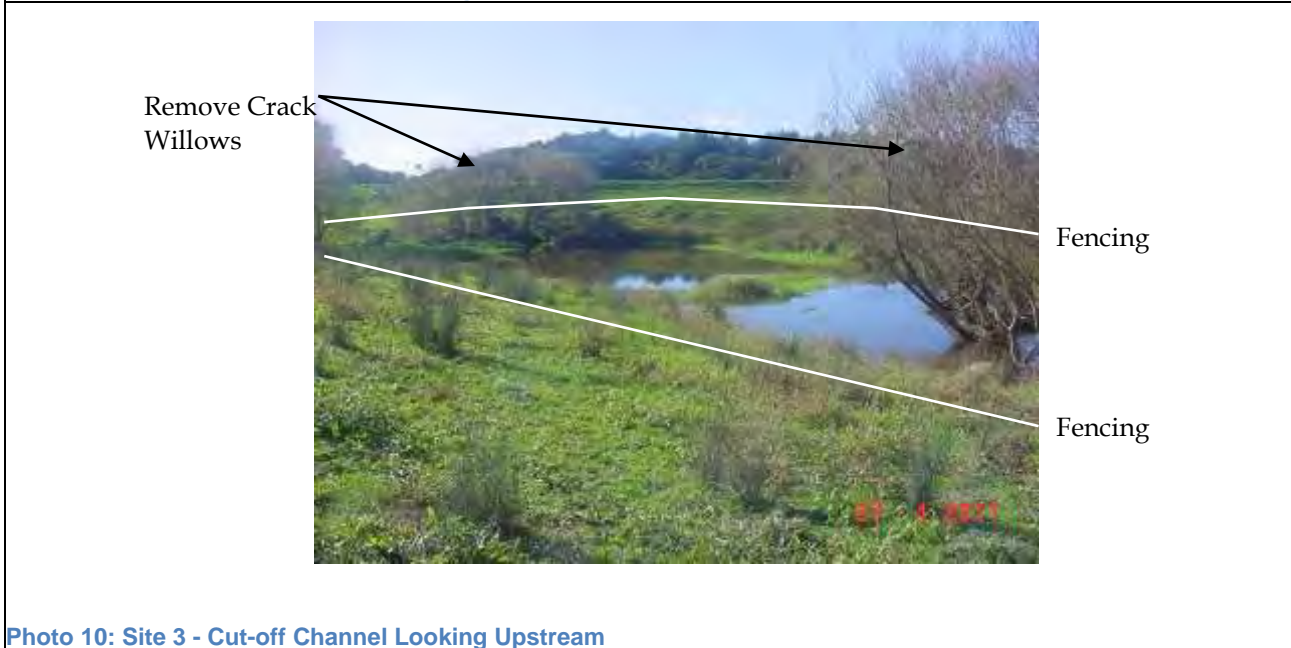


Photo 10: Site 3 - Cut-off Channel Looking Upstream



Increase height
of existing
bundwall

Photo 11: Site 3 – Cut-off Channel Showing Possible Location of Bundwall



Fencing

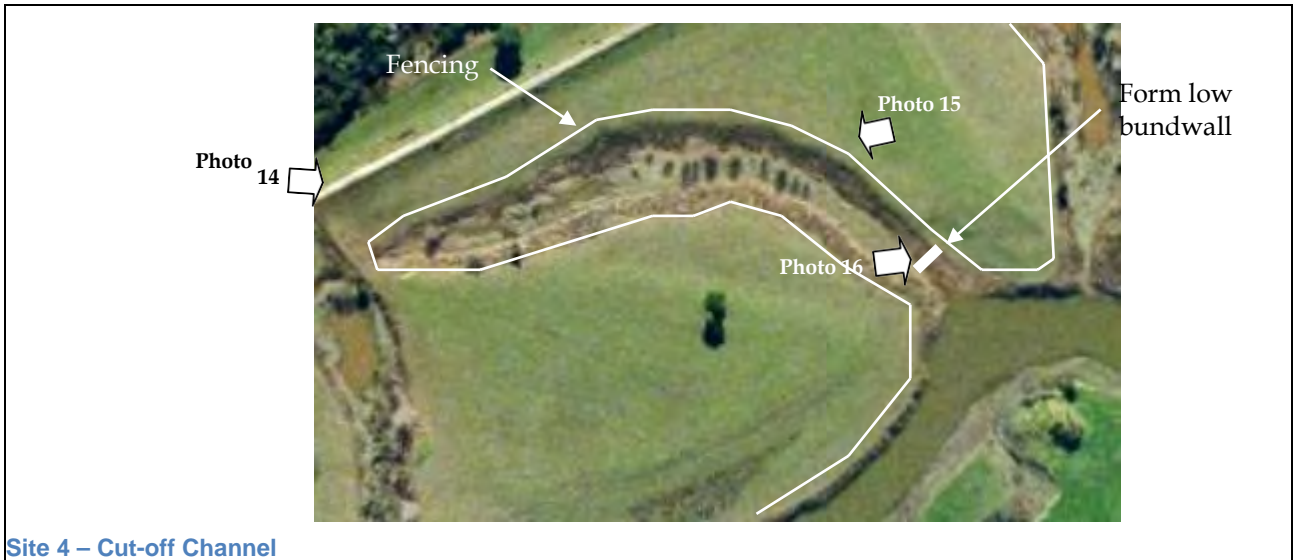
Photo 12: Site 3 – Riparian Margins of Wairua River Channel Looking Downstream



Wairua
River
fencing

Cutoff
channel
fencing

Photo 13: Site 3 – Riparian Margins of Wairua River Channel Looking Upstream



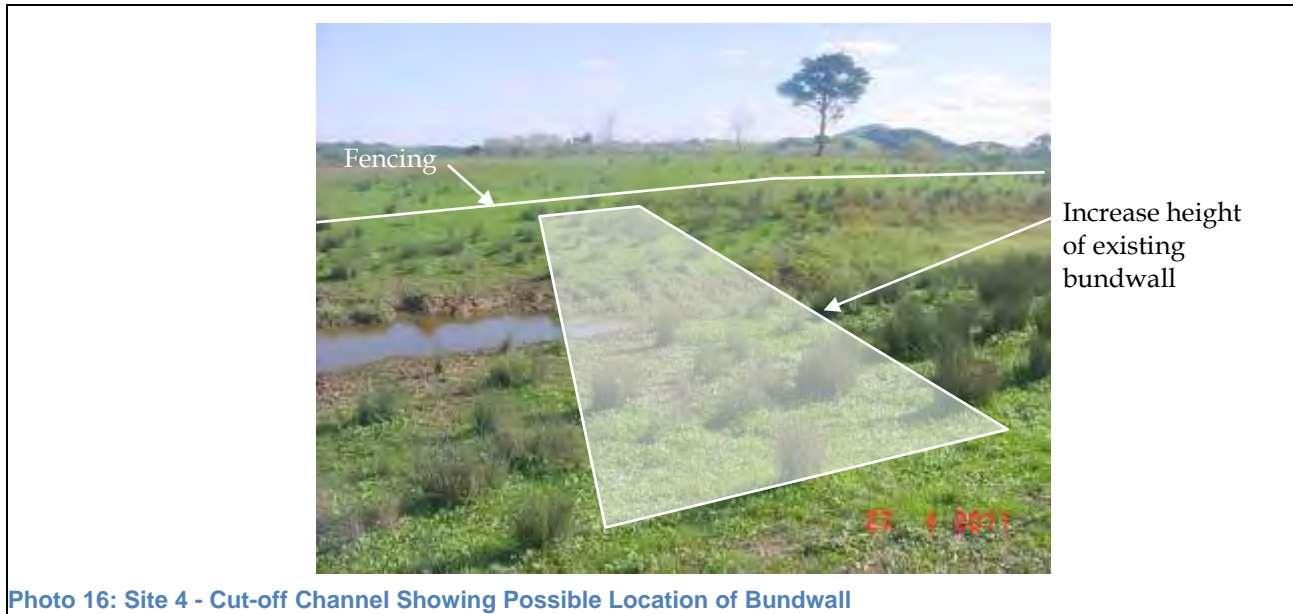
Site 4 – Cut-off Channel

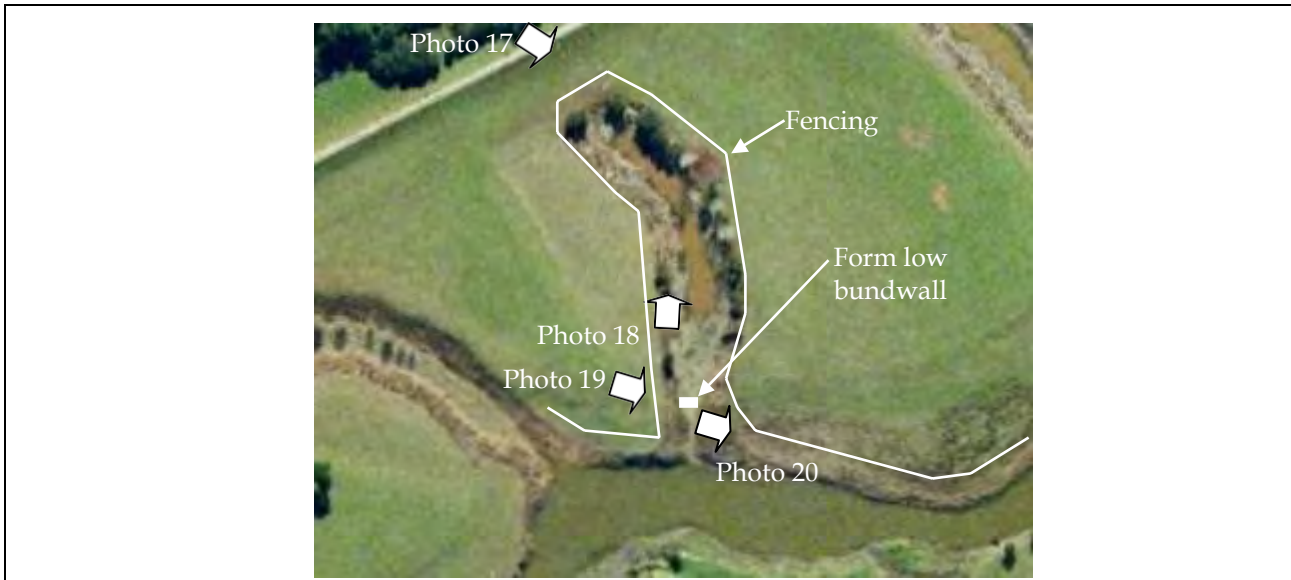


Photo 14: Site 4 - Cut-off Channel Looking Downstream



Photo 15: Site 4 - Cut-off Channel Looking Upstream





Site 5 – Cut-off Channel

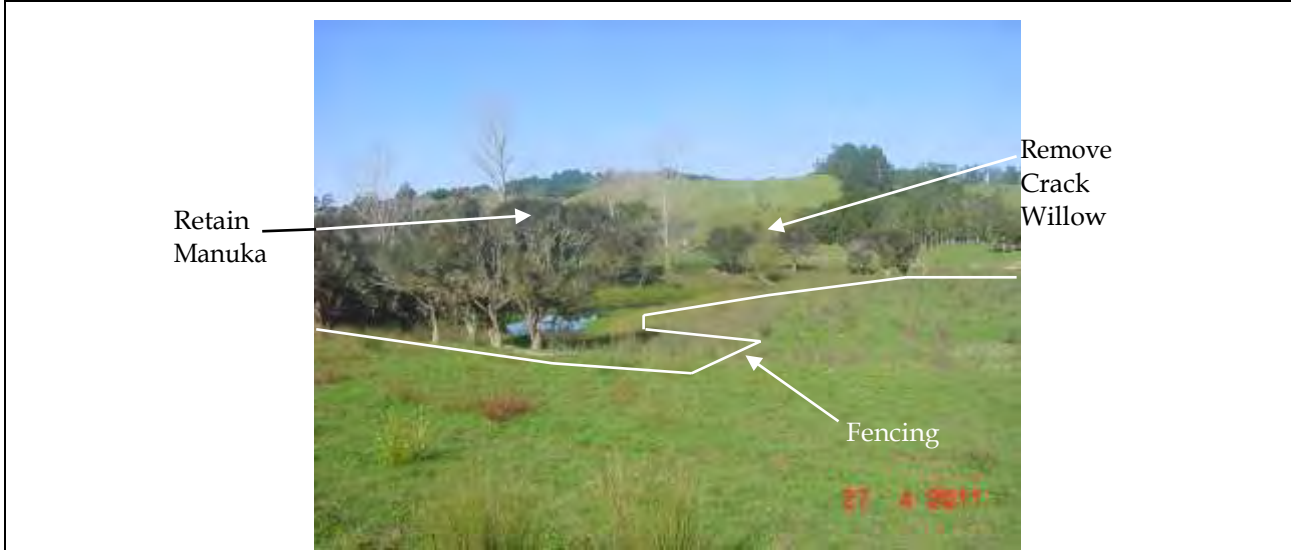


Photo 17: Site 5 - Cut-off Channel Looking Downstream



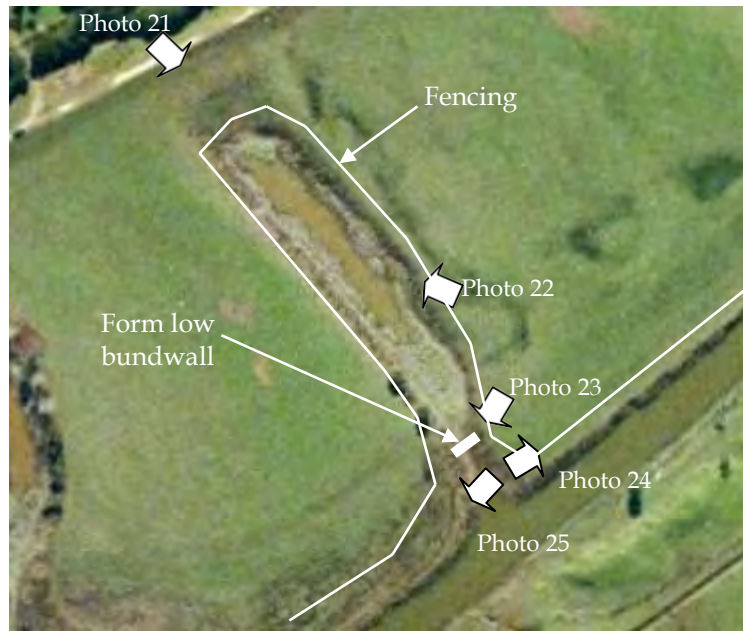
Photo 18: Site 5 - Cut-off Channel Looking Upstream



Photo 19: Site 5 - Cut-off Channel Showing Possible Location of Bundwall



Photo 20: Site 5 - Riparian Margins of Wairua River Channel Looking Upstream



Site 6 – Cut-off Channel



Photo 21: Site 6 - Cut-off Channel Looking Downstream



Photo 22: Site 6 - Cut-off Channel Looking Upstream



Photo 23: Site 6 - Cut-off Channel Showing Possible Location of Bundwall



Photo 24: Site 6 - Riparian Margins of Wairua River Channel Looking Upstream

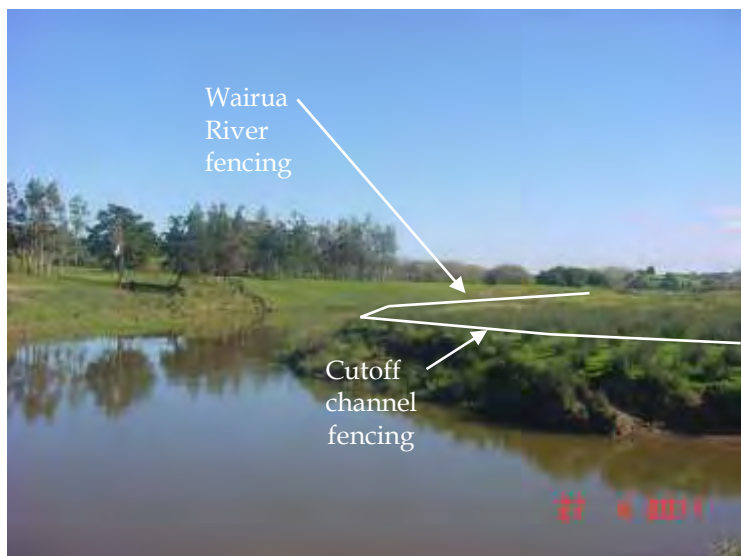
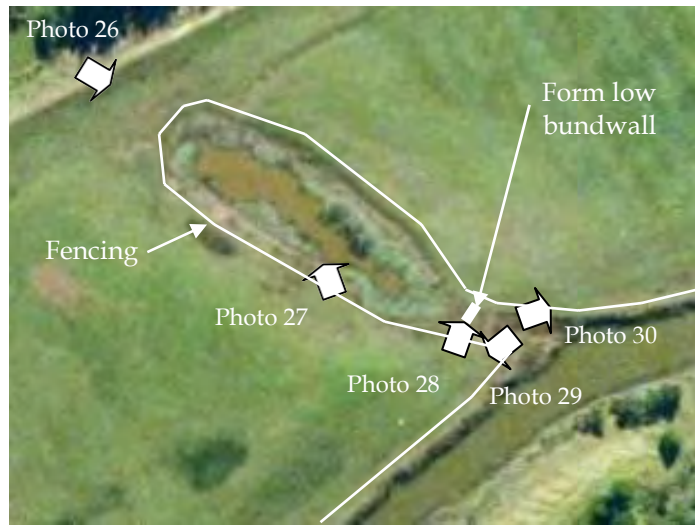


Photo 25: Site 6 - Riparian Margins of Wairua River Channel Looking Downstream



Site 7 – Cut-off Channel



Photo 26: Site 7 - Cut-off Channel Looking Downstream

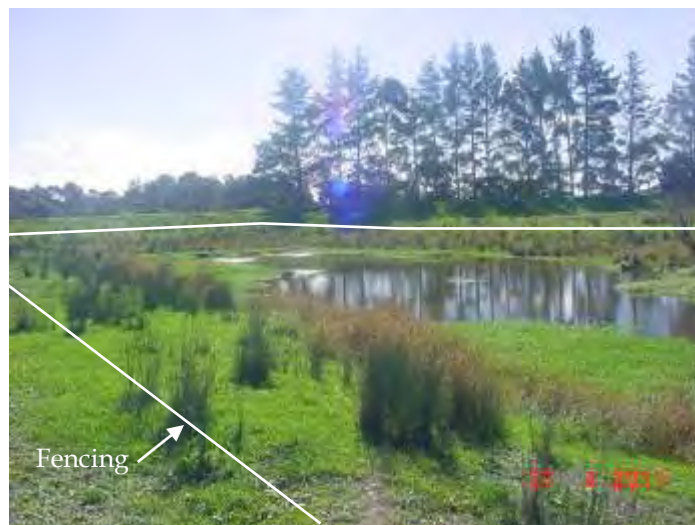


Photo 27: Site 7 - Cut-off Channel Looking Upstream



Photo 28: Site 7 - Cut-off Channel Showing Possible Location of Bundwall

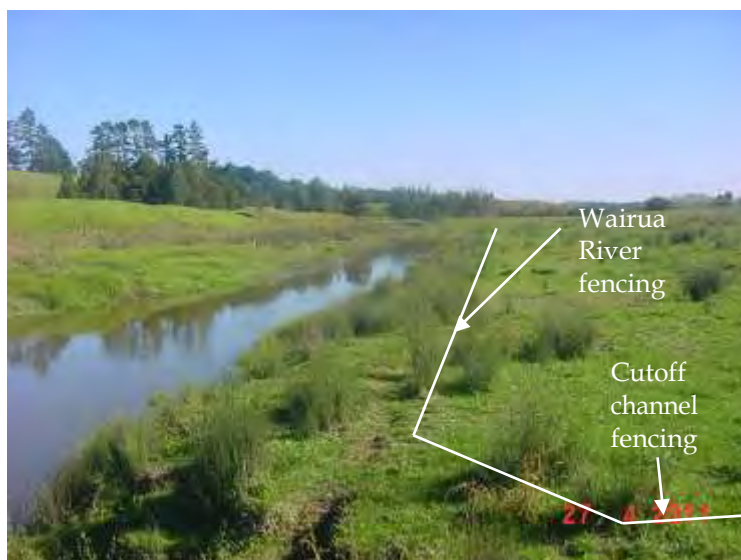


Photo 29: Site 7 - Riparian Margins of Wairua River Channel Looking Downstream

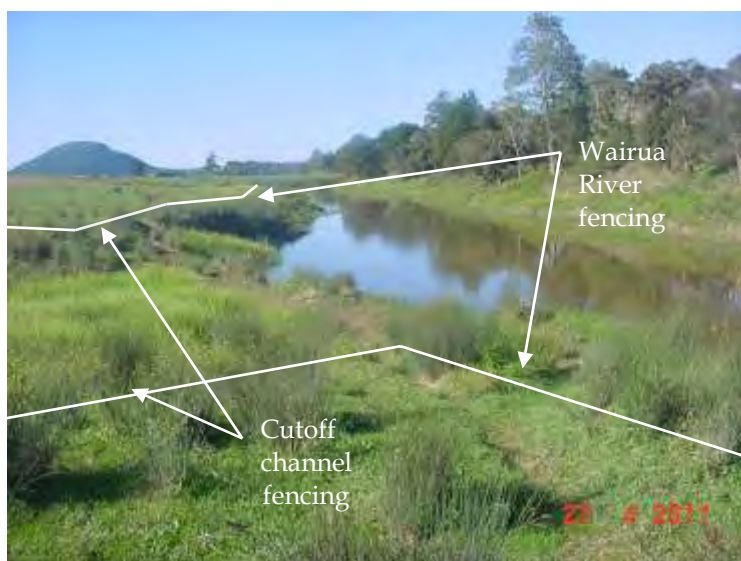
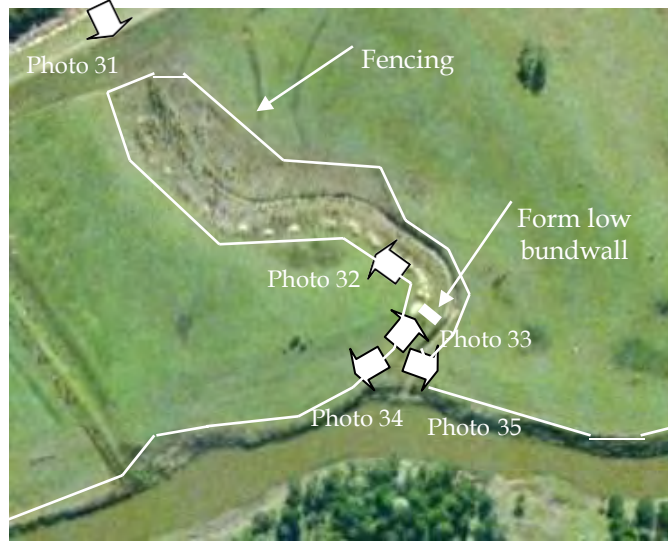


Photo 30: Site 7 - Riparian Margins of Wairua River Channel Looking Upstream



Site 8 – Cut-off Channel



Photo 31: Site 8 - Cut-off Channel Looking Downstream

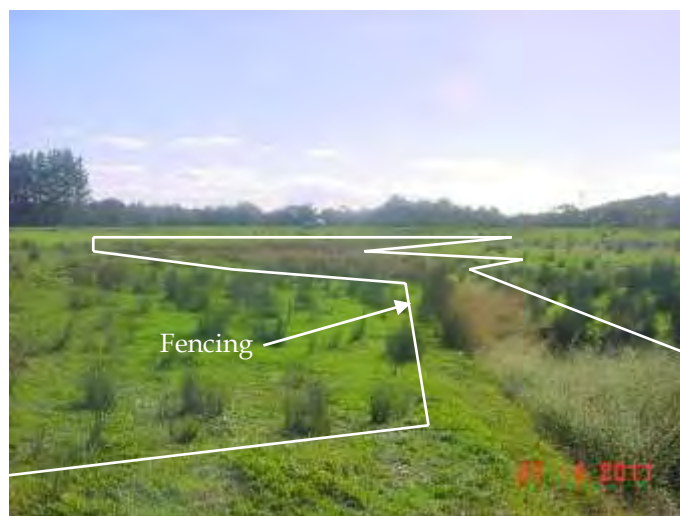


Photo 32: Site 8 - Cut-off Channel Looking Upstream



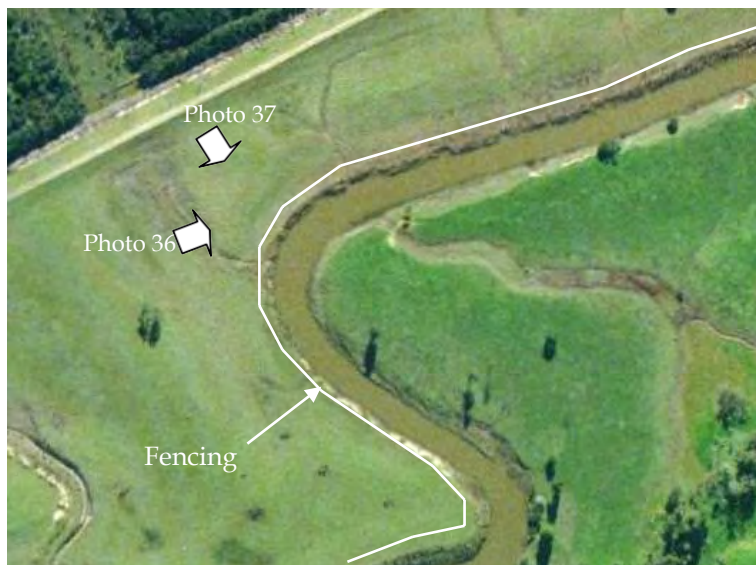
Photo 33: Site 8 - Cut-off Channel Showing Possible Location of Bundwall



Photo 34: Site 8 - Riparian Margins of Wairua River Channel Looking Downstream



Photo 35: Site 8 - Riparian Margins of Wairua River Channel Looking Upstream



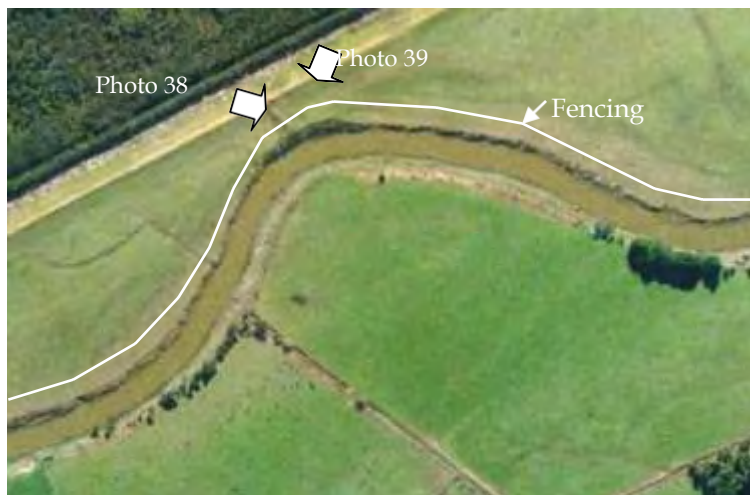
Site 9 – Wairua River Channel



Photo 36: Site 9 - Riparian Margins of Wairua River Channel Looking Downstream



Photo 37: Site 9 – Riparian Margins of Wairua River Channel Looking Upstream



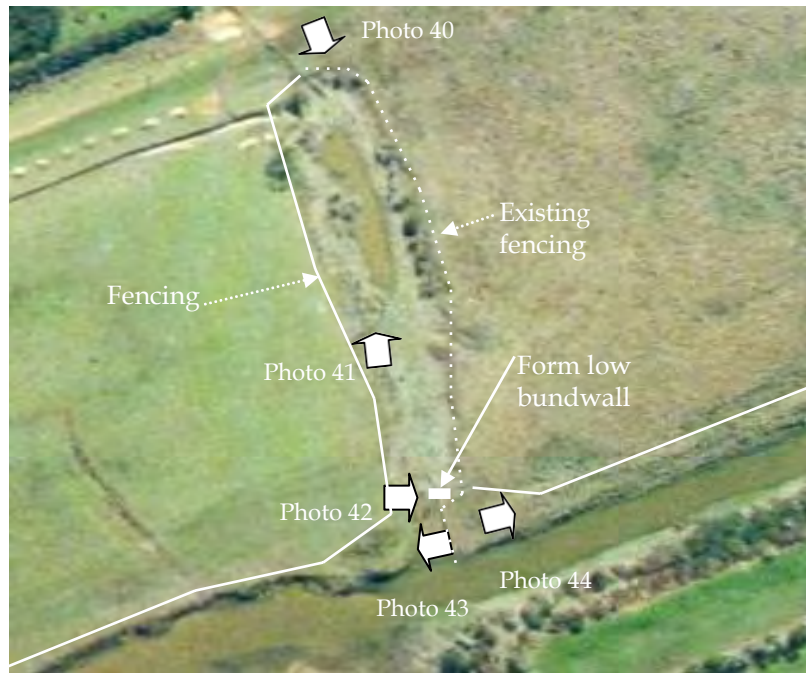
Site 10 – Wairua River Channel



Photo 38: Site 10 – Riparian Margins of Wairua River Channel Looking Downstream



Photo 39: Site 10 – Riparian Margins of Wairua River Channel Looking Upstream



Site 11 – Cut-off Channel

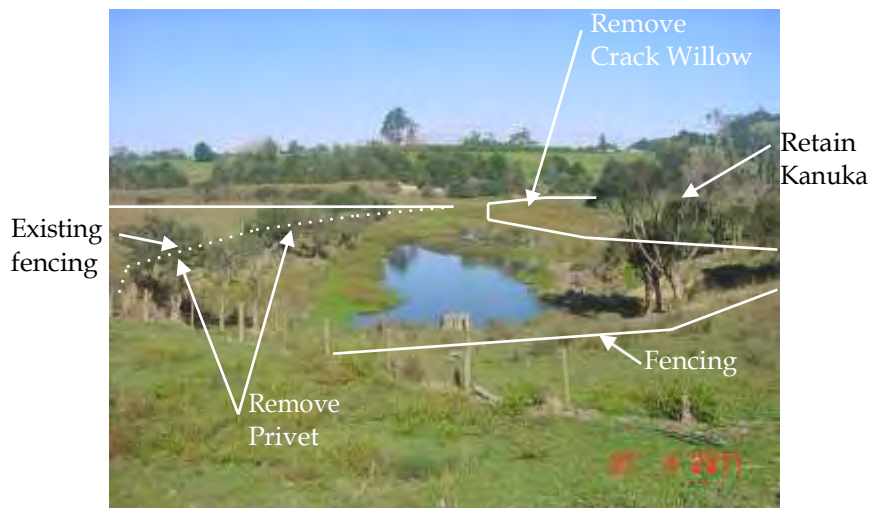


Photo 40: Site 11 - Cut-off Channel Looking Downstream



Photo 41: Site 11 - Cut-off Channel Looking Upstream

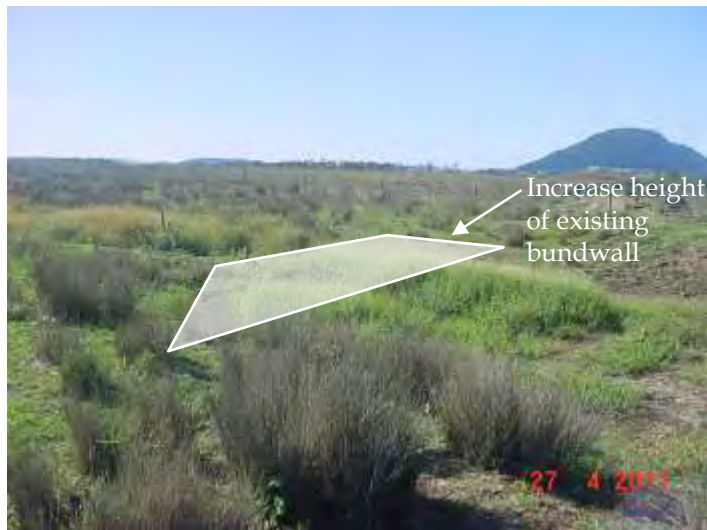


Photo 42: Site 11 - Cut-off Channel Showing Possible Location of Bundwall



Photo 43: Site 11 - Riparian Margins of Wairua River Channel Looking Downstream

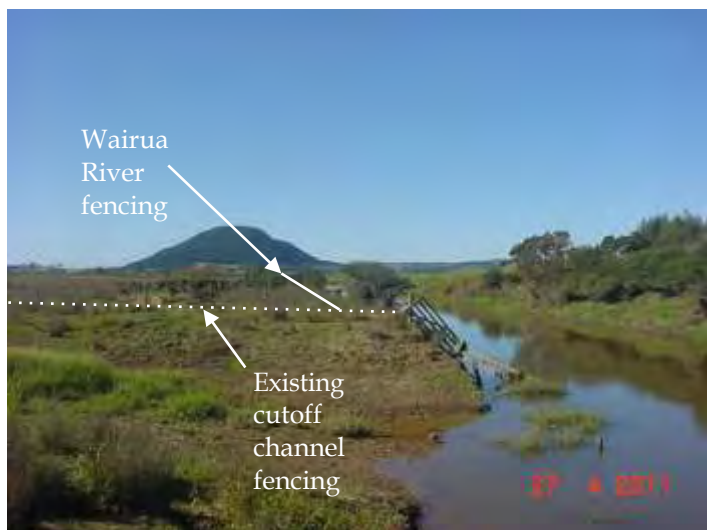
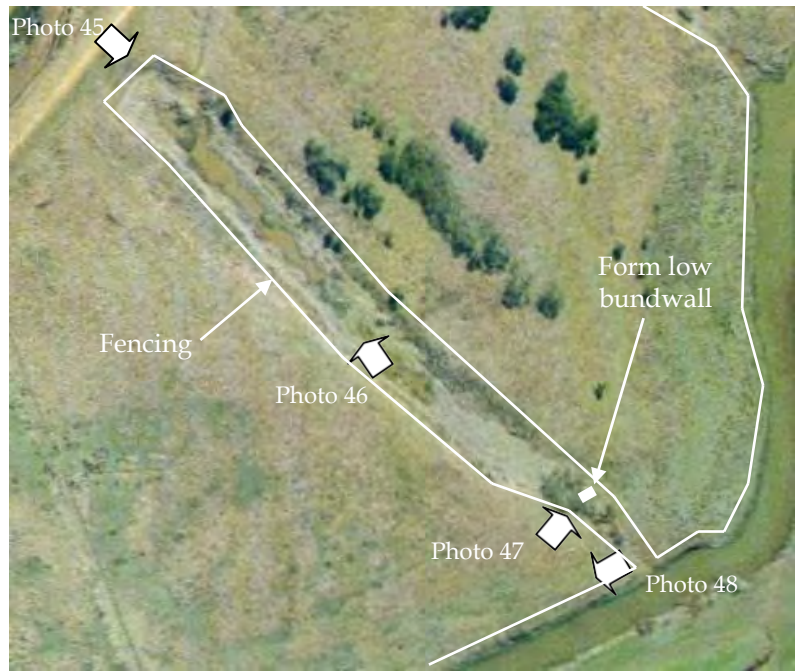


Photo 44: Site 11 - Riparian Margins of Wairua River Channel Looking Upstream



Site 12 – Cut-off Channel



Photo 45: Site 12 - Cut-off Channel Looking Downstream

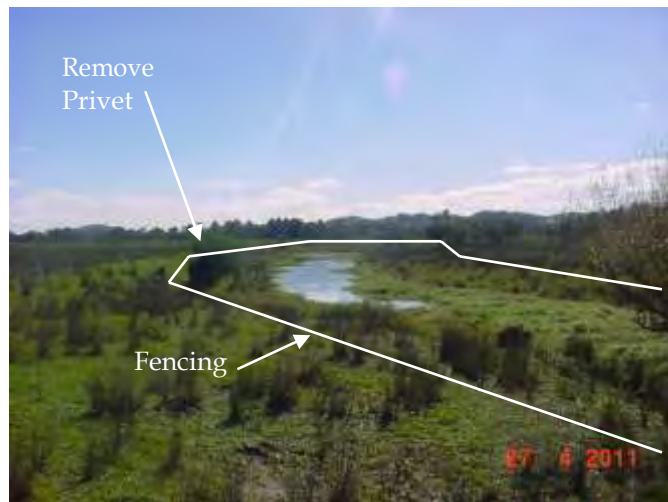


Photo 46: Site 12 - Cut-off Channel Looking Upstream

Remove
Crack
Willow



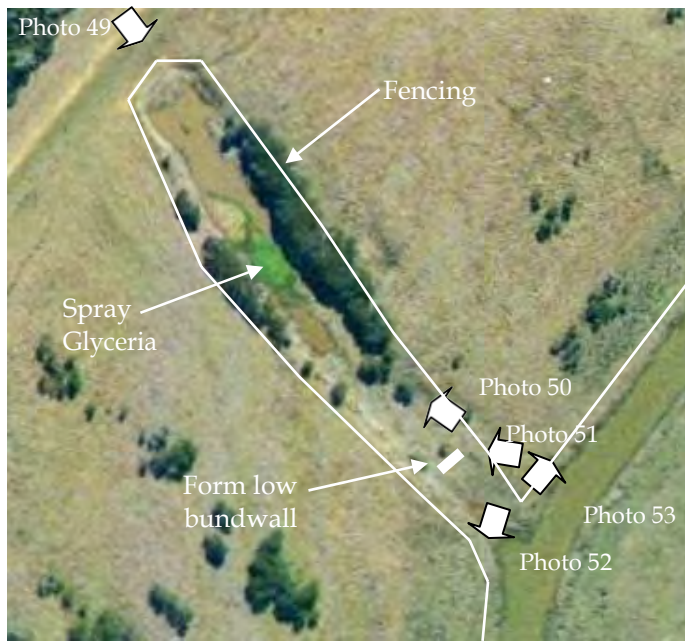
Increase height of
existing bundwall

Photo 47: Site 12 - Cut-off Channel Showing Possible Location of Bundwall

Fencing



Photo 48: Site 12 – Riparian Margins of Wairua River Channel Looking Downstream



Site 13 – Cut-off Channel

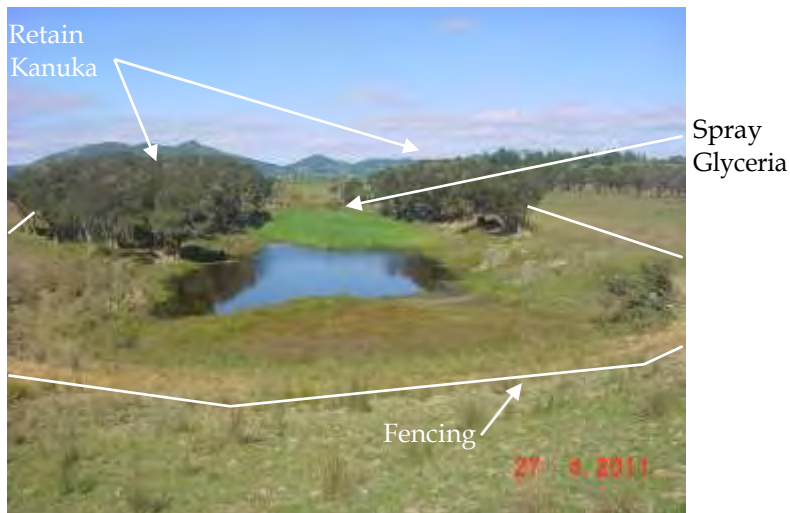


Photo 49: Site 13 - Cut-off Channel Looking Downstream



Photo 50: Site 13 - Cut-off Channel Looking Upstream

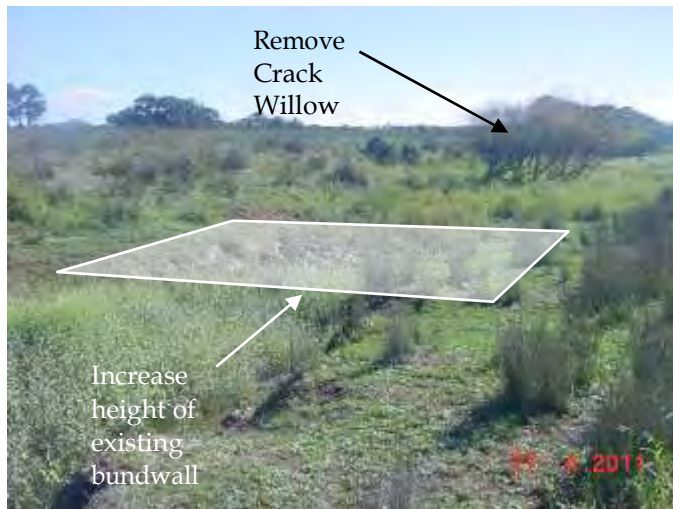


Photo 51: Site 13 - Cut-off Channel Showing Possible Location of Bundwall

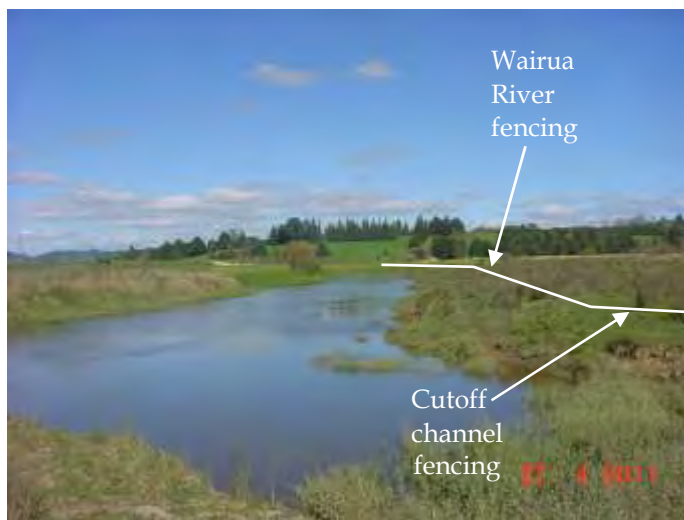
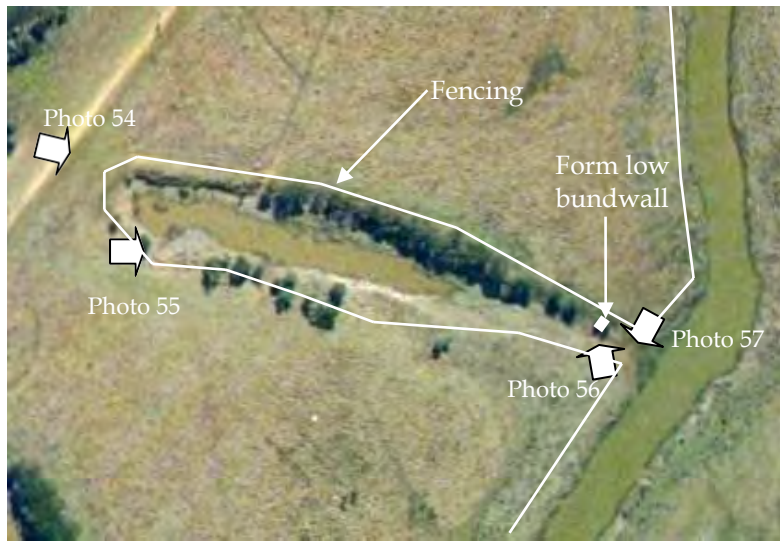


Photo 52: Site 13 - Riparian Margins of Wairua River Channel Looking Downstream



Photo 53: Site 13 - Riparian Margins of Wairua River Channel Looking Upstream



Site 14 – Cut-off Channel



Photo 54: Site 14 - Cut-off Channel Looking Downstream



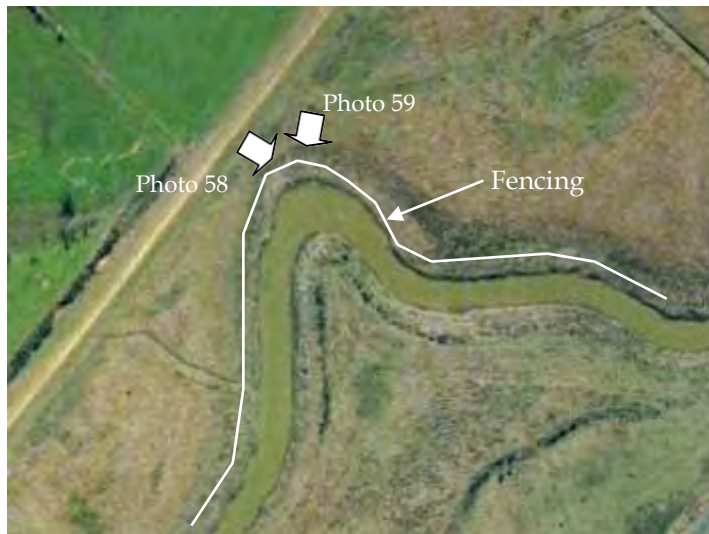
Photo 55: Site 14 - Cut-off Channel Looking Downstream



Photo 56: Site 14 - Cut-off Channel Showing Possible Location of Bundwall



Photo 57: Site 14 - Riparian Margins of Wairua River Channel Looking Downstream



Site 15 – Wairua River Channel



Photo 58: Site 15 – Riparian Margins of Wairua River Channel Looking Upstream



Photo 59: Site 15 – Riparian Margins of Wairua River Channel Looking Downstream



Site 16 – Wairua River Channel



Photo 60: Site 16 – Riparian Margins of Wairua River Channel Looking Downstream

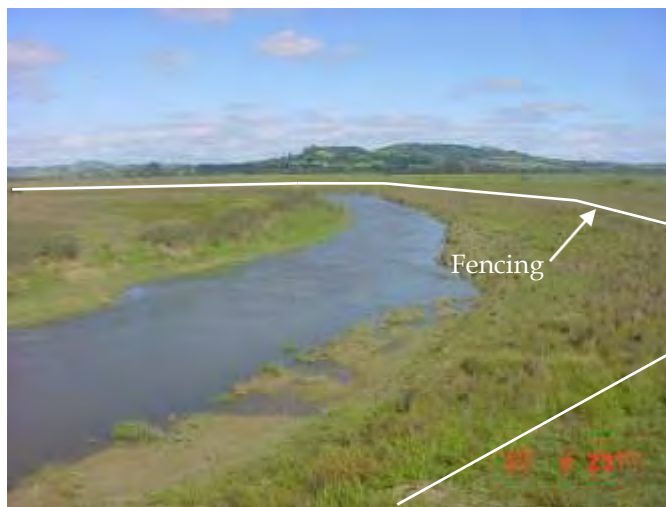
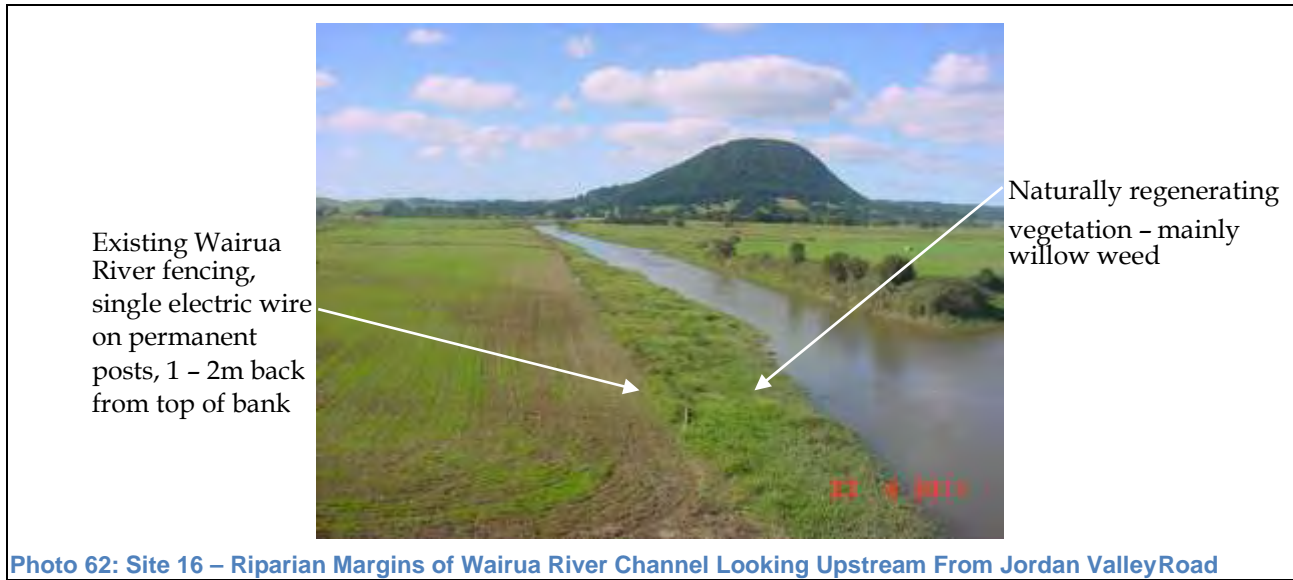
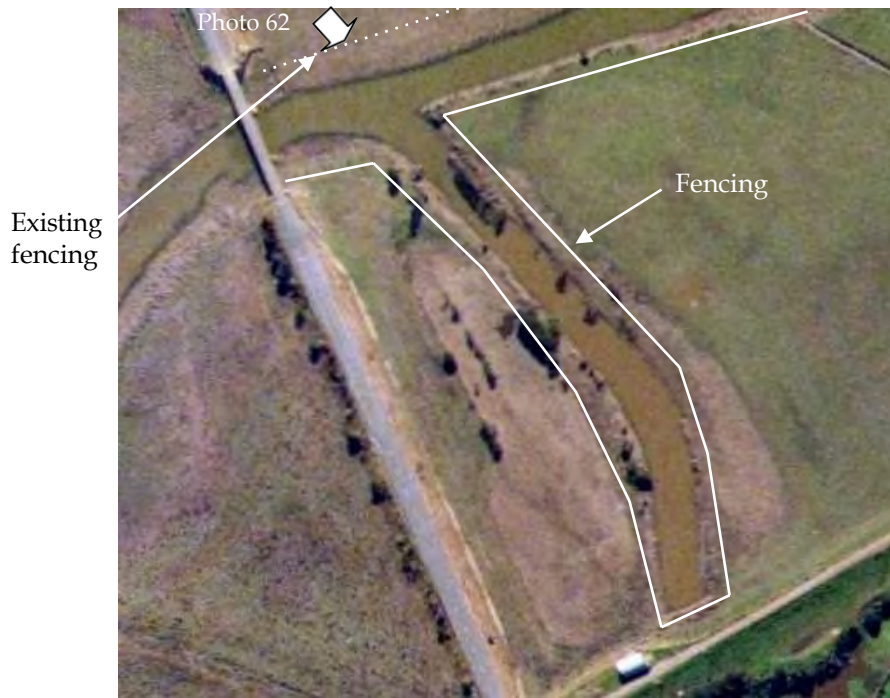


Photo 61: Site 16 – Riparian Margins of Wairua River Channel Looking Downstream From Jordan Valley Road



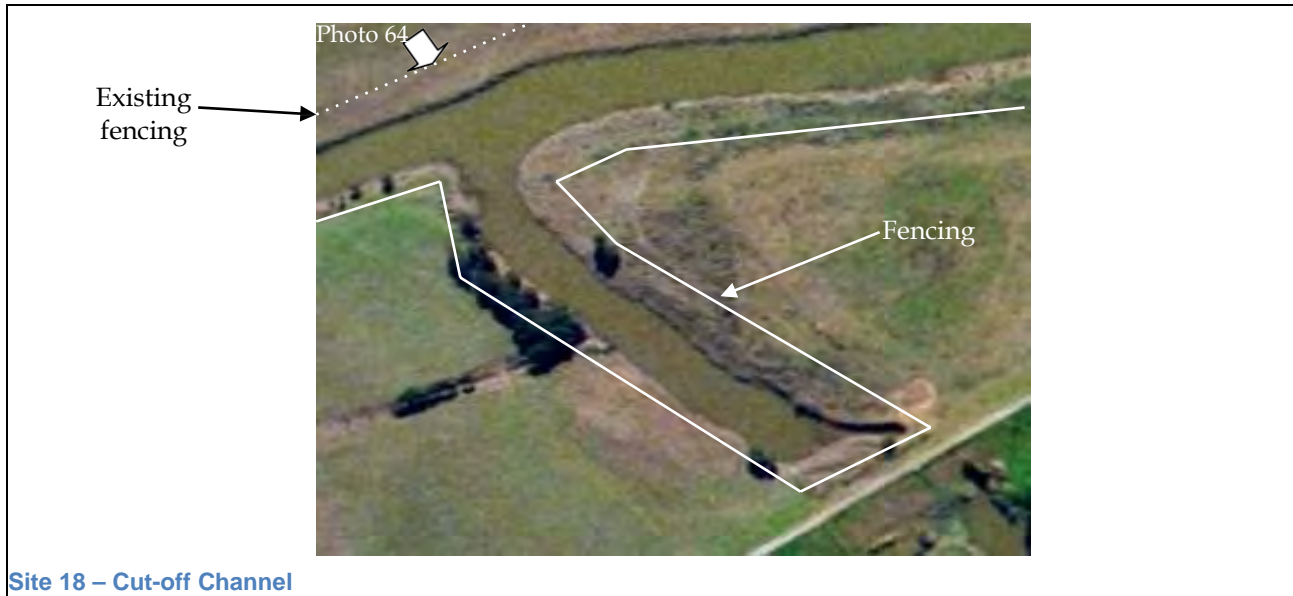


Site 17 – Cut-off Channel

Existing Wairua River
fencing (single electric
wire on permanent
posts, 1 - 2m back from
top of bank



Photo 63: Site 17 - Cut-off Channel Looking Upstream



Glossary of terms

Abbreviation	Description
iSMP	Initial Scheme Management Plan
ROBMP	Floodway <u>R</u> iparian and <u>O</u> x- <u>B</u> ow/ <u>C</u> ut- <u>O</u> ff Channels <u>M</u> anagement <u>P</u> lan
NRC	Northland Regional Council
NFGC	Northland Fish and Game Council
DoC	Department of Conservation
WDC	Whangarei District Council

**Ecology
North**

Ecological restoration & revegetation
Ecological assessment & reporting
Wetland management
Ecological pest management



Ecological Restoration Plan: Wairua Oxbows



David Wright
March 2016

Prepared for Living Water

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1. Background

In 2015, Ecology North was contracted by the Department of Conservation (DOC) to prepare a restoration plan for the Wairua oxbows, two oxbows adjacent to the Wairua River Government Purpose Wildlife Management Reserve (Wairua River GPWMR).

This restoration project is a collaboration between Living Water, the Whangarei District Council (WDC), Ngati Hau and Northland Fish & Game.

Living Water is a joint programme between DOC and Fonterra which seeks to work with local communities, dairy farmers, iwi/hapu and other stakeholders to improve sensitive water catchments. Living Water is being implemented over five sites across New Zealand. The Kaipara Harbour-Hikurangi catchment is one of these sites.

The Wairua oxbows are located in the rohe of Ngati Hau hapu. Ngati Hau are the traditional kaitiaki of this section of the Hikurangi floodplain and Wairua River. The Ngati Hau Resource Management Unit have been discussing the potential to take over the management of the land in which the oxbows are located from the WDC as a lease (Allan Halliday pers. com.).

WDC administer the land in which the oxbows are located. As part of their management programme for the Hikurangi Swamp Scheme, WDC have resource consent from the Northland Regional Council to maintain drainage systems and manage floodwaters through a series of spillways, water holding 'pockets' and pump stations to allow floodwater to be pumped directly into the Wairua River.

Northland Fish & Game are involved from the perspective of game bird management.

The consultants brief for this plan included:

Describe the current state of the terrestrial and freshwater biodiversity, including species lists and ecological descriptions of what is currently there.

Assess the values and identify threats.

Identify, describe and prioritise what restoration is required, including (but not exclusive to):

- Pest plant management considerations.
- Animal pest control considerations.
- Revegetation and hydrological considerations etc.
- A ranking of which actions should be undertaken in order of priority.
- Draft a maintenance animal pest and weed control program.
- Include opportunities to support and enhance threatened species.
- Include baseline and ongoing monitoring, using both cultural and scientific indicators.
- Include and describe restoration opportunities from a Mataranga Maori perspective via collaboration with Ngati Hau.

2. Description of site

The management/restoration area is approximately 7.4 hectares, comprising two main pieces of land on the inner (convex) bank of two oxbow lakes (Oxbows 1 & 2 in diagram 1).

The area also contains a straight narrow segment of land between the two oxbows, following a straight drain cut between the lakes (diagram 1).

The site forms part of the Hikurangi floodplain, adjoining the DOC administered Wairua River Government Purpose Wildlife Management Reserve to the west (Wairua Reserve) (diagram 1).

The main soils for the site are classified as Quaternary alluvial and swamp deposits in Hikurangi Swamp (Manning 2001).

Historically the Hikurangi floodplain is estimated to have covered around 12,000 hectares (Clarkson *et al.* 2015). However, this number may be lower depending on the classification of what actually constitutes wetland habitat. The types of habitats listed within the floodplain include marsh, fen, swamp, peat bog, intermediate wetland, riverine flood forest and gumland. At the present, only 3.5 - 4% of this wetland habitat remains (Conning 2001, Clarkson *et al.* 2015).

The Wairua oxbows are cut off lakes (oxbows) that originally formed meanders of the Wairua River (diagram 1). In the mid-late Twentieth Century, the Wairua River was straightened and drained as part of the Hikurangi drainage works, thus cutting off the oxbows and altering the ground hydrology of the site (drying). In addition, a floodwater stopbank was built between the river and oxbows (diagram 1), hindering the movement of floodwater, sediment and aquatic flora and fauna between the two sections of floodplain.

The restoration area has until recently, been leased for cattle grazing. The majority of land in Oxbow 2 is mixed pasture/exotic grassland, with some mixed indigenous and exotic shrubland around the inner edge (diagram 1). Oxbow 1 has a relatively full canopy of mixed indigenous and exotic shrubs and trees – however, the understory and groundcover tiers are generally weedy and open mainly due to grazing pressure. The soils too have been affected by cattle access, showing signs of compaction and pugging.

Historically, it is likely that the vegetation cover for this area would have been a mix of riverine floodplain forest and ephemeral wetland/sedgeland.

The main historic pressures that are likely to have contributed to the change of the site to its current state include:

- Changes to hydrology (e.g. drainage, construction of the stopbank etc.).
- Stock pressure (e.g. grazing, trampling, spreading of pest plants, eutrophication of water bodies etc.).
- Pest plant invasion.
- Increased nutrient levels from fertilisers and stock.
- General habitat loss from clearance.
- Effects of animal pests (e.g. rabbits, possums, gambusia etc.).

A recent report on the restoration values of sites across the Hikurangi floodplain (Clarkson *et al.* 2015) classified the Wairua River, of which this site is directly connected, as being 'Immediate' priority for restoration - particularly for threatened plant management.

3. Aim of this restoration plan

Aerial photos of the site from 1942 (diagrams 2 & 3), prior to the complete isolation of the oxbow lakes and creation of the stopbank and conversion to pasture, show the sites as being covered in a mix of forest/shrubland habitat with areas of probable ephemeral wetland. The photos provide an excellent template to work to.

The restoration will attempt to best replicate the likely vegetation cover present in 1942, based on the available aerial photos from that time (diagrams 2 & 3).

The aim of this restoration plan is to create a healthy functioning ecosystem, across a range of ecotones and habitat types able to support a wide range of flora and fauna, including threatened species, and to support ecological processes such as natural succession and carbon sequestration.

This plan is intended to be adaptive, based on monitoring and surveillance results. For example, it is envisioned that following the establishment of a planted pioneer/nursery cover, the process of natural succession will lead to an increase in plant diversity and a compositional change in the vegetation community (i.e. early succession shrubland such as manuka (*Leptospermum scoparium*), through to later successional forest species such as kowhai (*Sophora microphylla*) and kahikatea (*Dacrycarpus dacrydioides*)). However, based on the results of monitoring (e.g. photopoints and permanent vegetation quadrat plots) and walkover surveillance (e.g. pest plant surveillance), this natural process may require assistance, such as additional planting of later successional species to assist seed spread. These types of future/ongoing decisions should be made collaboratively between stakeholders and specialists based on monitoring outcomes.

Diagram 1: outline of restoration area (yellow outline)



Diagram 2: Extent of vegetation of Oxbow 1 in 1942. (photography courtesy of DOC)



Diagram 3: Extent of vegetation of Oxbow 2 in 1942. (photography courtesy of DOC)



The clearer areas are potentially ephemeral wetland/sedgeland habitat, similar to that present in the Wairua Reserve.

The orange lines indicate the location of the current stopbank.

4. Current biodiversity values and threats

The site forms part of the DOC Protected Natural Area Programme (PNAP) level one site – the 178 hectare ‘Wairua River Wildlife Management Reserve’ (Q06/150) (Manning 2001).

In October 2015 a series of ecological surveys were undertaken across the site, including:

- A slow walk vegetation, bird and general habitat survey of the shrubland and lake habitat of both oxbows. Undertaken by Lisa Forester (NRC), Katrina Hansen (NRC), Wendy Holland (DOC), Amy Bazeley (AB Ecology) and David Wright (Ecology North).
- A fish survey of the edges of the two oxbow lakes. This was done by setting a total of 20 Gee Minnow (3mm) traps and 10 Kilwell Bait Traps into each of the oxbow lakes for one night. Due to the wide nature of these lakes, the traps were baited with fresh Vegemite to attract fish to the traps. Undertaken by Mike McGlynn (Ecology North), Katrina Hansen and David Wright.
- A reptile survey in the shrubland in Oxbow 1. This was done by setting ten Gee Minnow traps across the shrubland habitat in Oxbow 1. Five were placed on the ground for terrestrial species, and five were tied into trees for arboreal species. The traps were baited with canned peaches, and left in place for one night. In addition, a nocturnal spotlight survey of the site was carried out. Undertaken by Mike McGlynn, Katrina Hansen and David Wright.
- A fish survey of the drain running between the two oxbows. Ten Gee Minnow (3mm) traps were set at 20 metre intervals along the length of the drain, and left for one night. Undertaken by David Wright.

The results of these surveys are as follows:

4.1 Terrestrial vegetation

4.1.1 Oxbow 1

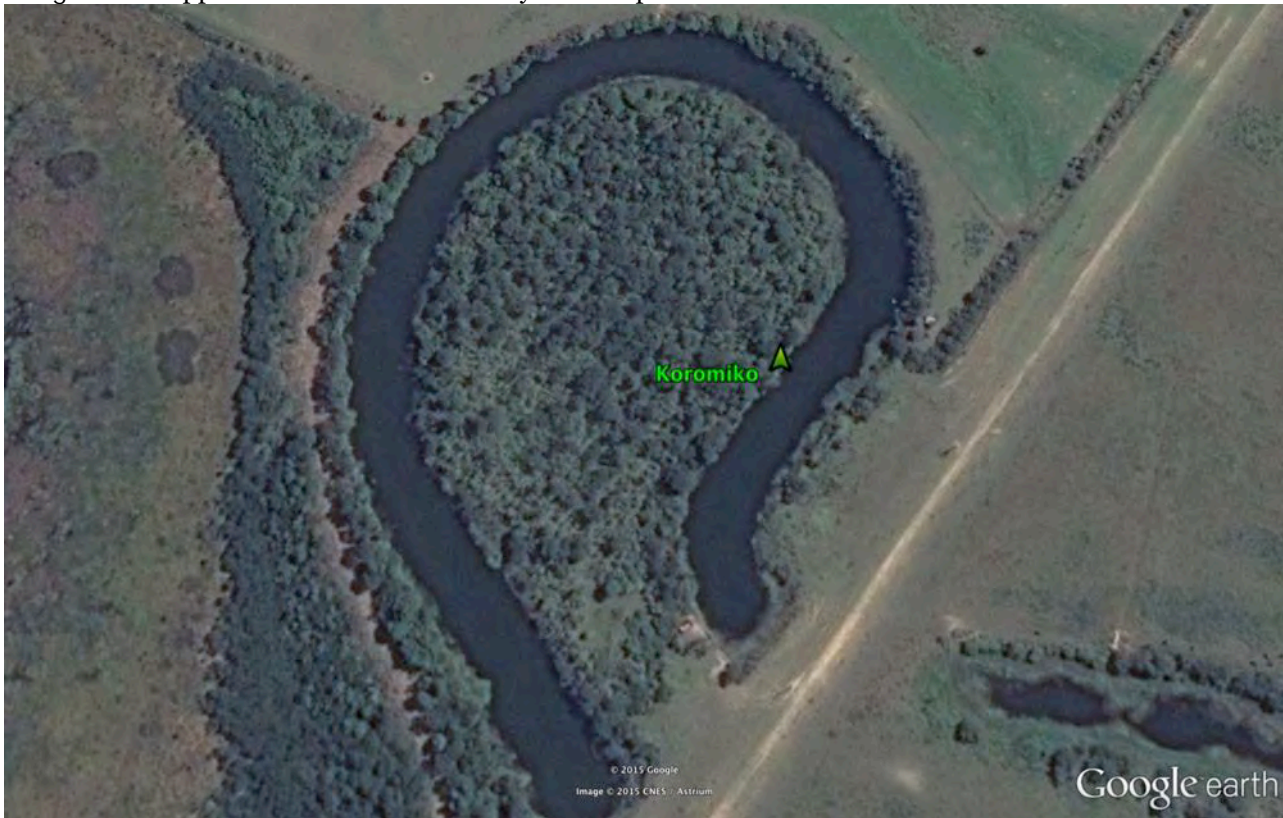
The terrestrial vegetation in Oxbow 1 comprises a mix of indigenous and exotic treeland dominated by weeping mapou (*Myrsine divaricata*) and common Chinese privet (*Ligustrum sinense*) with a relatively open canopy of 4 – 6 metres in height. Common emergent species include kanuka (*Kunzea robusta*), kowhai and kahikatea up to approximately 18 metres in height.

The understory and groundcover tiers are relatively open and weedy due to prolonged cattle browse and trampling. The main pest plants identified include Chinese privet, tradescantia (*Tradescantia fluminensis*), Japanese honeysuckle (*Lonicera japonica*), blackberry (*Rubus fruticosus* agg.) and gorse (*Ulex europeaus*).

A total of 47 indigenous and 19 exotic plant species were recorded from Oxbow 1 (appendix 1 & 2).

A group of approximately four nationally threatened koromiko *Hebe* aff. *bishopiana* (Taxonomically Indeterminate/Nationally Critical) were present on the eastern side of the remnant on the oxbow bank (approximate location - diagram 4).

Diagram 4: Approximate location of surveyed swamp koromiko in Oxbow 1



4.1.2 Oxbow 2

The terrestrial vegetation in Oxbow 2 is predominantly exotic grassland/pasture, with a narrow band of mixed indigenous and exotic forest running close to the water edge (diagram 1).

The shrubland is dominated by manuka and totara (*Podocarpus totara*), with common Chinese privet. The canopy height varies along the length of the site, ranging from approximately 4 – 6 metres. Emergent kanuka is common, up to approximately 18 metres in height. The high proportion of totara in the shrubland at Oxbow 2 indicates a potentially drier substrate than that of the majority of existing shrubland in Oxbow 1.

38 indigenous and 21 exotic plant species were recorded in Oxbow 2 (appendix 1 & 2).

A number of the nationally threatened heart-leaved kohuhu (*Pittosporum obcordatum*) (Nationally Vulnerable) were present in Oxbow 2 during the vegetation survey (mainly seedlings and small shrubs) (approximate location - diagram 5). However, at the time of writing this plan, stock have had extended access into the Oxbow 2 and have caused a considerable level of damage, which is likely to have impacted on the kohuhu seedlings.

4.1.3 Connecting drain

The vegetation along the western side of the drain is connected to the Wairua Reserve, and is predominantly manuka with a canopy height of around five metres. Occasional Chinese privet is also present, as are patches of tradescantia.

On the eastern side, the cover is mainly mixed pasture, with some young manuka regeneration.

The aquatic vegetation in the drain is predominantly a mix of kutakuta (*Eleocharis sphacelata*) and alligator weed (*Alternanthera philoxeroides*), with common parrot's feather (*Myriophyllum aquaticum*).

Diagram 5: Approximate area where *Pittosporum obcordatum* are located in Oxbow 2



4.2 Aquatic habitat

The vegetation in the oxbow lakes is largely confined to the shallower edges, with mainly open water in the deeper middle sections. Alligator weed is common. Parrot's feather is also present, mixed with a range of shallow water/wetland species such as kutakuta, swamp millet (*Isachne globosa*) and mercer grass (*Paspalum distichum*).

4.3 Birds

A total of 28 bird species were recorded from the site (appendix 3). Of these, 17 were indigenous and 11 exotic.

Two species identified from the surveys are classified as 'At Risk': kawau/black shag (*Phalacrocorax carbo*) (Naturally Uncommon) and kawau tui/little black shag (*Phalacrocorax sulcirostris*) (Naturally Uncommon).

Nathan Burkepile (Northland Fish and Game) has observed the nationally threatened matuku/Australasian bittern (*Botaurus poiciloptilus*) (Nationally Endangered) at the site. While matuku were not observed as part of the ecological surveys, they were observed close by in subsequent visits to wetland habitat in the Wairua Reserve.

4.4 Reptiles and amphibians

No reptiles were caught, or observed anywhere across the site. This is likely to be due to predation pressure (e.g. rats, mustelids, feral cats etc.), accompanied by the high level of ecological degradation (e.g. lack of ground cover from grazing etc...).

Southern bell frogs (*Litoria raniformis*) were heard calling in both oxbow lakes. Southern bell frogs (or growling grass frogs) are an introduced species native to south-eastern Australia.

4.5 Fish

A total of four fish species were caught across the site during the surveys (appendix 3), including three indigenous and one introduced pest species.

Extremely high numbers of the pest fish - plague minnow/gambusia (*Gambusia affinis*) were caught across all areas.

A single black mudfish (*Neochanna diversus*) (At Risk-Relict) was caught in the connecting drain, and another was seen but not caught on the western edge of Oxbow 1. Black mudfish have been recorded from several locations within the Hikurangi floodplain including the adjacent Wairua Reserve (Price & Dean 2014).

A total of 23 Cran's bullies (*Gobiomorphus basalis*) were trapped along the edge of Oxbow 1. Two appeared to be gravid. The largest concentrations of bully were on the western side of the site below an area of dense overhanging manuka. This is possibly due to the shaded environment limiting the density of gambusia.

Given the size range of bullies caught, it is possible that there is a resident population present (as opposed to fish moving in with flood waters). Bullies, being bottom feeders and breeders may also be surviving in the presence of gambusia (surface feeders) due to their substrate habitat preference (Mike McGlynn pers. comm.)

Two shortfin eel (*Anguilla australis*) were trapped in Oxbow 2.

Due to the limitations of the trapping methodology, no larger deep-water fish were caught. Catfish (*Ameiurus nebulosus*) are known to be present in the Wairua River and some of the oxbows (Price & Dean 2014, Allan Halliday and Nathan Burkepile pers. comm.), and are likely to be present in these oxbow lakes, as may be longfin eels (*Anguilla dieffenbachii*) (Price & Dean 2014, Mike McGlynn pers. comm.).

4.6 Invertebrates

A total of 14 invertebrate species were observed from the site (appendix 3) during the vegetation, nocturnal spotlighting and trapping surveys. Of these, eleven are terrestrial/arboreal and three aquatic or aquatic in the larval stage.

Although the invertebrate survey is based on anecdotal observations, this level of observed diversity should be considered low for a site such as this, and is likely reflective of predation pressure (particularly rats), accompanied by the high level of ecological degradation across the site.

4.7 Mammals

Both brushtail possums (*Trichosurus vulpecula*) and rabbits (*Oryctolagus cuniculus*) were observed in the shrubland habitat in Oxbow 1.

Cattle (*Bos taurus*) have been accessing the site. Stock will retain access until the grazing lease expires in mid 2016.

4.8 Significant species in the adjoining Wairua Reserve

A number of ecologically significant species not recorded as part of these surveys have been recorded in the adjoining Wairua Reserve. Given appropriate management, these have the potential to naturally spread or be reintroduced into the restoration site. These include (list from Clarkson et al. (2015)):

- Rough rasp fern (*Doodia squarrosa*) (At Risk – Naturally Uncommon).
- Giant hypolepis (*Hypolepis dicksoiodes*) (At Risk – Naturally Uncommon).
- Marsh crake (*Porzana pusilla*) (At Risk - Relict).
- Matata/fernbird (*Bowdleria punctata*) (At Risk - Declining).
- Banded rail (*Gallirallus philippensis*) (At Risk - Declining).

4.9 Threats

The main threats identified for the site, addressed as part of this restoration plan include:

- Control of pest plants.
- Control of animal pests.
- Gambusia management through additional planting.
- Management of the drains leading out of the site (hydrology).
- Cattle access.

5. Restoration opportunities

This site has significant value as an ecological restoration project, particularly due to:

1. Being an 'At Risk Threatened Land Environment' (Walker et al. 2007).
2. Containing the remnant 'bones' of a functioning natural ecosystem (e.g. existing indigenous cover, seed source etc...).
3. Its connectivity to the Wairua Reserve (ecological corridor/connectivity, seed source for natural succession, source for potential wildlife and rare plant re-colonisation etc...).
4. The presence of two threatened plant species; Hikurangi Swamp koromiko and heart-leaved kohukohu.
5. The potential to restore a sequence from freshwater lake and ephemeral wetlands, to riverine forest and shrubland habitat types (ecotones), providing good quality habitat for a range of wildlife species such as water fowl and waders etc...
6. The potential to increase the habitat suitability for mudfish, Cran's bully and other indigenous fish species through increased water shading (reduced gambusia pressure).
7. Providing an example of best practice oxbow restoration.

6. Restoration requirements

The main focus of restoration should include the following actions:

1. Revegetation planting of:
 - The open dry areas in both oxbow areas.
 - The length of the connecting drain between the lakes.
 - Ephemeral wetlands in the low-lying areas of current pasture in Oxbow 2.
 - Potential infill planting around the oxbow edges.
2. Pest plant control across the site. The initial control should target:
 - Chinese privet
 - Tradescantia
 - Japanese honeysuckle
 - Blackberry
 - Gorse
 - Selaginella (*Selaginella kraussiana*)
 - Barberry (*Berberis glaucocarpa*)
 - Hawthorn (*Crataegus monogyna*)
3. Control of mammalian animal pests across the site:
 - Possums
 - Rodents
 - Mustelids (stoats, ferrets, weasels)
 - Cats
 - Hedgehogs
 - Rabbits
4. Management of the connecting drain between the oxbows as potential mudfish habitat.
5. The infilling/blocking of the drain below Oxbow 2 to potentially raise the water table.
6. Rehabilitation/excavation of the ephemeral wetland areas likely to have been present in the 1942 aerial photo of Oxbow 2 (diagram 3).
7. Enhancement of the populations of threatened koromiko and kohukohu, along with the creation of a functioning ecosystem mosaic, able to support the natural re-colonisation of a range of threatened and at risk species.
8. Completion and maintenance of stock proof fences.

6.1 Revegetation planting

The type of planting will be site/habitat specific.

The identified planting areas have been divided into definite and potential sites. The definite sites are to be planted in sequence, while the decision to plant the potential areas will be made based on monitoring results at the end of year 3 (2018). These potential sites are the narrow sections of oxbow edges presently lacking vegetative cover. It may be that following a few years of cattle exclusion, natural regeneration may be adequate to provide the cover needed for these areas. However, if this is not achieved, then it may be necessary to carry out some level of additional planting.

6.1.1 Manuka dominated shrubland planting.

Table 1: Outline of shrubland planting

Explanation	<p>This will cover widest range of planting areas (diagram 5). The dominance of manuka will provide a fast growing cover to attain a quick canopy closure, so reducing the ability for further pest plant spread/establishment, and to act as a nursery to facilitate the natural regeneration/succession process. The main riverine forest species (e.g. kahikatea, totara etc.) are present at the site and in the adjoining Wairua Reserve, so should spread into the planting area relatively quickly.</p> <p>This will cover the majority of the definite planting sites, and a section of potential planting along the edge of oxbow 2 (diagram 6).</p> <p>The use of manuka with occasional cabbage trees along the connecting drain should increase the habitat value for mudfish, by providing cover and debris into the drain, and by creating an environment too shaded for a large gambusia population.</p>										
Approx. size	Potentially 3.25 hectares. Planted in 1 – 1.25 hectare blocks (appendix 4).										
Timing	<p>Can be started straight away (year 1/2016). The species mix for first year will be more manuka dominant, due to timing of seed collection and propagation.</p> <p>Planting should be done in winter, post-duck shooting season (August).</p>										
Spacing	Blanket plant at one metre centres.										
Species list	<table data-bbox="389 1178 1439 1397"> <tr> <td><i>Coprosma propinqua</i> (mingimingi)</td> <td>2%</td> </tr> <tr> <td><i>Cordyline australis</i> (ti kouka/cabbage tree)</td> <td>2%</td> </tr> <tr> <td><i>Kunzea robusta</i> (kanuka)</td> <td>25%</td> </tr> <tr> <td><i>Leptospermum scoparium</i> (manuka)</td> <td>70%</td> </tr> <tr> <td><i>Phormium tenax</i> (harakeke/flax)</td> <td>1%</td> </tr> </table>	<i>Coprosma propinqua</i> (mingimingi)	2%	<i>Cordyline australis</i> (ti kouka/cabbage tree)	2%	<i>Kunzea robusta</i> (kanuka)	25%	<i>Leptospermum scoparium</i> (manuka)	70%	<i>Phormium tenax</i> (harakeke/flax)	1%
<i>Coprosma propinqua</i> (mingimingi)	2%										
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<i>Kunzea robusta</i> (kanuka)	25%										
<i>Leptospermum scoparium</i> (manuka)	70%										
<i>Phormium tenax</i> (harakeke/flax)	1%										
Monitoring	<p>Annual photopoints and biennial vegetation quadrats.</p> <p>Twice annual pest plant surveillance checks.</p>										

6.1.2 Ephemeral wetland planting in Oxbow 2.

Table 2: Outline of ephemeral wetland planting

Explanation	Excavation works should be carried out to create shallow ephemeral wetland habitat, similar to what appears to have been present in the 1942 aerial photos (diagram 3). A mix of <u>wet root tolerant</u> manuka (i.e. manuka grown from seed collected from plants growing in wet conditions), along with mixed sedge species should be used based on those present in the Wairua Reserve, such as <i>Carex maorica</i> , <i>C. virgata</i> , <i>C. lessoniana</i> , <i>C. subdola</i> , <i>Machaerina articulata</i> and <i>Eleocharis acuta</i> .																
Approx. size	Dependant on the amount of excavation carried out. Potentially up to 7,500 m ² .																
Timing	Excavation of the site in January-February 2017. Planting to be done in April 2018 (pre-duck shooting season). This allows the excavated wetlands to be left for a winter and summer to assess peak water levels and to allow further pest plant control prior to planting.																
Spacing	Wet root tolerant manuka can be cluster planted through the site at one metre centres. Sedges can be cluster planted at 500mm centres depending on habitat suitability. Plant approximately 1,000 manuka and 10,000 mixed sedges (25% cover at 500mm centres). Broadcast additional sedge/wetland plant seeds through the non-planted areas (first ensure that pest plants are sprayed out prior to broadcast), thus spreading seed into the non-planted areas from both physical broadcasting and natural ongoing seeding from the planted clusters.																
	<table> <tr> <td><i>Baumea articulata</i></td> <td>10% - in wetter sections</td> </tr> <tr> <td><i>Carex gaudichaudiana</i></td> <td>10%</td> </tr> <tr> <td><i>Carex lessoniana</i> (rautahi)</td> <td>20%</td> </tr> <tr> <td><i>Carex maorica</i></td> <td>20%</td> </tr> <tr> <td><i>Carex subdola</i></td> <td>10%</td> </tr> <tr> <td><i>Carex virgata</i> (purei)</td> <td>20%</td> </tr> <tr> <td><i>Eleocharis acuta</i></td> <td>10% - in wetter sections</td> </tr> <tr> <td><i>Leptospermum scoparium</i> (manuka)</td> <td>100% (1,000 plants)</td> </tr> </table>	<i>Baumea articulata</i>	10% - in wetter sections	<i>Carex gaudichaudiana</i>	10%	<i>Carex lessoniana</i> (rautahi)	20%	<i>Carex maorica</i>	20%	<i>Carex subdola</i>	10%	<i>Carex virgata</i> (purei)	20%	<i>Eleocharis acuta</i>	10% - in wetter sections	<i>Leptospermum scoparium</i> (manuka)	100% (1,000 plants)
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<i>Eleocharis acuta</i>	10% - in wetter sections																
<i>Leptospermum scoparium</i> (manuka)	100% (1,000 plants)																
Monitoring	Annual photopoints and biennial vegetation quadrats.																

This wetland species mix is based on those present in ephemeral wetland habitat in the connecting Wairua Reserve. However, it is possible that once excavated, the site may not be suited to this range of species, depending on the soil types. If necessary, this species list may require to be altered to suit the conditions.

6.1.3 Additional edge planting of Oxbow 1.

Table 3: Outline of lake-edge planting

Explanation	<p>This planting is only to be done in year 4/2019 if necessary, dependant on monitoring results. A decision will be made at the end of year 3 (2018), and if necessary planting will be undertaken in year 4.</p> <p>The purpose of this planting is to provide a denser level of lake edge shading amongst the established shrubland along the water edge, particularly following the creation of gaps with the removal of the existing privet.</p> <p>It is envisioned this will provide higher quality habitat for indigenous aquatic fauna, particularly Cran's bully and mudfish by creating sub-optimal habitat for gambusia (e.g. increased shading, reduced water temperature).</p> <p>Manuka will provide a fast growing dense canopy and should be the main focus of any dry bank planting. Other species can be added such as flax (<i>Phormium tenax</i>), mahoe (<i>Melicytus ramiflorus</i>) and mingimingi (<i>Coprosma propinqua</i>). This will also provide the opportunity to plant more swamp koromiko (Restoration action 7).</p> <p>Sedges can be planted in the shallow ephemeral areas of the lake edge.</p>										
Approx. size	7,500 m ² .										
Timing	Planting should be done in autumn, when the ground is wet but not completely flooded (April - pre duck shooting season).										
Spacing	<p>Plant at varied spacing dependant on gaps in the existing canopy (particularly following the removal of pest plants).</p> <p>Aim for one metre tree spacing between the plantings and existing vegetation.</p> <p>Sedges can be spaced at 500 mm centres depending on habitat suitability.</p>										
Species list	<p>Dry edges</p> <table data-bbox="395 1574 1428 1765"> <tr> <td><i>Coprosma propinqua</i> (mingimingi)</td> <td>5%</td> </tr> <tr> <td><i>Hebe</i> aff. <i>bishopiana</i> (swamp koromiko)</td> <td>10%</td> </tr> <tr> <td><i>Leptospermum scoparium</i> (manuka)</td> <td>70%</td> </tr> <tr> <td><i>Phormium tenax</i> (harakeke/flax)</td> <td>10%</td> </tr> <tr> <td><i>Melicytus ramiflorus</i> (mahoe)</td> <td>5%</td> </tr> </table>	<i>Coprosma propinqua</i> (mingimingi)	5%	<i>Hebe</i> aff. <i>bishopiana</i> (swamp koromiko)	10%	<i>Leptospermum scoparium</i> (manuka)	70%	<i>Phormium tenax</i> (harakeke/flax)	10%	<i>Melicytus ramiflorus</i> (mahoe)	5%
<i>Coprosma propinqua</i> (mingimingi)	5%										
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<i>Leptospermum scoparium</i> (manuka)	70%										
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	<p>Damp edges - sedges</p> <table data-bbox="395 1832 1428 1975"> <tr> <td><i>Carex lessoniana</i> (rautahi)</td> <td>15%*</td> </tr> <tr> <td><i>Carex maorica</i></td> <td>15%</td> </tr> <tr> <td><i>Carex subdola</i></td> <td>15%</td> </tr> <tr> <td><i>Carex virgata</i> (purei)</td> <td>15%</td> </tr> </table>	<i>Carex lessoniana</i> (rautahi)	15%*	<i>Carex maorica</i>	15%	<i>Carex subdola</i>	15%	<i>Carex virgata</i> (purei)	15%		
<i>Carex lessoniana</i> (rautahi)	15%*										
<i>Carex maorica</i>	15%										
<i>Carex subdola</i>	15%										
<i>Carex virgata</i> (purei)	15%										

* The ratio of sedge species will be dependant on the availability of seed from the site.



Diagram 5: Planting areas in Oxbow 1 & the connecting drain for year 1 (August 2016)



Diagram 6: Planting areas in Oxbow 2 including areas of ephemeral wetland restoration. The strip planting along the oxbow edge will only be carried out if necessary in year 4 (2019)



Diagram 7: Potential oxbow edge planting area in Oxbow 1

6.2 Pest plant control

In the context of this restoration plan, the main focus of pest plant control should be on the management of terrestrial species (with the exception of maintenance of the excavated ephemeral wetlands). As the aquatic pest plants are widespread through the shallower sections of the lakes, it would be beneficial in the future, once the restoration is established, to consider controlling some of these aquatic species.

The initial pest plant knock down across the site is programmed to be carried out in January - March 2016.

At each planting area, all pest plant species should be controlled prior to the commencement of planting.

Following the initial control, regular surveillance and follow up control should be carried out at least twice yearly in spring and autumn.

Control should follow the most suitable low impact methods available. A pest plant control plan is included as Appendix 5 of this restoration plan.

6.3 Animal pest control

DOC are planning to commence extensive animal pest control in the Wairua Reserve in 2016. It has been agreed that DOC will also cover the oxbows as part of this programme.

6.4 Enhancement of mudfish habitat along the connecting drain

The planting of manuka with occasional cabbage trees along the length of this drain (6.1.1) will provide the main shading cover required. This should reduce the number of predatory gambusia and shade out much of the alligator weed currently present in the drain.

If locally sourced wheki (*Dicksonia squarrosa*) are available, these can also be added to the drain edge planting as a source of ongoing debris material (fallen fronds) for the drain.

Additional plant debris should be collected and added to the drain as part of the restoration activities (e.g. flax and cabbage tree leaves, fern fronds etc...) to create a substrate cover for the mudfish, particularly if the drain dries over the summer season.

6.5 Blocking of the drain downstream of Oxbow 2

The blocking of the drain around 200 metres to the west of Oxbow 2 should help to raise and maintain the groundwater levels through the restoration area, and potentially in the Wairua Reserve. The drain will need to be excavated down through any layers of deposited sediment associated with the drain, ideally to a clay layer if possible. The drain and associated excavation should then be filled/plugged with low-permeable clay material. This work will be done under the supervision of WDC and Northland Fish and Game.

6.6 Rehabilitation/excavation of the ephemeral wetland systems

Rehabilitation of the ephemeral wetland systems will involve the creation of a series of dips, hollows and mounds through the Oxbow 2 site identified as likely ephemeral wetland

in the 1942 aerial photos (diagram 3). Much of this area is already lower lying than the surrounding landscape, and should not require a lot of excavation.

The creation of these sites should aim to replicate similar ephemeral wetland habitat present in the Wairua Reserve.

This excavation work will be done under the supervision of WDC and Northland Fish and Game.

6.7 Enhancement of threatened plant species.

As *Hebe* aff. *bishopiana* and *Pittosporum obcordatum* are already present, enhancement of these populations should be the focus of threatened plant restoration effort.

The Ngati Hau nursery at Akerama Marae have a number of *Pittosporum obcordatum* grown from seed from upstream on the Hikurangi floodplain. It is recommended that, if available, 200 – 300 of these should be grown into pb5 size, and purchased to be planted in the existing shrubland area in Oxbow 1. Additional seed should be collected to grow plants for Oxbow 2 once the revegetation planting has become established there.

Seed should also be collected, starting summer 2015/16, to propagate *Hebe* aff. *bishopiana* for both of the main planting areas. These should also be incorporated into the additional edge planting in Oxbow 1 (6.1.2).

It is envisioned that following the removal of stock and ecological pest species, the natural regeneration process will facilitate the self-reintroduction of a range of plant species from the adjoining Wairua Reserve and surrounding landscape.

6.8 Completion and maintenance of stock proof fences.

At the time of writing this plan, a fence has been erected along the eastern edge of Oxbow 1, with the remaining fencing along the eastern length of the site planned for January – March 2016.

During a subsequent visit to the site, the gate leading into Oxbow 1 had been left open. It is therefore recommended that this gate be locked.

7. Monitoring

Five monitoring methods are recommended for this site.

- Photopoints.
- Permanent vegetation quadrats.
- Annual systematic pest plant and rabbit sign surveillance walks.
- Five-minute bird counts.
- Freshwater fish trapping (August for mudfish).
- Lizard trapping (including surveillance for the invasive plague skink).

This ongoing monitoring offers the opportunity for joint collaboration between WDC (as land administrators) and the Ngati Hau Resource Management Unit (traditional kaitiaki), providing both scientific outcome and cultural indicators of restoration success.

For details on monitoring methods refer to the monitoring plan for the project.

8. References

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Appendix 1 – Indigenous plant species lists

<i>Indigenous species –Oxbow 1</i>			
Dicot trees, shrubs & lianas		Monocot trees, shrubs, and lianas	
<i>Calystegia tuguriorum</i>	NZ bindweed	<i>Cordyline australis</i>	ti kouka
<i>Carpodetus serratus</i>	putaputaweta		
<i>Coprosma areolata</i>		<i>Ripogonum scandens</i>	supplejack
<i>Coprosma parviflora</i>	leafy coprosma		
<i>Coprosma propinqua</i>	mingimingi	Monocot herbs and grasses	
<i>Coprosma rhamnoides</i>		<i>Oplismenus hirtellus</i>	basket grass
<i>Coprosma rigida</i>		<i>Phormium tenax</i>	harakeke
<i>Coprosma robusta</i> × <i>C. propinqua</i>		<i>Isachne globosa</i>	swamp millet
<i>Coprosma rotundifolia</i>			
<i>Coprosma tenuicaulis</i>	swamp coprosma	Monocot rushes & sedges	
<i>Dacrycarpus dacrydioides</i>	kahikatea	<i>Carex maorica</i>	
<i>Hebe aff. bishopiana</i>	swamp koromiko	<i>Carex virgata</i>	purei
<i>Hedycarya arborea</i>	porokaiwhiri	<i>Cyperus ustulatus</i>	umbrella sedge
<i>Kunzea robusta</i>	kanuka	<i>Eleocharis acuta</i>	
<i>Leptospermum scoparium</i>	manuka	<i>Eleocharis sphacelata</i>	kutakuta
<i>Melicytus micranthus</i>	swamp mahoe	<i>Isolepis prolifera</i>	
<i>Myrsine australis</i>	mapou	<i>Juncus edgariae</i>	wiwi
<i>Myrsine divaricata</i>	weeping mapou	<i>Juncus planifolius</i>	grass-leaf rush
<i>Podocarpus totara</i>	totara	<i>Juncus sarophorus</i>	fan-flower rush
<i>Sophora microphylla</i>	kowhai		
<i>Streblus heterophyllus</i>	turepo	Ferns	
<i>Muelhenbeckia australis</i>	pohuehue	<i>Azolla rubra</i>	azolla
<i>Parsonsia heterophylla</i>	kaihua	<i>Blechnum molle</i>	mokimoki
<i>Rubus australis</i>	tataramoa	<i>Blechnum parrisiae</i>	rasp fern
		<i>Deparia petersenii</i>	
Dicot herbs		<i>Hypolepis distans</i>	
<i>Centella uniflora</i>	centella	<i>Pteridium esculentum</i>	bracken
<i>Persicaria decipiens</i>	knotweed	<i>Pyrrosia elaeagnifolia</i>	leather-leaf fern
		<i>Microsorium pustulatum</i>	hound's tongue

Indigenous species –Oxbow 2

Dicot trees, shrubs & lianas		Monocot trees, shrubs, and lianas	
<i>Coprosma areolata</i>		<i>Cordyline australis</i>	ti kouka
<i>Coprosma parviflora</i>	leafy coprosma	<i>Ripogonum scandens</i>	supplejack
<i>Coprosma propinqua</i>	mingimingi		
<i>Coprosma rhamnoides</i>		Monocot herbs and grasses	
<i>Coprosma rigida</i>		<i>Microlaena avenacea</i>	bush rice grass
<i>Coprosma rotundifolia</i>		<i>Phormium tenax</i>	harakeke
<i>Dacrycarpus dacrydioides</i>	kahikatea	<i>Isachne globosa</i>	swamp millet
<i>Hedycarya arborea</i>	porokaiwhiri		
<i>Kunzea robusta</i>	kanuka	Monocot rushes & sedges	
<i>Leptospermum scoparium</i>	manuka	<i>Carex maorica</i>	
<i>Melicytus micranthus</i>	swamp mahoe	<i>Carex virgata</i>	purei
<i>Myrsine divaricata</i>	weeping mapou	<i>Cyperus ustulatus</i>	umbrella sedge
<i>Podocarpus totara</i>	totara	<i>Eleocharis acuta</i>	
<i>Pittosporum obcordatum</i>	kohukohu	<i>Eleocharis sphacelata</i>	kutakuta
<i>Muelhenbeckia australis</i>	pohuehue	<i>Isolepis prolifera</i>	
<i>Parsonsia heterophylla</i>	kaihua	<i>Isolepis sp.</i>	
<i>Rubus australis</i>	tataramoa	<i>Juncus edgariae</i>	wiwi
		<i>Juncus planifolius</i>	grass-leaf rush
Dicot herbs		<i>Juncus sarophorus</i>	fan-flower rush
<i>Centella uniflora</i>	centella		
		Ferns	
		<i>Azolla rubra</i>	azolla
		<i>Blechnum molle</i>	mokimoki
		<i>Blechnum parrisiae</i>	rasp fern
		<i>Deparia petersenii</i>	
		<i>Pyrrosia elaeagnifolia</i>	leather-leaf fern

Appendix 2 – Exotic plant species lists

Exotic Species – Oxbow 1			
Dicot trees, shrubs & lianas		Monocot herbs and grasses	
<i>Berberis glaucocarpa</i>	barberry	<i>Gladiolus undulatus</i>	gladiolus
<i>Crataegus monogyna</i>	hawthorn	<i>Paspalum distichum</i>	mercier grass
<i>Ligustrum sinense</i>	Chinese privet	<i>Tradescantia flumenensis</i>	tradescantia
<i>Lonicera japonica</i>	Japan honeysuckle	Monocot rushes & sedges	
<i>Rubus fruticosus</i> agg.	blackberry	<i>Carex ovalis</i>	oval sedge
<i>Ulex europeaus</i>	gorse	<i>Cyperus eragrostis</i>	umbrella sedge
Dicot herbs		<i>Isolepis levynsiana</i>	flat sedge
<i>Alternanthera philoxeroides</i>	alligator weed	<i>Juncus bufonius</i>	
<i>Callitriche stagnalis</i>	water starwort	<i>Juncus effusus</i>	leafless rush
<i>Jacobaea vulgaris</i>	ragwort		
<i>Lotus pedunculatus</i>	lotus		
<i>Mentha</i> sp.			
<i>Myostis laxa</i>	forget-me-not		
<i>Myriophyllum aquaticum</i>	parrot's feather		
<i>Persicaria hydropiper</i>	water pepper		
<i>Persicaria strigosa</i>			
<i>Ranunculus flammula</i>	spearwort		
<i>Rumex obtusifolius</i>	broad-leaf dock		

Exotic Species – Oxbow 2			
Dicot trees, shrubs & lianas		Monocot herbs and grasses	
<i>Crataegus monogyna</i>	hawthorn	<i>Gladiolus undulatus</i>	gladiolus
<i>Ligustrum sinense</i>	Chinese privet	<i>Paspalum distichum</i>	mercier grass
<i>Lonicera japonica</i>	Japan honeysuckle	<i>Tradescantia flumenensis</i>	tradescantia
<i>Rubus fruticosus</i> agg.	blackberry	Monocot rushes & sedges	
<i>Ulex europeaus</i>	gorse	<i>Carex ovalis</i>	oval sedge
Dicot herbs		<i>Cyperus eragrostis</i>	umbrella sedge
<i>Alternanthera philoxeroides</i>	alligator weed	<i>Juncus effusus</i>	leafless rush
<i>Callitriche stagnalis</i>	water starwort		
<i>Jacobaea vulgaris</i>	ragwort	Lycophytes	
<i>Lotus pedunculatus</i>	lotus	<i>Selaginella kraussiana</i>	selaginella
<i>Myriophyllum aquaticum</i>	parrot's feather		
<i>Persicaria hydropiper</i>	water pepper		
<i>Persicaria strigosa</i>			
<i>Ranunculus flammula</i>	spearwort		
<i>Rumex obtusifolius</i>	broad-leaf dock		

Appendix 3 – Fauna species lists

Bird species – combined oxbows

Indigenous

Black swan	<i>Cygnus atratus</i>
Kahu/Australasian harrier	<i>Circus approximans</i>
Kawau tui/little black shag	<i>Phalacrocorax sulcirostris</i>
Kawau/black shag	<i>Phalacrocorax carbo</i>
Kotare/kingfisher	<i>Halcyon sancta</i>
Kuruwhengi/Australasian shoveler*	<i>Anas rhynchotis</i>
Matuku/Australasian bittern*	<i>Botaurus poiciloptilus</i>
Piwiwharauoa/shining cuckoo	<i>Chrysococcyx lucidus</i>
Piwakawaka/fantail	<i>Rhipidura fuliginosa</i>
Pukeko	<i>Porphyrio melanotus</i>
Putangitangi/paradise shelduck	<i>Tadorna variegata</i>
Riroriro/grey warbler	<i>Greygone igata</i>
Ruru/morepork	<i>Ninox novaeseelandiae</i>
Spur-winged plover	<i>Vanellus miles</i>
Tete/grey teal	<i>Anas gracilis</i>
Welcome swallow	<i>Hirundo neoxena</i>
White-faced heron	<i>Egretta novaehollandiae</i>

Exotic

Australian magpie	<i>Gymnorhina tibicen</i>
Blackbird	<i>Turdus merula</i>
California quail	<i>Callipepla californica</i>
Chaffinch	<i>Fringilla coelebs</i>
Dunnock	<i>Prunella modularis</i>
Eastern rosella	<i>Platycercus eximius</i>
Goldfinch	<i>Carduelis carduelis</i>
Greenfinch	<i>Carduelis chloris</i>
House sparrow	<i>Passer domesticus</i>
Mallard	<i>Anas platyrhynchos</i>
Pheasant	<i>Phasianus colchius</i>

* Presence pers. comm. Nathan Burkepile, Northland Fish & Game

Fish species – combined oxbows and connecting drain

Indigenous		Caught
Black mudfish	<i>Neochanna diversus</i>	Connecting drain
Cran's bully	<i>Gobiomorphus</i> <i>basalis</i>	Oxbow 1
Shortfin eel	<i>Anguilla australis</i>	Oxbow 2
Exotic/pest species		
Plague minnow	<i>Gambusia affinis</i>	All sites

Invertebrate observations – combined oxbows

Terrestrial/arboreal/aerial	
Auckland tree weta	<i>Hemideina thoracica</i>
Black headed jumping spider	<i>Trite planiceps</i>
Bumblebee	<i>Bombus</i> sp.
Damselfly	Zygoptera
Dragonfly	Anisoptera
Earth worm	Megascolecidae
Honey bee	<i>Apis mellifera</i>
Leaf vein slug	Athoracophoridae
Nurseryweb spider	<i>Dolomedes minor</i>
Orb web spider	Araneidae
Stick insect	Phasmatodea
Vagrant spider	Zoropsidae
Wolf spider	Lycosidae
Aquatic	
Damselfly nymph	Zygoptera
Dragonfly nymph	Anisoptera
Water beetle	Dytiscidae

Appendix 4 - Planting methodology and yearly planting areas

Pest plant control should be undertaken prior to planting. In the pasture, spray the area in late summer, then spray the regrowth around four weeks prior to planting. This may be done by quad boom-sprayer. However, in sites where significant natural regeneration has occurred, it may be necessary to use a lower impact method so as to minimise damage to the natural regeneration (e.g. use of selective herbicides and/or spot spraying with backpack sprayers). If necessary, the grass may need to be slashed prior to planting.

Species mixes and spacing should follow the lists outlined in tables 1 – 3 for each specific area. This is principally one-metre centres (10,000 per ha) for the dry sites and wetland manuka, and 500mm centres (40,000 per ha) for the sedges in the wetter areas.

All plants listed in tables 1 – 3 should be revegetation grade size (e.g. 5.5cm tube etc.).

Given the costs to plant the entire ephemeral wetlands with sedge species at close spacing, it is recommended that these areas instead be cluster planted to a minimum of 25% cover of the site (i.e. 10,000 plants per hectare). In this way, clusters of closely centred plants (500mm) are spread through the wetlands to aid the natural regeneration process through the introduction of seed sources. In combination with planting, a mixture of wetland species seeds can be hand broadcast through the non-planted areas to aid establishment.

The planting of the drier areas should be done in winter, when the ground is wettest (August – post duck shooting season). The wetland plantings should be done in early autumn, before water levels reach their peak (April – pre duck shooting season).

Revegetation grade plants can be planted using the forestry cut method. Using a commercial grade planting spade, a cut is made in the ground, and spread apart by levering the spade back and forth wide enough to easily (without force) bury the plant to the top of the potting mix. The cut soil around the plant is then carefully closed and firmed with the foot.

Larger (pb) grade plants (e.g. *Pittosporum obcordatum*), need to be placed in a hole approximately 1.5 times wider than the root ball, with the soil returned around the roots firmed with the ball of the foot.

Ensure that all plants are well watered prior to planting.

Any root bound pb grade plants should have the roots gently teased apart prior to planting. This should not be required for the revegetation/tube/ grade plants (and should definitely not be done to manuka or kanuka due to the sensitivity of their roots to disturbance).

All plants being introduced to the site should be checked to be free of plague skink eggs and Argentine ants.



Year 1 (2016): Oxbow 1 & drain shrubland planting (approximately 1 hectare).



Year 2 (2017): Oxbow 2 shrubland planting (approximately 1.25 hectares)



Year 3 (2018): Oxbow 2 ephemeral wetland areas (approximately 7,500m²)



Year 4 (2019): Potential Oxbow 2 shrubland edge planting (approximately 8,000m²)



Year 4 (2019) – Potential oxbow 1 edge planting area

Appendix 5 - Pest plant control methods

For the purpose of ecological restoration, the initial pest plant control should cover the following species, which pose a direct threat to the establishment of plantings and the process of natural regeneration:

- Chinese privet
- Tradescantia
- Japanese honeysuckle
- Blackberry
- Gorse
- Selaginella
- Barberry
- Hawthorn

Operators carrying out spray work must hold the appropriate legal qualifications for herbicide use issued by WorkSafe New Zealand (i.e. Growsafe for application and Approved Handlers Certificate to purchase and transport some herbicides – for details refer to <http://www.growsafe.co.nz>). All operators must also wear the appropriate personal protection equipment for the job.

There are two commonly used approaches to pest plant control; species led and site led.

A species led approach targets individual species across a site, so that each species is controlled one by one, usually in a hierarchical manner based on the level of threat, difficulty/ease of control/management of seed source etc...

A site led approach targets a range of species across an entire given area, where a site is often divided into sections with all pests targeted within each section in a systematic manner.

For the initial pest plant knockdown at this site, a mainly species led approach is recommended - where appropriate, groups of species can be targeted together based on the type of control methods required (table A). Thus, all tree species that need to be cut down and the stump treated with herbicide, or foliar sprayed with sodium glyphosate should be targeted together etc.

For this purpose the initial target species have been divided into five management control type groups (table A).

The control of these groups should be done systematically as a grid system, where the management area is divided into manageable sized grids dependant on the number of people working. Each grid area should be completely covered for the target plant, before moving into an adjoining area.

The optimum timing for pest plant control is usually spring and autumn, when the plants are most active. However this can vary by species and by weather conditions (e.g. wet summer, warm winter). It is recommended that the main control be carried out from spring to early autumn, with follow up spraying of pasture in the planting areas in late autumn – early winter (refer to section 7 – planting methodology). In Northland blackberry should only be foliar sprayed in summer and autumn.

Foliar spraying should be undertaken on calm dry days (or if windy in a sheltered site).

The risk of spray drift damage to surrounding desirable species can be reduced by using an 'air induction' type nozzle (creates larger droplets) on the spray gear, and when practicable using a spray shield. Generally, work on windy days should be restricted to physical control (e.g. cutting back vines in preparation for spraying, hand-pulling, or cutting and treating cut stumps).

To identify areas that have been sprayed, a commercial marker dye should be added to the spray units as per the label instructions.

Particular care must be taken around areas of desirable indigenous habitat/vegetation. If the pest plant is located amongst desirable plants, all effort should be made to reduce the risk of non-target plants.

There will be regrowth/residual seed germination of the majority of pest species across the site the next few months following the control operation. If the timing is right, follow up control should be done approximately three months later. However, if the three months fall into the winter period, then the follow up should be postponed until late next spring.

Ongoing pest plant surveillance

After the follow up control operation, regular monitoring and surveillance of control success, future pest plant invasion and the spread and impacts of non-targeted exotic vegetation identified in the ecological surveys (appendix 2) should be undertaken annually (late spring). This should involve a quick systematic walk across the sites by a person or persons able to identify pest plants. This can be done using the grid system, or across the entire site at one time (will be dependant on the level of pest plant spread/occurrence).

During this walkover any pest plants identified should be recorded and their location marked with flagging tape for future control.

Particular vigilance should be given to the possible invasion of sweet grass (*Glyceria maxima*). This highly invasive and smothering pest species is common in the drains and shallow water close by, but not currently present at this site.

The identified pest plants should then be controlled as soon as possible, to reduce spread (e.g. seeding).

Table A: Targeted pest plants and control methods

Group 1	
Chinese privet Barberry Hawthorn	<p>Small plants/seedlings: hand pull, or foliar spray with metsulfuron-methyl (5g/10 litre), with penetrant.</p> <p>Larger trees: chainsaw close to the ground, and immediately spray the stump with 500ml/litre (50%) of sodium glyphosate administered in a small spray bottle.</p>
Group 2	
Japanese honeysuckle Blackberry	<p>For small infestations; cut and scrape stem close to ground, treat stump immediately with 500ml/litre (50%) of sodium glyphosate administered in a small spray bottle.</p> <p>Larger infestations: spray with metsulfuron-methyl (5g/10L), or triclopyr or picloram (label rates), with penetrant (1ml/litre). Take particular care to avoid overspray or drift. The vines should be pulled off the surrounding desirable vegetation before spraying (if necessary cut the vines back to reduce the potential spray contact with the surrounding desirable vegetation).</p>
Group 3	
Gorse	<p>Small seedlings: hand pull when possible, or spray with sodium glyphosate (10ml/litre), with penetrant (1ml/litre).</p> <p>Larger plants: cut close to the ground, and immediately spray the stump with 500ml/litre (50%) of sodium glyphosate administered in a small spray bottle, or spread on picloram gel (e.g. Vigilant). Or foliar spray with triclopyr or picloram (label rates), with penetrant (1ml/litre). Take particular care to avoid overspray or drift.</p>
Group 4	
tradescantia	<p>Spray with triclopyr (6ml/litre), with penetrant (1ml/litre).</p> <p>Take particular care to avoid overspray or drift.</p>
Group 5	
Selaginella	<p>Spray with triclopyr (6ml/litre), with penetrant (1ml/litre). Spray with a mix of sodium glyphosate (100ml/10 litre) plus metsulfuron-methyl (2g/10 litre), with penetrant.</p> <p>Take particular care to avoid overspray or drift.</p>

Potential pest plants

Based on the species identified at the site and in the surrounding landscape, the following species may become an issue in the future, and should be watched for during surveillance.

Table B: Potential pest plants and control methods

Black wattle (<i>Acacia</i>) & brush wattle (<i>Paraserianthes</i>)	<p>Seedlings: hand-pull.</p> <p>Saplings and larger trees: cut and immediately spray the stump with 500ml/litre (50%) of sodium glyphosate administered in a small spray bottle.</p>
Mercer grass	<p>Where spray can be applied with low risk to surrounding desirable vegetation, spray or wipe with sodium glyphosate (10ml/litre), with penetrant.</p> <p>In sensitive areas use haloxyfop (10ml/litre) with crop oil.</p>
Pampas grass	<p>Where spray can be applied with low risk to surrounding desirable vegetation, spray with strong mix of sodium glyphosate (20ml/litre), with penetrant (1ml/litre).</p> <p>In sensitive areas use haloxyfop (10ml/litre) with crop oil.</p>
Soft rush	<p>Already present, but may become a hindrance to regeneration in the excavated ephemeral wetlands.</p> <p>Where spray can be applied with low risk to surrounding desirable vegetation, spray with sodium glyphosate (10ml/litre), with penetrant.</p> <p>For large plants or large infestations, plants can be cut back close to the ground and the regrowth treated with sodium glyphosate (10ml/litre) and penetrant.</p> <p>Another option for plants amongst desirable vegetation is to apply spray with a spray shield which can cover the target plant, and reduce contact with the surrounding plants.</p>
Sweet grass	<p>Where spray can be applied with low risk to surrounding desirable vegetation, spray or wipe with sodium glyphosate (10ml/litre), with penetrant.</p> <p>In sensitive areas use haloxyfop (7.5ml/litre), with crop oil.</p>
Woolly nightshade	<p>Seedlings: hand-pull (hold close to the ground to get roots as well), or foliar spray with triclopyr (6ml/litre) and penetrant.</p> <p>Larger plants: cut close to ground, treat stump immediately with strong triclopyr (10ml/litre) and penetrant, or picloram gel.</p>

Appendix 6 – Monitoring methods

The following is a summary of the methods to be used for monitoring.

Monitoring summary table (adapted from original by P. Gerbeaux – Department of Conservation)

Objective	Management actions	Desired outcome	Outcome measure	Outcome monitoring (method)	Outcome reporting		Output Reporting	
					Data format	Monitoring freq.	Action description	Output measure
Restore natural hydrological functioning of oxbow lakes	Block drain below Oxbow 2 Allow debris & sediment build up in drains	Raised water table	Water level	Piezometer	Level above datum	Twice yearly (summer & winter)	Recording water level fluctuations	Chart from piezometer (annual trends)
Enhance habitat for indigenous fish species (particularly black mudfish)	Rehabilitate/excavate the ephemeral wetland areas historically present and cluster plant with indigenous sedge species & manuka. Undertake pest plant control	Ponds functioning as ephemeral habitats (increase of potential fish habitat)	Water level and area of indigenous sedgeland established	Piezometer, photopoints and pest plant surveillance	Water levels & area of habitat (m ² & % cover)	Baseline when developed. Then twice yearly (summer & winter)	Recording water level fluctuations & area of sedgeland established	Chart from piezometer & area cover
	Pest fish control (through increased shading)	Increased black mudfish populations through reduced gambusia numbers	Total mudfish individuals	Gee-minnow trapping	Number of fish	Yearly (August)	Increased black mudfish populations	Number of black mudfish caught
	Habitat creation along connecting drain	Increased black mudfish	Shading cover	Area of shading	% shade along the length of the drain	Baseline then every second year	Increased black mudfish populations	Number of black mudfish increasing
	Assess natural regeneration along oxbow edges. Additional planting if necessary	Increased indigenous fish populations	Shading cover	Area of shading	% shade along the length of both oxbows	Visual assessment in year 3	Increased indigenous fish populations	Number of fish catches increasing
Restore threatened plant populations in the two oxbows (swamp koromiko and heart-leaved kohuhu)	Community (Ngati Hau) supplementary planting	Populations of swamp koromiko and heart-leaved kohuhu increased	Number of healthy individual plants	Plant counts and health status	Number of plants/health status (good, poor, dead)	Yearly	Increased number of threatened plants	Number of threatened plants increasing
	Pest plant control	Understorey and groundcover progressively returned to indigenous dominance	% indigenous cover & number of individual threatened plant species	Permanent vegetation quadrats & photopoints; pest plant surveillance (for potential additional control)	Plant list & % indigenous cover	Baseline then annually		

Restore/enhance other natural habitats (incl. natural ecotones, providing suitable habitat for a range of wildlife (e.g. lizards, Cran's bully, waterfowl & waders))	Revegetation planting	Indigenous sequences restored, from freshwater lakes and ephemeral wetlands, to riverine forest and shrubland habitat.	% native cover	Permanent vegetation quadrats & photopoints; pest plant surveillance	plant list + % native cover for each quadrat	Yearly	N/A	N/A
	Animal Pest Control	Increased bird numbers	Bird numbers and diversity	Five-minute bird counts			N/A	N/A
		Reptile populations	No. of lizards	Lizard trapping	Lizard list + number of individuals	Baseline then every second year	N/A	N/A
Provide potential for future Matauranga Maori focused restoration practice	Ongoing consultation/partnership with Ngati Hau	TBC with Ngati Hau					N/A	N/A

A6.1 Photopoints

To be done annually (December).

A total of seven photopoints were set up across the site on 15 December 2015. At two of these points, an additional photo was taken in a different direction to gain a wide range of views of the site. In total there are 9 photos across the site.

At each photopoint records were made of the:

- Location
- Date
- Time
- Weather conditions
- Camera type and settings
 - Zoom
 - Focus
 - Shutter speed
- Camera position
 - Compass bearing
 - Tripod height
- GPS Co-ordinates

The camera position was also marked with a waratah stake with an attached numbered orange plastic identification tag for ease of location in the future (in conjunction with the GPS marks).

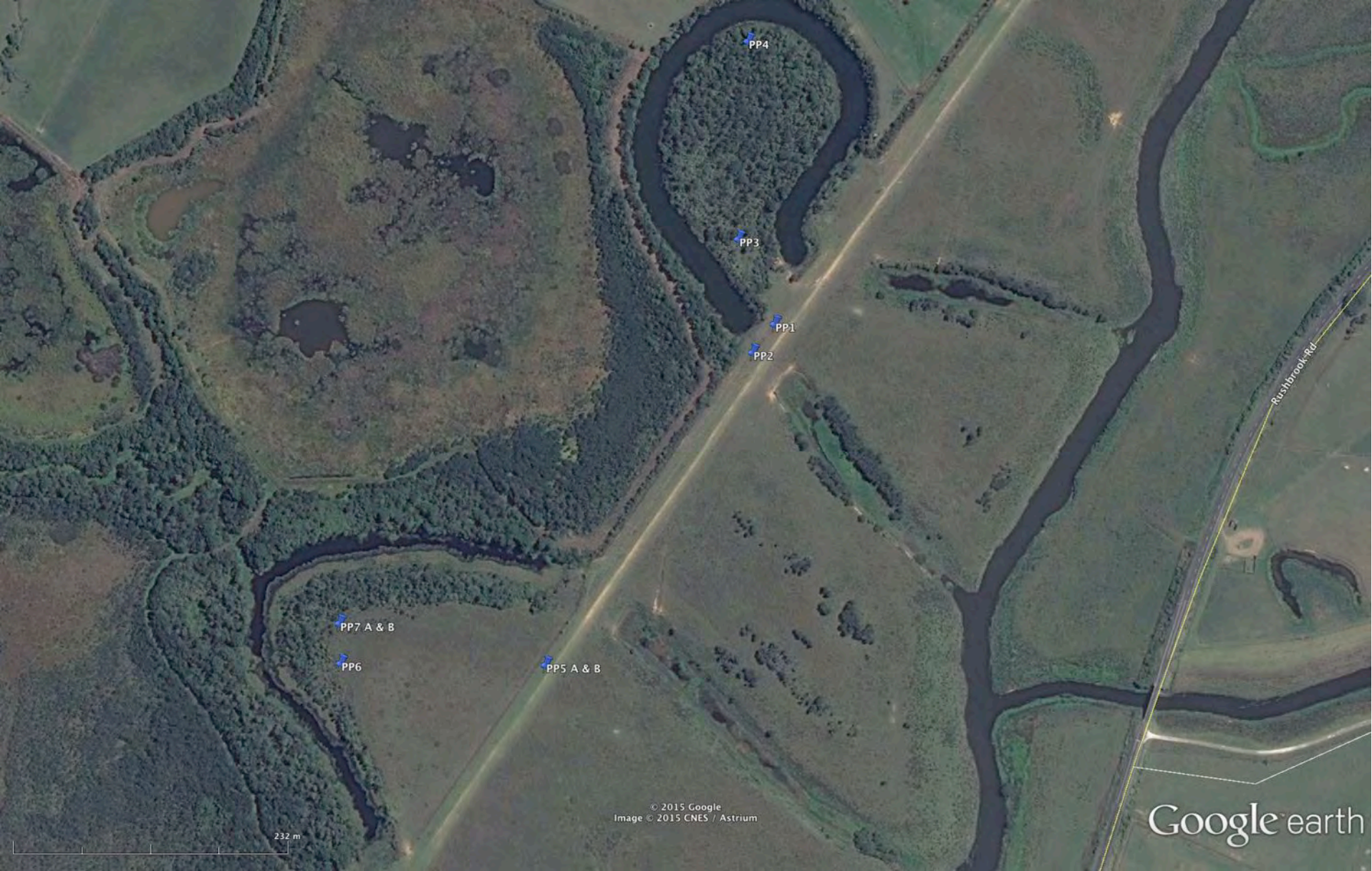
The purpose of photopoints is to provide a replicable photograph of a set area, which can be used over time to compare and monitor changes to that area (e.g. growth of plantings, level of natural habitat regeneration and reductions in pest plants).

The original photos were taken using a Canon EOS 7d MkII (crop frame) digital SLR camera with a 28mm-350mm zoom lens on a tripod.

These photopoints should be replicated annually as close as possible to the same date (15 December).

Copies of the photos are included at the end of this plan. The digital images have also been supplied to the Department of Conservation.

Position of photopoints



Location	Photopoint 1
Date	15 December 2015
Time	13.20
Weather conditions	Overcast – light westerly
Zoom	28mm
Focus	Infinity
Shutter speed	250/second
Camera position	
Compass bearing	3420 (magnetic)
Tripod height	1620mm
GPS Co-ordinates	E1711393 N6058151



PP1

Location	Photopoint 2
Date	15 December 2015
Time	13.30
Weather conditions	Overcast – light westerly
Zoom	28mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	2000 (magnetic)
Tripod height	1510mm
GPS Co-ordinates	E1711373 N6058127



PP2

Location	Photopoint 3
Date	15 December 2015
Time	12.15
Weather conditions	Overcast – light westerly
Zoom	35mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	1600 (magnetic)
Tripod height	1425mm
GPS Co-ordinates	E1711367 N6058229



PP3

Location	Photopoint 4
Date	15 December 2015
Time	12.15
Weather conditions	Overcast – light westerly
Zoom	35mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	2000 (magnetic)
Tripod height	1425mm
GPS Co-ordinates	E1711367 N6058229



PP4

Location	Photopoint 5A
Date	15 December 2015
Time	13.55
Weather conditions	Overcast – light westerly
Zoom	28mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	2860 (magnetic)
Tripod height	1610mm
GPS Co-ordinates	E1711183 N6057861



PP5A

Location	Photopoint 5B
Date	15 December 2015
Time	13.57
Weather conditions	Overcast – light westerly
Zoom	35mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	2200 (magnetic)
Tripod height	1610mm
GPS Co-ordinates	E1711183 N6057861



PP5B

Location	Photopoint 6
Date	15 December 2015
Time	14.07
Weather conditions	Overcast – light westerly
Zoom	28mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	1980 (magnetic)
Tripod height	1407mm
GPS Co-ordinates	E1711010 N6057871



PP6

Location	Photopoint 7A
Date	15 December 2015
Time	14.18
Weather conditions	Overcast – light westerly
Zoom	28mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	880 (magnetic)
Tripod height	1570mm
GPS Co-ordinates	E1711010 N6057906



PP7A

Location	Photopoint 7B
Date	15 December 2015
Time	14.20
Weather conditions	Overcast – light westerly
Zoom	28mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	2700 (magnetic)
Tripod height	1570mm
GPS Co-ordinates	E1711010 N6057906



PP7B

A6.2 Vegetation quadrats

To be repeated every second year (December 2018, 2020 etc.).

A total of six 10 x 10 metre quadrats were set up across the site on 25 February 2016 by Katrina Hansen (Northland Regional Council) and David Wright (Ecology North).

Four are located within areas of existing shrubland (two in Oxbow 1 & two in Oxbow 2).

Two are located in what is currently open pasture within the revegetation planting zones. Of these, the Quadrat 5 location is likely to be part of the ephemeral wetland excavation in Oxbow 2. It is therefore possible that this site may need to be moved to fit in with the excavation and wetland rehabilitation works. This quadrat is intended to provide an indicative baseline of the current pre-revegetation cover within the pasture habitat.

The quadrats are marked with wooden survey posts. Additionally, the northeastern corner of each quadrat has been recorded by GPS.

Once measured out, a string line was run to each corner to mark the extent of the quadrat. Only plants rooted within the quadrat were included in the survey.

Vegetation within the quadrats was divided into four height tiers;

- Groundcover – all vegetation lower than 500mm in height,
- Understory – all vegetation between 0.5 – 4 metres in height,
- Canopy – all vegetation above 4 metres forming an obvious canopy,
- Emergent – all individual trees greater than 4 metres in height above the predominant canopy.

Due to the diversity of the groundcover, this tier was measured by giving each species an individual score, where;

- 1 = <10% cover
- 2 = 10-30% cover
- 3 = 31-50% cover
- 4 = 51-70% cover
- 5 = 71-90% cover
- 6 = >90% cover

The understory, canopy and emergent tiers were given a percentage cover ranking (i.e. the percentage cover of each species across the horizontal plane within each tier). This was done by the two recorders undertaking a visual estimate of cover within each tier.

While this method has the potential for biases through variation in the estimates of cover by different individuals, it should be sufficiently accurate to measure general changes to vegetative structure over time.

At each quadrat records were made of the:

- Location
- Date
- Wind direction
- Wind speed (based on the Beaufort Scale)
- Cloud cover (measured in a percentage out of eight)
- GPS recording of the northeastern corner of the quadrat (NZTM)

Location of vegetation quadrats



Quadrat 1

Located within the existing forest/shrubland in Oxbow 1.

Survey date 25 February 2016
 Wind direction SE
 Speed (Beaufort Scale) 1
 Cloud cover 1/8
 GPS (NE cnr) E1711428
 N6058393

Groundcover	Score
mixed pasture	4
<i>Blechnum parrisiae</i>	1
<i>Coprosma rigida</i>	1
<i>Cyperus eragrostis</i>	1
<i>Jacobaea vulgaris</i>	1
<i>Juncus effusus</i>	1
<i>Kunzea robusta</i>	1
<i>Ligustrum sinense</i>	2
<i>Muelhenbeckia australis</i>	1
<i>Myrsine divaricata</i>	2
<i>Oplismenus hirtellus</i>	2
<i>Rubus squarrosa</i>	1
<i>Sophora microphylla</i>	1
<i>Tradescantia flumenensis</i>	3
Sub-canopy (0.5 - 4 m)	% cover
Nil	Nil
Canopy (>4 m)	
Open	15
<i>Hedycarya arborea</i>	10
<i>Podocarpus totara</i>	40
<i>Kunzea robusta</i>	20
<i>Myrsine divaricata</i>	5
<i>Muelhenbeckia australis</i>	10
Emergent (>4 m above canopy)	
Open	50
<i>Kunzea robusta</i>	40
<i>Podocarpus totara</i>	10

Key to groundcover score

- 1 <10%
- 2 10-30%
- 3 31-50%
- 4 51-70%
- 5 71-90%
- 6 >90%

Quadrat 2

Located within the existing forest/shrubland in Oxbow 1.

Survey date 25 February 2016
 Wind direction SE
 Speed (Beaufort Scale) 1
 Cloud cover 1/8
 GPS (NE cnr) E1711383
 N6058226

Groundcover	Score
mixed pasture	5
<i>Blechnum parrisiae</i>	1
<i>Centella uniflora</i>	1
<i>Coprosma rigida</i>	1
<i>Dacrycarpus dacrydioides</i>	1
<i>Jacobaea vulgaris</i>	1
<i>Juncus effusus</i>	1
<i>Juncus tenuis</i>	1
<i>Kunzea robusta</i>	1
<i>Ligustrum sinense</i>	2
<i>Myrsine divaricata</i>	1
<i>Oplismenus hirtellus</i>	1
<i>Persicaria strigosa</i>	1
<i>Ranunculus</i> sp.	1
<i>Rubus fruticosus</i>	1
<i>Ulex europeaus</i>	1
Sub-canopy (0.5 - 4 m)	% cover
Open	35
<i>Myrsine divaricata</i>	30
<i>Ligustrum sinense</i>	5
<i>Muelhenbeckia australis</i>	5
<i>Dacrycarpus dacrydioides</i>	5
<i>Ulex europeaus</i>	15
Un-identified rush	5
Canopy (>4 m)	
Nil	Nil
Emergent (>4 m above canopy)	
Open	90
<i>Sophora microphylla</i>	10

Key to groundcover score

1 <10%
 2 10-30%
 3 31-50%
 4 51-70%
 5 71-90%
 6 >90%

Quadrat 3

Located within existing open pasture in Oxbow 1.

Survey date 25 February 2016
Wind direction SE
Speed (Beaufort Scale) 1
Cloud cover 5/8
GPS (NE cnr) E1711407
 N6058169

Groundcover	Score
mixed pasture	4
<i>Juncus bufonius</i>	1
<i>Juncus edgariae</i>	1
<i>Juncus effusus</i>	1
<i>Paspalum dilatatum</i>	2
<i>Pennisetum clandestinum</i>	3
<i>Ranunculus</i> sp.	1
<i>Ulex europeus</i>	1

Key to groundcover score

1 <10%
2 10-30%
3 31-50%
4 51-70%
5 71-90%
6 >90%

Quadrat 4

Located within the existing forest/shrubland in Oxbow 2.

Survey date 25 February 2016
 Wind direction SE
 Speed (Beaufort Scale) 1
 Cloud cover 4/8
 GPS (NE cnr) E1711123
 N6057939

Groundcover	Score
mixed pasture	5
<i>Blechnum parrisiae</i>	1
<i>Carex</i> sp.	1
<i>Coprosma propinqua</i>	1
<i>Coprosma rhamnoides</i>	1
<i>Coprosma rigida</i>	1
<i>Crataegus monogyna</i>	1
<i>Jacobaea vulgaris</i>	1
<i>Juncus bufonius</i>	1
<i>Juncus effusus</i>	1
<i>Kunzea robusta</i>	1
<i>Ligustrum sinense</i>	3
<i>Muelhenbeckia australis</i>	1
<i>Myrsine divaricata</i>	3
<i>Podocarpus totara</i>	1
<i>Rubus fruiticosus</i>	1
Sub-canopy (0.5 - 4 m) % cover	
Open	80
<i>Myrsine divaricata</i>	5
<i>Ligustrum sinense</i>	5
<i>Parsonsia heterophylla</i>	5
<i>Podocarpus totara</i>	5
Canopy (>4 m)	
Open	10
<i>Ligustrum sinense</i>	20
<i>Myrsine divaricata</i>	25
<i>Podocarpus totara</i>	35
Emergent (>4 m above canopy)	
Open	85
<i>Kunzea robusta</i>	15

Key to groundcover score

- 1 <10%
- 2 10-30%
- 3 31-50%
- 4 51-70%
- 5 71-90%
- 6 >90%

Quadrat 5

Located in existing open pasture in Oxbow 2 – a generic site to be repositioned following wetland excavation.

Survey date 25 February 2016
Wind direction SE
Speed (Beaufort Scale) 1
Cloud cover 4/8
GPS (NE cnr) E1711104
 N6057895

Groundcover	Score
mixed pasture	4
<i>Juncus effusus</i>	2
<i>Oenanthe pimpinelloides</i>	4
<i>Paspalum dilatatum</i>	2
<i>Ranunculus</i> sp.	1
<i>Rubus fruticosus</i>	1
<i>Ulex europeus</i>	1

Key to groundcover score

1	<10%
2	10-30%
3	31-50%
4	51-70%
5	71-90%
6	>90%

Quadrat 6

Located within the existing forest/shrubland in Oxbow 2.

Survey date 25 February 2016
 Wind direction SE
 Speed (Beaufort Scale) 1
 Cloud cover 4/8
 GPS (NE cnr) E1710994
 N6057876

Groundcover	Score
Open ground	1
mixed pasture	3
<i>Blechnum parrisiae</i>	1
<i>Carex</i> sp.	1
<i>Coprosma propinqua</i>	1
<i>Cyperus eragrostis</i>	1
<i>Kunzea robusta</i>	1
<i>Ligustrum sinense</i>	3
<i>Myrsine divaricata</i>	2
<i>Oplismenus hirtellus</i>	1
<i>Ranunculus</i> sp.	1
<i>Rubus fruiticosus</i>	1
Sub-canopy (0.5 - 4 m)	
	% cover
Open	20
<i>Myrsine divaricata</i>	20
<i>Ligustrum sinense</i>	15
<i>Kunzea robusta</i>	5
<i>Podocarpus totara</i>	25
<i>Muelhenbeckia australis</i>	5
<i>Coprosma rhamnoides</i>	5
<i>Melicytus micranthus</i>	5
Canopy (>4 m)	
Open	75
<i>Podocarpus totara</i>	25
Emergent (>4 m above canopy)	
Open	95
<i>Kunzea robusta</i>	5

Key to groundcover score

1 <10%
 2 10-30%
 3 31-50%
 4 51-70%
 5 71-90%
 6 >90%

A6.3 Freshwater fish surveys

To be repeated in winter every second year (August 2017, 2019 etc.).

A total of seventy trapping positions were set at approximately twenty metre intervals along the edge of two oxbow lakes and connecting drain in August 2015 by Mike McGlynn (Ecology North), Katrina Hansen (Northland Regional Council) and David Wright (Ecology North).

Each trap position was numbered according to the location (refer to aerial photo on page 60), with NO 1-30 on the northern oxbow, SO 1-30 on the southern oxbow and DR 1-10 along the connecting drain.

The traps were positioned close to the oxbow edge. Care was taken to ensure that a small amount of the top of the trap was left protruding from the water to allow captured fish access to air (as the oxbows tend to have low levels of dissolved oxygen). The traps were tied to emergent and bankside vegetation so as to avoid movement and sinking of the traps. In most cases the water depth was sufficient to allow the placement of the trap, however some sites required digging to increase water depth.

At both of the oxbows a total of twenty 3mm Gee Minnow and ten Kilwell Bait traps were set for one night, baited with a teaspoon of vegemite in a small camera film canister with a single 3-4mm hole in the end to allow the vegemite to slowly run out.

Along the drain, ten Gee Minnow traps were set.

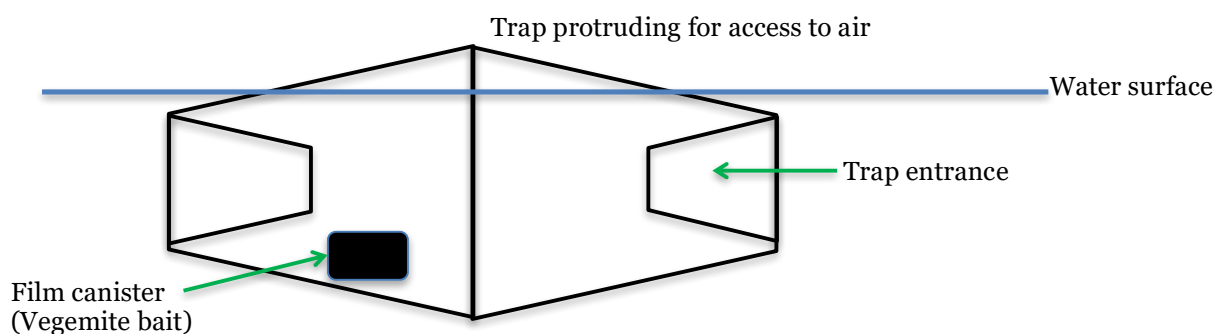
Due limitations in the number of traps available, each site was fished on consecutive dry (rainless) nights. Night 1 – Oxbow 1, night 2 – Oxbow 2, night 3 – the connecting drain.

Traps were laid out in the afternoon, then checked and emptied early the following morning.

All fish and invertebrate species caught in the traps were recorded. Any indigenous fish were measured (length) and released as soon as possible in the same place as capture.

The introduced pest fish species *Gambusia* was recorded as being present or absent. In most cases, the numbers of *Gambusia* caught were too high to make counting individuals practical.

Example of trap setting



Position of fish traps



Results of fish survey

Site	Species	Size	Comment/additional obs.
Northern Oxbow			
N1	Gambusia		
N2	Gambusia; Cran's bully	51mm	
N3	Gambusia		
N4	Gambusia		water beetle
N5	Gambusia		dragonfly nymphs
N6	Gambusia		
N7	Gambusia; Cran's bully	62mm	
N8	Gambusia		
N9	Gambusia; Cran's bully	66mm	
N10	Gambusia		potential mudfish sighting
N11	Gambusia		
N12	Gambusia		
N13	Gambusia		
N14	Gambusia		water beetle
N15	Gambusia; Cran's bully	41mm	
N16	Gambusia		
N17	Gambusia		
N18	Gambusia		
N19	Gambusia; Cran's bully	63mm	dragonfly nymph
	Cran's bully	42mm	
N20	Gambusia		
N21	Gambusia; Cran's bully	86mm	N21 site has dense overhanging vegetation (e.g. manuka). This may have an influence on the high number of bully's caught at this site (shading of the water).
	Cran's bully	76mm	
	Cran's bully	45mm	
	Cran's bully	64mm	
	Cran's bully	70mm	
	Cran's bully	65mm	
	Cran's bully	70mm	
	Cran's bully	42mm	
	Cran's bully	44mm	
	Cran's bully	43mm	
N22	Gambusia		
N23	Gambusia		
N24	Gambusia; Cran's bully	44mm	
N25	Gambusia		
N26	Gambusia; Cran's bully	69mm 38mm 41mm 44mm	gravid
N27	Gambusia; Cran's bully	71mm	
N28	Gambusia		
N29	Nil		
N30	Gambusia		

<i>Southern Oxbow</i>			
S1	Gambusia		water beetle
S2	Gambusia		water beetle
S3	Gambusia		
S4	shortfin eel	500mm	
S5	Gambusia		
S6	Gambusia		
S7	Gambusia		
S8	Gambusia		
S9	Gambusia		water beetle, dragonfly nymph
S10	Gambusia		water beetle
S11	Gambusia		
S12	Gambusia		water beetle
S13	Gambusia		
S14	shortfin eel	600mm	
S15	Gambusia		
S16	Gambusia		water beetle
S17	Gambusia		water beetle
S18	Gambusia		water beetle, dragonfly nymph
S19	Gambusia		water beetle
S20	Gambusia		water beetle
S21	Gambusia		
S22	Gambusia		water beetle
S23	Gambusia		water beetle
S24	Gambusia		water beetle
S25	Gambusia		water beetle
S26	Gambusia		water beetle
S27	Gambusia		water beetle
S28	Gambusia		water beetle
S29	Gambusia		water beetle
S30	Gambusia		water beetle
<i>Connecting Drain</i>			
DR1	Gambusia		water beetle
DR2	Gambusia		water beetle
DR3	Gambusia		water beetle
DR4	Gambusia		water beetle
DR5	Gambusia		water beetle
DR6	Gambusia		water beetle
DR7	Gambusia; mudfish	122mm	water beetle
DR8	Gambusia		water beetle
DR9	Gambusia		water beetle
DR10	Gambusia		water beetle

A6.4 Bird monitoring

A baseline of bird observations was carried out during the initial ecological surveys of the site in October and December 2015 (Appendix 3 – page 26). This will provide the baseline of species present at the site.

In early summer of year 2 (2017) a series of five-minute bird count stations should be put in place, to be repeated at two yearly intervals (2019 etc.).

The methodology should follow the DOC protocol available at <http://www.doc.govt.nz/our-work/five-minute-bird-counts/>

A minimum of five count points are recommended, two in each of the oxbow areas and one along the connecting drain revegetation area. Each site should be located to cover a range of habitat areas, such as lake edge, existing shrubland, revegetation planting and pasture edges.

Recommended locations of five-minute bird count points



A6.5 Lizard trapping

To be repeated in winter every second year (summer 2017, 2019 etc.).

In November 2015 a series of Gee Minnow traps were set by Mike McGlynn (Ecology North), Katrina Hansen (Northland Regional Council) and David Wright (Ecology North) to survey for lizards.

This was done in the forest area of Oxbow 1, where five Gee Minnow were placed on the ground for terrestrial species, and five were tied into trees for arboreal species.

The traps were baited with canned peaches, by placing a slice of peach inside each trap, and left in place for one night.

Traps were laid out in the late afternoon, then checked early the following morning.

No lizards were caught in any of the traps.

It is recommended that this methodology be repeated, but expanded to cover all areas of existing forest/shrubland, and revegetation planting.

A6.6 Water depth monitoring

It is proposed a piezometer be used to monitor the potential changes to groundwater depth following the blocking of the drain below Oxbow 2, and to the water levels in the excavated ephemeral wetland areas in Oxbow 2.

A piezometer is a device that measures liquid pressure in relation to gravity, and can be used to measure changes to both underground and aboveground water height. Thus providing information on the success of management aimed at reinstating historical groundwater levels lost through drainage, and hydrological levels of the ephemeral wetland excavation areas.

It is recommended that a simple piezometer be installed in a low lying section of land in Oxbow 1 prior to the blocking of the downstream drain, and another in the ephemeral wetland area in Oxbow 2 following excavation works.

Appendix 7 - Wairua Oxbow restoration time line

Task	Year 1 2016				Year 2 2017				Year 3 2018				Year 4 2019				Year 5 2020			
	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr
Pest plant control																				
Initial pest plant control	■																			
On-going pest plant control				■		■		■		■		■		■		■		■		Ⓟ
Planting																				
Planting site preparation	■	■			■	■			■	■										
Shrubland planting			Aug				Aug													
Ephemeral wetland planting									April											
Oxbow edge planting *														Aug						
Planting maintenance				■		■		■		■		■		■		*		*		*
Plant replacement (previous year planting) *							Aug				Aug			April						
Planting <i>Pit. Obcordatum</i> in Oxbow 1										Aug										
Excavation of ephemeral wetlands					■															
Fence check & maintenance					■				■				■				■			Ⓟ
Monitoring																				
Baseline	■																			
Permanent vegetation quadrats									■				■				■			Ⓟ
Photopoints					■				■				■				■			Ⓟ
Five minute bird counts					■				■				■				■			Ⓟ
Lizard surveys									■				■				■			Ⓟ
Fish surveys							Aug							Aug						Ⓟ
Pest plant surveillance (walk over site)				■			■				■			■		■				Ⓟ
Annual monitoring summary					■				■				■				■			Ⓟ

* these tasks will be dependant on monitoring results (e.g. assessing natural regeneration around the oxbow edges, plant loss from planting areas etc.)

➔ indicates task may need to continue (based on monitoring/surveillance results and budget considerations)

Appendix 8 - Work plan budget approximations

Year 1 (2016) – planting one hectare of shrubland

Action	Details	Timing	Approx. cost
Initial pest plant control	Underway.	Summer	\$6,000
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring	\$800
Animal pest control	Contribution to DOC animal pest control.		\$200
Baseline monitoring	Set up baseline - part of restoration plan contract.	Spring & Summer	\$0
Planting site preparation	One hectare sprayed for year 1 planting.	March	\$500
Plant purchase	10,000 manuka to be purchased August (post duck shooting season).	August	\$12,000
Planting project management	30 hours for planting supervision and project mngt.	Ongoing	\$2,100
Planting labour	100 person hours x \$35.00.	August	\$3,500
Plant transport/incidentals			\$1,000
Planting maintenance	Spray releasing (dependant on surveillance results)	Spring & Autumn	\$1,200
		Total	\$27,300

Year 2 (2017) – planting 1.25 hectares of shrubland and excavating wetland sites

Action	Details	Timing	Approx. cost
Monitoring	Repeat photopoints and fish surveys. Carry out five minute bird counts. Write result summary.	Summer	\$1,000
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring & Autumn	\$1,600
Animal pest control	Contribution to DOC.	Ongoing	\$200
Fence check/maintenance	To be done by Northland Fish and Game and/or WDC.	Summer	\$0
Ephemeral wetland excavation	1 bulldozer & 1 excavator for 3 days (includes blocking drain below Oxbow 2).	Summer	\$6,600
Planting site preparation	Spraying of planting area prior to planting.	Jan/Feb	\$500
Planting project management	40 hours for planting supervision and project mngt.	Ongoing	\$2,800
Planting labour	120 person hours x \$35.	August	\$4,200
Plant transport/incidentals			\$1,000
Plant purchase	12,000 mixed plants for shrubland revegetation	August	\$14,400
Plant replacement	Replace lost plants from previous year (dependant on monitoring results).	August	\$1,000
Planting maintenance	Spray releasing (dependant on surveillance results).	Spring & Autumn	\$1,200
		Total	\$34,500

Year 3 (2018) – planting of ephemeral wetland

Action	Details	Timing	Approx. cost
Monitoring	Repeat quadrats, photopoints and lizard survey. Write result summary.	Winter & Summer	\$1,350
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring & Autumn	\$800
Animal pest control	Contribution to DoC (possum & rats).	Ongoing	\$200
Fence check/maintenance	To be done by Northland Fish and Game and/or WDC.	Summer	\$200
Planting site preparation	Spraying of excavated wetlands for planting.	January & March	\$700
Planting project management	40 hours for planting supervision and project mngt.	Ongoing	\$2,800
Planting labour	110 person hours x \$35	May & August	\$3,850
Plant transport/incidentals			\$1,000
Plant purchase	10,000 sedges for ephemeral wetland. 1,000 manuka 200-300 <i>Pittosporum obcordatum</i> for Oxbow 1.	April April August	\$12,000 \$1,200 \$1,500
Seed collection for wetland	Collecting and broadcasting sedge seeds into wetlands.	Summer - Winter	\$500
Plant replacement	Replace lost plants from previous year (dependant on monitoring results).	August	\$1,000
Planting maintenance	Spray releasing (dependant on surveillance results).	Spring & Autumn	\$1,200
		Total	\$28,300

Year 4 (2019) – site maintenance (potential planting of oxbow edges)

Action	Details	Timing	Approx. cost
Photopoint monitoring	Repeat photopoints and five minute bird counts. Write result summary.	Summer	\$600
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring & Autumn	\$800
Animal pest control	Contribution to DOC.	Ongoing	\$200
Fence check/maintenance	To be done by Northland Fish and Game and/or WDC.	Summer	\$0
Project management	Overseeing maintenance, deciding on necessity of additional planting etc.	Ongoing	\$1,400
Plant replacement	Replace lost plants from previous year wetland planting (dependant on monitoring results).	April	\$1,000
Planting maintenance	Spray releasing (dependant on surveillance results).	Spring & Autumn	\$1,200
		Total	\$5,200

Year 5 (2020) – site maintenance

Action	Details	Timing	Approx. cost
Monitoring	Repeat quadrats, photopoints, fish and lizard survey. Write result summary.	Winter & Summer	\$1,750
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring & Autumn	\$800
Animal pest control	Contribution to DOC.	Ongoing	\$200
Fence check/maintenance	To be done by Northland Fish and Game and/or WDC.	Summer	\$0
Project management	Overseeing maintenance etc.	Ongoing	\$1,000
Planting maintenance	Spray releasing (dependant on surveillance results).	Spring & Autumn	\$1,200
		Total	\$4,950

Appendix 9 – Task checklist

Year 1 (2016)

Task	Description	Timing	Completed (tick when complete)
Undertake baseline monitoring	Photopoints, vegetation quadrats, fish surveys, lizard survey, bird list	Spring and summer 2015/16	✓
Pest plant control in existing forest/shrubland	Control of pest plants, particularly: Chinese privet, tradescantia, Japanese honeysuckle, blackberry, gorse, selaginella, barberry, hawthorn	Summer and autumn 2015/16	
Plant site preparation for year 1 planting	Spray one hectare of pasture	Autumn 2016 (April)	
	Respray prior to planting	Winter 2016 (August)	
Manuka planting	Plant one hectare site in Oxbow 1 and along the connecting drain	Winter 2016 (August)	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Spring 2016	
Additional pest plant control	Dependant on outcomes of surveillance	Spring 2016	

Year 2 (2017)

Task	Description	Timing	Completed
Monitoring	Retake photopoints, set up initial five-minute bird count points	Summer 2017 (January)	
Ephemeral wetland excavation	Dig out sites for year 3 wetland planting	Summer 2017	
Check fences	Check and maintain stock fences	Summer 2017	
Plant site preparation for year 2 planting	Spray 1.25 hectare of pasture	Autumn 2017 (April)	
	Respray prior to planting	Winter 2017 (August)	
Additional pest plant control	Dependant on outcomes of surveillance	Autumn 2017	
Maintenance of year 1 planting	Pest plant control, plant replacement as necessary	Autumn & winter 2017	
Fish monitoring	Fish trapping as monitoring	Winter 2017 (August)	
Monitoring summary	Write summary of photopoint, bird and fish monitoring results, along with any surveillance results	Winter 2017	
Manuka planting	Plant 1.25 hectare site in Oxbow 2	Winter 2017 (August)	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Spring 2017	
Pest plant control	Control of pest plants in existing forest and planting areas, dependant on surveillance results	Spring 2017	

Year 3 (2018)

Task	Description	Timing	Completed
Monitoring	Redo vegetation quadrats, photopoints and lizard surveys	Summer 2018	
Monitoring summary	Write summary of photopoint and lizard surveys along with any surveillance results	Summer 2017	
Check fences	Check and maintain stock fences	Summer 2018	
Plant site preparation for year 3 planting	Spray one hectare of ephemeral wetlands	Summer 2018	
	Respray prior to planting	Autumn 2018 (April)	
Additional pest plant control	Dependant on outcomes of surveillance	Autumn 2018	
Wetland planting	Cluster plant through areas of ephemeral wetland rehabilitation	Autumn 2018 (April)	
Carry out replacement planting in year 2 area	If necessary, replace plants in year 2 shrubland planting	Winter 2018 (August)	
Plant <i>Pittosporum obcordatum</i>	If plants are ready/available – plant <i>P. obcordatum</i> in Oxbow 1		
Pest plant surveillance	Walk over site identifying the need for pest plant control	Spring 2018	
Pest plant control	Control of pest plants in existing forest and planting areas, dependant on surveillance results	Spring 2018	

Year 4 (2019)

Task	Description	Timing	Completed
Monitoring	Redo photopoints and bird counts	Summer 2019	
Check fences	Check and maintain stock fences	Summer 2019	
Additional pest plant control	Dependant on outcomes of surveillance	Autumn 2019	
Carry out replacement planting in year 3 area	If necessary, replace plants in year 3 wetland planting	Winter 2019 (August)	
Fish monitoring	Fish trapping as monitoring	Winter 2019 (August)	
Monitoring summary	Write summary of photopoint, bird and fish monitoring results, along with any surveillance results	Winter 2019	
Oxbow edge planting	If deemed necessary by the ecologists, carry out additional edge planting of the oxbow lakes	Winter 2019 (August)	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Spring 2019	
Pest plant control	Control of pest plants in existing forest and planting areas, dependant on surveillance results	Spring 2019	

Year 5 (2020)

Task	Description	Timing	Completed
Monitoring	Redo vegetation quadrats, photopoints and lizard surveys	Summer 2020	
Monitoring summary	Write summary of photopoint and lizard surveys along with any surveillance results	Summer 2020	
Check fences	Check and maintain stock fences	Summer 2020	
Additional pest plant control	Dependant on outcomes of surveillance	Autumn 2020	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Spring 2019	
Pest plant control	Control of pest plants in existing forest and planting areas, dependant on surveillance results	Spring 2019	



Ecological Restoration Plan: Tanekaha Oxbow, Hikurangi



**David Wright
January 2017**

Prepared for Whangarei District Council

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1. Background

In 2016, Ecology North was contracted by the Whangarei District Council (WDC) to prepare a restoration plan for the WDC administered 'Tanekaha Oxbow', located on Jordan Valley Road in Hikurangi (diagram 1).

Environmental restoration is a required condition of the resource consent held by WDC to operate the Hikurangi Flood Management Scheme (CON20031137501). As part of the consent, a Riparian and Ox-Bow Management Plan (ROMP) has been required to be prepared and followed. However, in the original draft of the ROMP, only locations within the berm land (flood channel) were identified. This potentially conflicts with the Scheme original design by developing vegetative barriers which could potentially restrict the flow through the Scheme area. For this reason, areas outside of the bermland owned by WDC have been assessed for environmental restoration opportunities. This site has been identified by WDC staff as being one of the preferred location for environmental restoration within the Hikurangi Flood Management Scheme.

2. Description of site

The management/restoration area totals approximately 1.25 hectares, comprising a large area of open land on the inner (convex) bank of an oxbow lake and a long narrow section of land running along both sides of a drainage channel leading into the oxbow (diagram 2).

The site forms part of the Hikurangi floodplain.

Within this plan, the areas have been divided into two main sections: the large land area surrounded by the oxbow (oxbow) and the long narrow drainage channel (Tanekaha Drain) edges (drain) (diagram 2).

The oxbow area comprises approximately one hectare. Historically, a large section of the oxbow's interior had clay excavated to be used to construct the adjacent stopbanks, leaving a deep circular (damp) depression in the middle of the site, with little remaining top soil.

The topography of the oxbow ranges from steep (along the oxbow edge), sloping to flat.

The drain planting area is long and narrow, totalling approximately 2,600m². The eastern side of the channel (approximately 2,000m²) covers the steep drain bank and a section of flats, while the narrower western side (approximately 600m²) only covers the steep drain bank up to an existing farm fence.

The main water feed into the oxbow is along the Tanekaha Drain. Water exits the oxbow through a WDC owned pump station, with water pumped under the adjacent stopbank into a connecting channel to the east, leading directly into the Wairua River.

Some recently surveyed drainage channels close to this site contain low numbers of black mudfish (*Neochanna diversus*) (At Risk-Relict). It is hoped that given good management of this and close by sites (e.g. the creation of shading through appropriate planting), that this area may be able to support a sustainable mudfish population.

The management area is mainly surrounded/adjoined by agricultural pastureland, managed as part of the Hikurangi Swamp Scheme. An area of wetland to the east (Borrow

Cut Wetland) is managed by Northland Fish and Game for water birds, and has had significant planting done as part of the management.

The vegetation cover over the site is mainly open, with mixed pasture species, including large areas of kikuyu grass (*Pennisetum clandestinum*). Some indigenous trees, particularly totara (*Podocarpus totara*) are growing around the outer edge of the oxbow.

A total of 11 indigenous tree and shrub species were recorded from a survey of the site in December 2016, which included one Nationally Threatened and two regionally significant species (table 1).

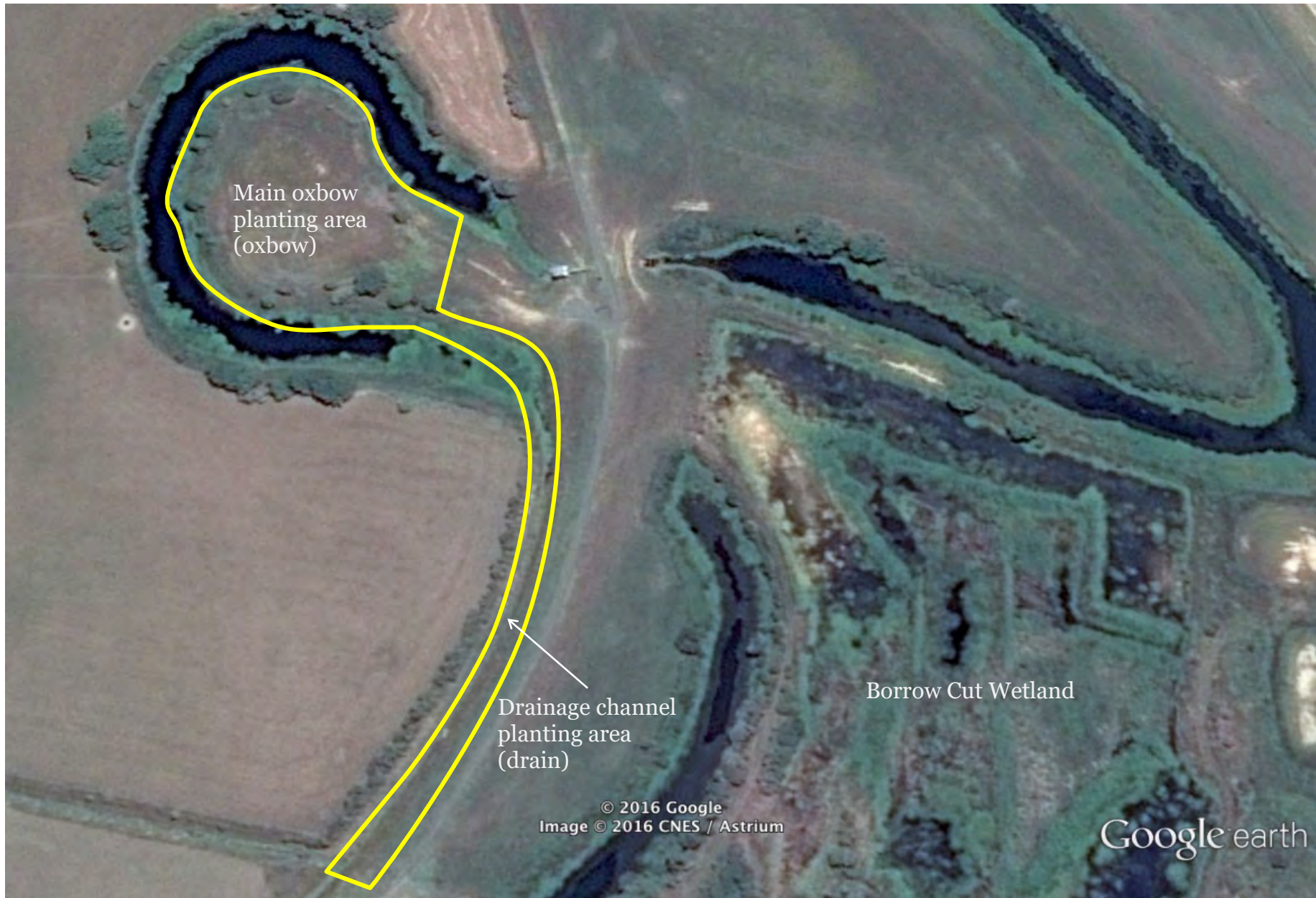


Diagram 2: Approximate outline of restoration area

<i>Coprosma propinqua</i> var. <i>propinqua</i>	mingimingi	Regionally uncommon
<i>Coprosma rhamnoides</i>	small-leaved coprosma	
<i>Dacrycarpus dacrydioides</i>	kahikatea	Regionally uncommon
<i>Hedycarya arborea</i>	porokaiwhiri/pigeonwood	
<i>Kunzea robusta</i>	kānuka	
<i>Leptospermum scoparium</i>	mānuka	
<i>Myrsine divaricata</i>	weeping mapou	Regionally uncommon
<i>Nestegis lanceolata</i>	white maire	
<i>Pittosporum obcordatum</i>	heart-leaved kohuhu	Nationally Vulnerable
<i>Podocarpus totara</i>	totara	
<i>Sophora microphylla</i>	kowhai	

Table 1: Indigenous vegetation from site

<i>Ligustrum sinense</i>	Chinese privet
<i>Pennisetum clandestinum</i>	kikuyu grass
<i>Persicaria hydropiper</i>	water pepper
<i>Phytolacca octandra</i>	inkweed
<i>Rubus fruticosus</i>	Blackberry
<i>Ulex europeaus</i>	Gorse

Table 2: Exotic vegetation from site

3. Aim of this restoration plan

The aim of this plan is to provide a recommended approach for the ecological revegetation of the site.

This plan is intended to be adaptive, based on monitoring and surveillance results. For example, it is envisioned that following the establishment of a planted pioneer/nursery cover, the process of natural succession will lead to an increase in plant diversity and a compositional change in the vegetation community (i.e. early succession shrubland such as mānuka (*Leptospermum scoparium*), through to later successional forest species such as kahikatea (*Dacrycarpus dacrydioides*)). However, given the relatively isolated nature of the site with potentially limited seed spread, it is likely that this natural process may require assistance, such as additional planting of late successional species following the formation of a forest canopy across the site.

4 Current threats

The main identified threats, addressed as part of this restoration plan include:

- The presence and continued invasion of pest plant species.
- Cattle access.

5. Restoration opportunities

This site has significant value as an ecological restoration project, particularly due to the:

1. Classification as a Level 2 Threatened Land Environment (10-20% indigenous cover left).
2. Close proximity on a landscape level to existing areas of high ecological significance, such as the Wairua Reserve and Oxbows (ecological steppingstone/connectivity, seed source for natural succession and plant spread, source for potential wildlife and plant re-colonisation etc...).
3. Close proximity to other ecological restoration sites on the Hikurangi Floodplain (e.g. Wairua Oxbows, Jordan Valley Road Shrubland and Borrow Cut Wetland etc.).
4. Presence of a Nationally Vulnerable tree species - heart-leaved kohukohu (*Pittosporum obcordatum*) and two regionally uncommon species – weeping mapou (*Myrsine divaricata*) and mingimingi (*Coprosma propinqua* var. *propinqua*).
5. Potential to reintroduce threatened plant species, particularly Hikurangi Swamp koromiko (*Veronica* aff. *bishopiana*), present in nearby sites.
6. Potential to increase the habitat suitability for black mudfish and other indigenous fish and aquatic species through increased water shading (improved habitat value).

6. Restoration requirements

The focus of restoration will include the following actions:

1. Pest plant control. The initial control will target the removal of all exotic vegetation from the site.
2. Reintroduction of top soil to the excavated area.
3. Revegetation planting of the entire site.
4. Introduction of late successional tree species in year 3 (2019).
5. Upgrading of the stock fences where appropriate.

7. Pest plant control

The initial focus of restoration effort will require the removal of the exotic/pest plant species identified in table 2.

This will be done manually by back pack sprayer, quad bike spray boom and cutting and treating the stumps of larger trees and shrubs when condition suit (e.g. low wind and rain).

The pest plants will be controlled as groups, based on the type of methods required.

Any additional pest plant species that appear at the site between the initial survey and control time will be assessed and controlled using methods deemed appropriate by the project manager.

Method 1	
Chinese privet	Small plants/seedlings: can be hand pulled, or foliar sprayed with metsulfuron-methyl (5g/10 litre) with penetrant.
Gorse	Larger privet and gorse will be cut and the stump treated with picloram based herbicide gel such as Vigilant or Triumph.
Blackberry	
	Large patches of blackberry may need to be cut back and treated with foliar spray or picloram gel, depending on the value of the vegetation growing amongst the blackberry.
Method 2	
Kikuyu grass	Where spray can be applied with low risk to surrounding desirable vegetation, sodium glyphosate (10ml/litre) with penetrant will be used.
Inkweed	Any kikuyu in sensitive areas will be sprayed with haloxyfop (10ml/litre) with crop oil (grass selective herbicide).
	Inkweed growing amongst desirable vegetation will be cut and the stump treated with a picloram gel or metsulfuron herbicide (1g/litre).

Table 4: pest plant control methods

The initial pest plant control will be carried out in late summer 2017, and repeated prior to planting in late autumn/early winter 2017.

Ongoing regular post-planting surveillance and follow up control will be carried out at least twice yearly in spring and autumn for a period of no less than five years.

Contractors carrying out spray work must hold the appropriate legal qualifications for herbicide use issued by WorkSafe New Zealand (i.e. Growsafe for application and Approved Handlers Certificate to purchase and transport some herbicides. All operators must also wear the appropriate personal protection equipment suited for the job.

8. Importing a layer of topsoil into the main oxbow planting area

An area of raised land between the revegetation area and the Borrow Cut was identified to supply the small amount of top soil required to cover the excavated section of the oxbow. This was done in spring 2016.

9. Revegetation planting

The estimated size of the two planting areas are listed in table 3 (using the measurement tool in Google Earth Pro).

Planting Area	Size (approx.)	Plants required
Oxbow	10,000 m ²	10,000
Drain	2,600 m ²	3,000 (2,600 trees, 400 sedges)
Total	12,600m²	13,000

Table 5: Estimated planting areas and plants required to establish an indigenous canopy cover

9.1 Initial oxbow planting

The main aim of the oxbow area is to create a fast-growing canopy of appropriate indigenous species suited to the site. This will be predominantly mānuka (table 6).

Approx. size	Approximately 1.0 hectares.		
Timing	Planting to be done in winter 2017 (1 June – 31 August).		
Spacing	Blanket plant at one-metre centres.		
Species list	Species <i>Coprosma propinqua</i> (mingimingi) <i>Coprosma robusta</i> (karamu) <i>Cordyline australis</i> (ti kouka/cabbage tree) <i>Kunzea robusta</i> (kānuka) <i>Leptospermum scoparium</i> (mānuka) <i>Melicytus ramiflorus</i> (mahoe) <i>Phormium tenax</i> (harakeke/flax) <i>Veronica</i> aff. <i>bishopiana</i> (Hikurangi Swamp hebe)	Size reveg. reveg. reveg. reveg. reveg. reveg. reveg. pb 3 Total	Number 150 1,000 500 1,000 5,800 500 1,000 50 10,000
Monitoring	Annual photopoints. Twice annual pest plant surveillance checks.		

Table 6: Outline of initial oxbow planting

9.2 Drain planting

The main aim of the drain planting is to create a fast-growing cover of appropriate indigenous species to shade the drainage channel (water weed suppression and creation of fish habitat). This will be predominantly mānuka, with sedges on the drain edges (table 7).

Approx. Size	2,600 m ² .		
Timing	Initial planting already done in winter 2016 (2,000 plants on eastern side). Remainder of planting (1,000) to be done in winter 2017.		
Spacing	Sedges to be planted at 500mm centres depending on habitat suitability. Larger plants to be spaced at approximately one metre centres, taking into consideration the existing vegetation.		
Species list	Dry banks and flats <i>Kunzea robusta</i> (kānuka) <i>Leptospermum scoparium</i> (mānuka) <i>Melicytus ramiflorus</i> (mahoe) <i>Phormium tenax</i> (harakeke/flax)	Size reveg. reveg. reveg. reveg. Total	Number 500 1,600 200 300 2,600
	Drain edges - sedges <i>Carex maorica</i> <i>Carex virgata</i> (purei) <i>Cyperus ustulatus</i> (giant umbrella sedge)	Size reveg. reveg. reveg. Total	Number 100 100 200 400
Monitoring	Annual photopoints. Twice annual pest plant surveillance checks.		

Table 7: Outline of initial drain planting

9.3 Year three tree planting

This is planned for year three (2019). However, this will depend on the suitability of the canopy closure following the initial planting. If, in the opinion of the project manager, the canopy has not achieved a suitable cover (e.g. 75% cover), the tree planting may not be done until the following year (2020).

Approx. size	1.25 hectares		
Timing	Planting to be done in winter 2019 (1 June – 31 August).		
Spacing	No closer than five metres apart amongst established canopy.		
Species list	Species	Size	Number
	<i>Dacrycarpus dacrydioides</i> (kahikatea)	pb 3	250
	<i>Nestegis lanceolata</i> (white maire)	pb 3	100
	<i>Pittosporum obcordatum</i> (heart-leaved kohuhu)	pb 3	150
	<i>Prumnopitys taxifolia</i> (matai)	pb 3	100
		Total	600

Table 8: Outline of third year planting

9.4 Planting methodology

Where possible, all revegetation plants will be ecosourced from the Hikurangi floodplain. If this is unachievable, then plants will be at least from within the same gene pool as plants on the floodplain (i.e., from plants whose progeny have a reasonable chance of naturally occurring on the floodplain through the processes that disperse their seeds (e.g. upstream, upslope, upwind, bird dispersal etc.))

All plants being introduced to the site will be checked prior to arrival to be free of Argentine ants (*Linepithema humile*) and rainbow skink (*Lampropholis delicata*) eggs.

The majority of the initial planting will use revegetation grade sized plants, such as 5.5cm & 7cm tubes etc.

Planting is to be done in winter, when the soil moisture levels are generally highest (June - August).

Revegetation grade plants can be planted using the forestry cut method. Using a commercial grade planting spade, a cut is made in the ground, and spread apart by levering the spade back and forth wide enough to easily (without force) bury the plant to the top of the potting mix. The cut soil around the plant is then carefully closed and firmed with the foot.

The larger (pb) grade plants will need to be placed in a hole approximately 1.5 times wider than the root ball, with the soil returned around the roots firmed with the ball of the foot.

Approximately one tablespoon of good quality eighteen to twenty-four month slow-release fertiliser mixed with approximately one teaspoon of silica gel (e.g. Crystal Rain) will be placed in the bottom of the plant hole, and mixed in with the loose soil.

All plants are to be well watered prior to planting.

During the ongoing surveillance (below), an assessment of plant losses will be made, and if deemed necessary by the project manager, replacement planting will be done the following winter.

10 Upgrading of stock proof fences.

The fence along the eastern boundary has recently been replaced, and is in good stock-proof condition.

Extra fencing to stock-proof the northern and southern ends of the site is programmed for summer 2016.

11. Monitoring

Four monitoring methods are proposed for this site.

1. Photopoints.
2. Annual systematic pest plant surveillance walks.

11.1 Photopoints

To be done annually.

A total of four photopoints will be set up across the site – at the:

1. Southern end of the drain – looking north.
2. Northern end of drain – looking south.
3. Eastern side of the main oxbow planting area – looking west.
4. Western side of the main oxbow planting area – looking east.

At each photopoint records will be made of the:

- Location
- Date
- Time
- Weather conditions
- Camera type and settings
 - Zoom
 - Focus
 - Shutter speed
- Camera position
 - Compass bearing
 - Tripod height
- GPS Co-ordinates

The camera position will be marked by gps and a waratah stake with an attached numbered plastic identification tag for ease of location in the future.

The purpose of photopoints is to provide a replicable photograph of a set area, which can be used over time to compare and monitor changes to that area (e.g. growth of plantings, level of natural habitat regeneration and reductions in pest plants).

These photopoints should be replicated annually as close as possible to the same date.

11.2 Ongoing pest plant surveillance

After the follow up pest plant control operation, regular monitoring and surveillance of control success, potential spread of new species and loss of indigenous (planted) plants is to be undertaken twice annually (late spring and autumn). This will involve a quick systematic walk across the sites by a person or persons able to identify pest plants.

During this walkover, any identified pest plants requiring control are to be recorded and if appropriate/practical, their location marked with flagging tape for future management.

The identified pest plants are to be controlled as soon as possible, to reduce spread (e.g. seeding).

Appendix 1 – Tanekaha oxbow restoration time line

Task	Year 1 2017				Year 2 2018				Year 3 2019				Year 4 2020				Year 5 2021			
	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr
Pest plant control																				
Initial pest plant control																				
On-going pest plant control														*		*		*		→
Planting																				
Initial oxbow and drain planting																				
Late successional tree planting											*									
Plant replacement							*				*			*						
Upgrade fences																				
Monitoring																				
Photopoints																				→
Pest plant surveillance (walk over site)																				→

* these tasks will be dependant on monitoring results (e.g. plant loss from planting areas, level of canopy cover for late successional tree planting etc.)

→ indicates task may need to continue (based on monitoring/surveillance results and budget considerations)

Appendix 2 - Work plan budget approximations

Year 1 (2017) – Site preparation and initial planting

Action	Details	Timing	Approx. cost
Initial pest plant control	Spraying/control of entire site	Summer	\$2,000
Planting labour	125 person hours x \$40	June – August	\$5,000
Plant transport & incidentals			\$600
Plant purchase	11,000 mixed plants (excluding 2,000 planted 2015)	June - August	\$13,390
Fertiliser & silica gel			\$2,200
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring & autumn	\$1,200
Monitoring & surveillance	Photopoints, surveillance walkovers & general site visits	Ongoing	\$750
Project management	50 hours for general project management & planting organisation & supervision.	Ongoing	\$3,750
		Total	\$28,890

Year 2 (2018) – Planting maintenance

Action	Details	Timing	Approx. cost
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$1,200
Monitoring	Repeat photopoints and monitoring/surveillance walkovers.	Ongoing	\$750
Plant replacement	Dependant on survival/monitoring results (need for replacement?)	Winter	\$600
General project management	Site meetings etc.	Ongoing	\$750
		Total	\$3,300

Year 3 (2019) – site maintenance & adding late successional trees

Action	Details	Timing	Approx. cost
Plant purchase	Purchase of 600 pb3 trees	June - August	\$3,000
Planting labour	16 person hours x \$35	June – August	\$1,900
Fertiliser & silica gel			\$200
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$1,000
Replacement plant purchase	Dependant on survival/monitoring results (need for replacement?)	April - August	\$600
Monitoring	Repeat photopoints and monitoring/surveillance walkovers.	Ongoing	\$750
General project management	Site meetings etc.	Ongoing	\$750
		Total	\$8,200

Year 4 (2020) – site maintenance and monitoring

Action	Details	Timing	Approx. cost
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$1,000
Monitoring	Repeat photopoints and monitoring/surveillance walkovers.	Ongoing	\$750
Plant replacement	Dependant on survival/monitoring results (need for replacement?)	Winter	\$600
General project management	Site meetings etc.	Ongoing	\$750
		Total	\$3,100

Year 5 (2021) – site maintenance and monitoring

Action	Details	Timing	Approx. cost
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$500
Monitoring	Repeat photopoints and monitoring/surveillance walkovers.	Ongoing	\$750
General project management	Site meetings etc.	Ongoing	\$500
		Total	\$1,750

Appendix 3 – Summary of estimated costs and plant numbers

Plant numbers

Previously planted (2016)	Plants required
Eastern side of drainage channel	2,000
Total	2,000

Year 1 (2017)	Plants required
Main oxbow planting area	10,000
Western side of drainage channel	600
Sedges along drain edge	400
Total	11,000

Year 3 (2019)	Plants required
Main oxbow late succession trees	600
Total	600

Overall total plants	13,600
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Estimated costs

Year 1	Year 2	Year 3	Year 4	Year 5	Total
\$28,890	\$3,300	\$8,200	\$3,100	\$1,750	\$45,240



Ecological Restoration Plan: Jordan Valley Shrubland



David Wright
October 2016

Prepared for Living Water

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1. Background

In 2016, Ecology North was contracted by the Department of Conservation (DOC) and Whangarei District Council (WDC) to prepare a restoration plan for the WDC administered 'Jordan Valley Shrubland', located alongside Jordan Valley Road in Hikurangi (diagram 1).

This restoration project is collaboration between Living Water and WDC.

Living Water is a joint programme between DOC and Fonterra which seeks to work with local communities, dairy farmers, iwi/hapu and other stakeholders to improve sensitive water catchments. Living Water is being implemented over five sites across New Zealand. The Kaipara Harbour-Hikurangi catchment is one of these sites.

WDC administer the land in which the remnants are located. The land is a mix of road reserve and parks reserve (diagram 3), with an electricity and telecommunication line easement running through some of the site.

The Jordan Valley Remnants are located in the rohe of Ngati Hau hapu. Ngati Hau are the traditional kaitiaki of this section of the Hikurangi floodplain and close by Wairua River.

The consultants brief for the Living Water restoration plans include:

Describe the current state of the terrestrial and freshwater biodiversity, including species lists and ecological descriptions of what is currently there.

Assess the values and identify threats.

Identify, describe and prioritise what restoration is required, including (but not exclusive to):

- Pest plant management considerations.
- Animal pest control considerations.
- Revegetation and hydrological considerations etc.
- A ranking of which actions should be undertaken in order of priority.
- Draft a maintenance pest plant control program.
- Include opportunities to support and enhance any potential threatened species.
- Include baseline and ongoing monitoring.

2. Description of site

The management/restoration areas total approximately 2.5 hectares, comprising two narrow shrubland and small wetland remnants running along both sides of Jordan Valley Road (diagram 2).

The sites form part of the Hikurangi floodplain.

Historically, the Hikurangi floodplain is estimated to have covered around 12,000 hectares (Clarkson *et al.* 2015). However, this number may be lower depending on the classification

of what actually constitutes wetland habitat. The types of habitats listed within the floodplain include marsh, fen, swamp, peat bog, intermediate wetland, riverine flood forest and gumland. At the present, only 3.5 - 4% of this wetland habitat remains (Conning 2001, Clarkson *et al.* 2015).

It is likely that prior to historic clearance and drainage, the vegetation cover at the Jordan Valley site would have been a mix of riverine floodplain forest and possible ephemeral wetland/sedgeland, which would have received seasonal flooding from the near by Wairua River and associated floodplain system.

The main soils for the sites are classified as Quaternary alluvial and swamp deposits in Hikurangi Swamp (Manning 2001).

The remnant is classified as a Category 1 threatened land environment, with <10% indigenous cover remaining (Cieraad *et al.* 2015, Clarkson *et al.* 2015).

The topography of the site is predominantly flat with a series of drainage channels and small wetland areas (mainly historically excavated) with some small raised banks.

The main drainage channel in the southern remnant runs parallel and close (c. 2 metres away) to the road edge, with a couple of drains running off at right angles in a southern direction. This drain is mainly open due to continued vegetation management as part of the road maintenance, and is thus exposed to direct sunlight, and is quite weedy.

The main drain in the northern remnant runs along the pasture edge (c. 1 metre from the fence line), and is relatively shaded by tall vegetation, and thus has sections of fairly open water. The drains are connected by at least two culverts running under Jordan Valley Road near the eastern and western end of the remnants.

The main vegetation cover for the overall site is mixed exotic and indigenous shrubland with an average canopy height ranging from c. 2- 5 metres. The dominant canopy species is Chinese privet (*Ligustrum sinense*). The understory and groundcover tiers are mainly weedy (predominantly privet), with some indigenous regeneration.

Some small areas of open wetland are present, mainly covered with mixed low sedge, exotic climbers and herbaceous vegetation. It appears that the majority of these are excavated sites, likely part of the present and historic drainage system.

The remnants are surrounded/adjoined by agricultural pastureland, managed as part of the Hikurangi Swamp Scheme.

The main historic pressures that are likely to have contributed to the change of the sites to their current state include:

- General habitat loss from clearance.
- Ongoing road works and road edge maintenance.
- Ongoing management of vegetation along the power line corridor.
- Hydrological changes (e.g. drainage channels, declines to regular seasonal flooding etc.).
- Stock pressure (e.g. periodic grazing, trampling, spreading of pest plants, eutrophication of water ways etc.).

- Pest plant invasion.
- Increased nutrient levels into soils, waterbodies and wetlands from fertilisers and stock.
- Effects of animal pests (e.g. rabbits, possums, gambusia etc.).

A recent report on the restoration values of sites across the Hikurangi floodplain includes the Jordan Valley site (Clarkson *et al.* 2015). The report identifies the site as being ecologically significant for the presence of black mudfish (*Neochanna diversus*) (At Risk - Declining), a number of regionally uncommon plant species* (table 1), and the potential presence of *Juncus holoschoenus* var. *holoschoenus* (Threatened - Nationally Critical), identified during the PNAP survey of the site (Manning 2001) (however this species has not been seen during subsequent surveys). The report recommends the site for future restoration, listing the management priority as privet control, along with the surveillance of other troublesome pest plants and the upgrade of current boundary fences to exclude stock access to the sites.

3. Aim of this restoration plan

The aim of this plan to provide a recommended approach for the ecological restoration and management of the remnants, recognising that there are limitations to the restoration potential, associated with the ongoing management of the road corridor and electricity/telecommunication lines running through the site.

These limitations include tree exclusion areas on the safety 'vehicle runoff zones' (no trees >100mm stem diameter or dense vegetation such as flax) and a total planting prohibition within 1.5 - 2 metres of the road edge for WDC verge maintenance (diagram 4).

The restoration plan for the remaining areas will attempt to best replicate the likely historic vegetation cover present (riverine forest and ephemeral wetland), creating the best possible (given the narrow nature of the site) healthy functioning ecosystem, able to support a range of species, including threatened flora and fauna, and to support ecological processes such as natural succession and carbon sequestration.

The zones with tree planting restrictions will be designed to best complement the restored forest habitat, utilising low growing 'bendy' vegetation (e.g. the creation of wetlands and planting of low growing shrubs).

This plan is intended to be adaptive, based on monitoring and surveillance results. For example, it is envisioned that following the establishment of a planted pioneer/nursery cover, the process of natural succession will lead to an increase in plant diversity and a compositional change in the vegetation community (i.e. early successional shrubland such as manuka (*Leptospermum scoparium*), through to later successional forest species such as kowhai (*Sophora microphylla*) and kahikatea (*Dacrycarpus dacrydioides*)). However, given the relatively isolated nature of the site with potentially limited seed spread, based on the results of monitoring (e.g. photopoints and permanent vegetation quadrat plots) and walkover surveillance (e.g. pest plant surveillance), this natural process may require assistance, such as additional planting of later successional species. These types of future/ongoing decisions should be made collaboratively between stakeholders and specialists based on monitoring outcomes.

* A subsequent site survey also identified two nationally significant plant species (Table 1)



Diagram 1: Location of the Jordan Valley Shrubland site (yellow circle)



Diagram 2: Restoration area



Diagram 3: Approximate location of parks reserve (blue shading) – the remaining green shaded areas indicate the approximate areas of road reserve



Diagram 4: Location of planting limitation zones; the red areas are tree exclusion ‘vehicle runoff’ zones (no trees to be planted >100mm diameter), and the orange indicate a 1.5 – 2 metre planting exclusion set back for road maintenance (no planning whatsoever) (source WDC)

4. Current biodiversity values and threats

The site forms part of a DOC Protected Natural Area Programme (PNAP) level one site – the 10-hectare ‘Jordan Valley Shrubland’ (Qo6/155) (Manning 2001).

In May 2016 a slow walk vegetation, bird and general habitat survey of the remnants was undertaken by Lisa Forester and Katrina Hansen (NRC), Ben Herbert and Andrew Townsend (DOC), and David Wright (Ecology North).

In October 2016, a fish survey was carried out by David Wright along the drains on both sides of Jordan Valley Road. This was done by setting a total of 10 Gee Minnow (3mm) traps through the site for one night. The traps were baited with fresh Vegemite to attract fish to the traps.

The results of these surveys are as follows:

4.1 Vegetation cover

The shrubland vegetation cover is heavily dominated by Chinese privet, with common ti kouka/cabbage tree (*Cordyline australis*) (canopy and emergent), occasional *Coprosma* species and emergent totara (*Podocarpus totara*). The dense canopy, ranges in height from approximately 2 – 5 metres. Some emergent totara reach approximately 10 metres in height, with emergent ti kouka up to c. 8 metres.

The shrubland understory and groundcover tiers are dense and weedy. The dominant species is Chinese privet, with common regenerating *Coprosma* species (particularly in the southern remnant). Some large patches of tradescantia (*Tradescantia flumenensis*) are also spread through the site.

The drier sections of the sites not covered by shrubland - mainly the managed road edges, include Chinese privet, ti kouka, Japanese honeysuckle (*Lonicera japonica*), blackberry (*Rubus fruticosus* agg.), occasional manuka and flax (*Phormium tenax*) along with a mixture of pasture species.

The damper areas – including the drainage channels and sections of wetland habitat, have a mixed cover typified by *Persicaria*, Japanese honeysuckle, areas of dense sedges (*Carex Virgata*, *C. maorica* and *Cyperus ustulatus*), sweet grass/glyceria (*Glyceria maxima*), parrots feather (*Myriophyllum aquaticum*) and stands of *Baumea articulata*.

A total of 49 indigenous and 56 exotic plant species were recorded from the remnants during the two recent vegetation surveys (appendix 1 & 2).

4.2 Birds

A total of 19 bird species were recorded from the site (appendix 3). Of these, 7 were indigenous and 12 exotic.

All species observed are relatively common shrubland, grassland and open habitat species.

4.3 Reptiles

During the May 2016 survey, a number of skinks were observed moving among rocks and gravel on the road edge. One was caught and identified as the invasive introduced plague skink (*Lampropholis delicata*) (rainbow skink).

I am waiting for the temperatures to increase, to do a more detailed lizard survey and will include the results in the plan/report.

4.4 Fish

The fish survey in October 2016 caught only one species, the invasive introduced plague minnow/gambusia (*Gambusia affinis*). Of the ten traps set, three caught gambusia, two in the northern remnant and one in the southern remnant (appendix 3). All gambusia sites were relatively open water, with low levels of shading, as would be expected, as gambusia prefer open and warmer water.

Black mudfish are known from this site (Clarkson *et al.* 2015), with five fish caught as recently as 2014/15 (Pivac n.d.). It should then be assumed that black mudfish are still present in the waterways running through the remnants.

Black mudfish have also been recorded from several sites close by, within the connecting drainage, stream, river and wetland systems (Price & Dean 2014, Pivac n.d., pers. obs.).

4.5 Invertebrates

A total of 15 invertebrate species were observed from the site (appendix 3) during the surveys and site visits. Of these, eleven are terrestrial/arboreal and four fully aquatic or aquatic in the larval stage.

Although the invertebrate survey is based on anecdotal observations, this level of observed diversity should be considered low.

4.6 Mammals

A cat (*Felis catus*) was observed crossing the road at the western end of the remnant during a site visit.

It is likely that the usual suite of mammalian pest species will be present, such as possums (*Trichosurus vulpecula*), rabbits (*Oryctolagus cuniculus*), rats (*Rattus* spp.) and mustelids (*Mustela* spp.).

Clarkson *et al.* (2015) identified cattle access into the remnants as a threat to their long-term health, through insecure fences and possible periodic grazing of the 'long acre' by local farmers.

4.9 Threats

The main identified threats, addressed as part of this restoration plan include:

- Control of pest plants, particularly the Chinese privet.
- The potential control of rabbits to protect revegetation planting areas.
- Gambusia management through additional planting and provision of in stream debris.
- Cattle access.

5. Restoration opportunities

This site has significant value as an ecological restoration project, particularly due to:

1. Being classified as a Category 1 Threatened Land Environment (Cieraad *et al.* 2015).
2. Its close proximity on a landscape level to existing areas of high ecological significance, such as the Wairua Reserve (ecological steppingstone/connectivity, seed source for natural succession and plant spread, source for potential wildlife and plant re-colonisation etc...).
3. Close proximity to other ecological restoration sites on the Hikurangi Floodplain (e.g. Wairua Oxbows and Reserve, Tanekaha Oxbow and Borrow Cut Wetland etc.).
4. The potential to reintroduce threatened plant species (e.g. Hikurangi Swamp koromiko (*Veronica* aff. *bishopiana*), heart-leaved kohukohu (*Pittosporum obcordatum*) and possibly *Juncus holoschoenus*).
5. The potential to increase the habitat suitability for black mudfish and other indigenous fish and aquatic species through increased water shading (reduced gambusia pressure).
6. The potential to restore wetland habitat (aquatic nutrient filtration, creation of ecotone and increased habitat variability etc.).
7. The site's high level of visibility (visual example of good ecological restoration practice).

6. Restoration requirements

The main focus of restoration will include the following actions:

1. Pest plant control. The initial control will target the removal of the Chinese privet, then control of the remaining pest plant species deemed to pose threat (appendix 5).
2. Excavation of ephemeral wetland habitat, including sections of the no tree zones.
3. Revegetation planting of the entire site, within the management limitations imposed (no trees within the vehicle runoff zones and no planting at all in the 1.5 – 2 metre verge maintenance zones (diagram 4)).
4. Potential control of rabbits in and around planting areas. To be done if rabbits are deemed to pose a threat to the survival of young plants.
5. Reintroduction of the threatened plants *Veronica* aff. *bishopiana* (Hikurangi Swamp koromiko) and *Pittosporum obcordatum* (heart-leaved kohukohu), along with the creation of a functioning ecosystem mosaic, able to support the natural re-colonisation of a range of threatened and at risk species.
6. Assessment of the potential to reintroduce *Juncus holoschoenus* var. *holoschoenus*
7. Upgrading of the stock fence along the southern boundary.

6.1 Pest plant control

The initial focus of restoration effort will require the removal of the Chinese privet. Based on the site survey, the control can be done using two control methods depending on the type of vegetation growing amongst the privet (diagram 5).

1. Manual control: cutting large plants and treating the stumps with an appropriate herbicide. This is to be done in sections of the remnants with desirable vegetation regenerating amongst and under the privet.
2. Mechanical mulching: using a mechanised mulcher to run over the privet in areas where little desirable vegetation exists (mainly areas of very young privet cover), and rapidly following through to treat the stumps with an appropriate herbicide.

6.1.1 Manual removal of privet

In the areas deemed appropriate for manual privet control (diagram 5), plants will need to be cut by hand to avoid damage to desirable vegetation. This can be done using chainsaws and/or loppers and pruning saws.

As soon as possible/practical following the cutting of the privet, the freshly cut stump should be covered with a mix of 250ml of sodium glyphosate per litre of water.

Smaller privet seedlings should be foliar sprayed with care to reduce the risk of overspray on to surrounding desirable vegetation (e.g. using a spray shield).

All large cut stems and branches should be mulched, with the mulch spread back across the site (after the stumps and seedling have been sprayed).

It is important that the mulching and spreading is not done while the privet is in seed, as this will spread additional seed across the site.

6.1.2 Mechanical mulching

A large section of younger privet in the northern remnant (diagram 5) has little indigenous regeneration, and can therefore, be run over with a mechanical mulcher (e.g. tractor mounted).

At the southeastern end of this section, there are a number of large ti kouka, which will need to be cut around – avoiding damaging the trunks.

Areas of vegetation at the far western end of the northern remnant and a narrow strip close to the paddock/fence line (along the drainage channel) contain some significant desirable trees/plants, such as manuka, ti kouka and kanuka (*Kunzea robusta*). These areas will therefore, require manual privet control.

As soon as possible/practical following the mulching of the privet, the freshly cut stumps should be covered with a mix of 250ml of sodium glyphosate per litre of water. This can be done using a backpack sprayer blanket spraying the freshly cleared ground.

The timing of the control should be in late spring or early summer, prior to the setting of seed by the privet.

6.1.3 Remaining pest plant control

All of the remaining pest plants identified in appendix 5 should be controlled following the removal of the privet. Control methods are outlined in appendix 5.

The exception should be for Japanese honeysuckle. Where reachable, and where there is low risk of overspray onto desirable species, the honeysuckle should be foliar sprayed prior to being disturbed/cut during the privet control.

Control should follow the most suitable low impact methods available.

Following the initial control of all pest plants, the site is to be left for a period of approximately 18 months (two summers) before planting. This will allow a high proportion of the residual pest seeds to germinate, which can then be controlled prior to planting.

Following this, regular surveillance and ongoing control will be required to ensure that these (or any other) pest plants, particularly privet, are not able to re-establish.

6.2 Excavation of the ephemeral wetland systems

Two areas along the roadside in the southern remnant have been identified as suitable for the creation of ephemeral wetlands. These areas were chosen for their existing hydrology, and connectivity to existing wetland/sedgeland habitat (diagram 6). In addition, some sections are located within the vehicle runoff zones, and are suited to the planting of low growing wetland sedges/rushes etc.).

The creation of the ephemeral wetland will involve the digging of a series of dips and hollows along the existing drainage channel. This will have the advantage of creating additional habitat (ecotones), and will also help to filter nutrients and other contaminants running through the drainage channel.

All excavation work will be supervised by the restoration project manager, and any other person that may be required by DoC or WDC (e.g. roading staff).

As some of the excavation may also be under the electricity/telecommunication lines, work may need to be done under the requirements of Northpower (e.g. digger size etc.).



Diagram 5: Approximate outline of manual and mechanical privet control areas



Diagram 6: Ephemeral wetland excavation areas

6.3 Revegetation planting

The planting will be divided into three habitat types, and then by the roading management planting restrictions (vehicle runoff zones and the verge maintenance strip).

These planting restrictions are (diagram 4):

- Vehicle runoff zones: In these areas, no trees with a diameter greater than 100mm, or large dense plants such as flax are to be planted (to reduce the risk of car damage/occupant injury).
- Road verge maintenance strips. This is a 1.5 – 2 metre-planting setback running along the entire length of the site to allow road edge maintenance (slashing and spraying). No planting is to be done in these areas.

The three habitat planting types are:

- Dryland
- Wetland/sedgeland
- Damp drainage channels

Some sections of dryland planting fall within the vehicle runoff zones. In these areas, suitable small – low growing shrubs will be used.

The areas of created wetland in the vehicle runoff zones will be planted with a mixture of wetland sedge species.

The approximate estimated revegetation planting area is 2.3 hectares. This is based on the total management area (2.5 hectares) excluding the 1.5 – 2 metre planting exclusion.

The estimated size of each planting area is listed in table 1 (using the measurement tool in Google Earth Pro). The final extent of each area will need to be confirmed by ground truthing the site once the initial pest plant control and wetland excavation works have been completed.

Planting type	Area (approx.)	Estimate of plants required
Dryland without tree restrictions	18,500 m ²	18,500
Dryland with tree restrictions	2,500 m ²	2,500
Wetland	1,500 m ²	3,000 (2,000 sedges, 1,000 trees)
Damp drainage channels	500m ²	1,000
Total	23,000m²	25,000

Table 1: Estimated planting areas and plants required

I think that we should do the entire planting in one go. Otherwise we would need to stage the planting over two seasons, but this makes the ongoing weed control more complicated - either staging the initial control over two years, or carrying on with the control in the second year planting area for the additional time that it stays empty.

6.3.1 Dryland planting with no/few planting restrictions

Explanation	<p>This will cover the widest area (diagram 7). The dominance of manuka and kanuka will provide a fast growing cover to attain a relatively quick canopy closure, so reducing the ability for further pest plant spread/establishment, and to act as a nursery to facilitate the natural regeneration/succession process.</p> <p>Harakeke/flax is to be planted under the electrical/telecommunication lines running through the remnants.</p> <p>The main late successional floodplain forest species (e.g. kahikatea, totara etc.) are present at the site and surrounding landscape, so should spread into the dry planting area relatively quickly.</p>												
Approx. size	Approximately 1.85 hectares.												
Timing	<p>Planting to be done in winter 2018 (1 June – 31 August).</p> <p>This allows the site to be left for around 18 months to allow a high proportion of the residual pest plant seeds to germinate, which can then be controlled prior to planting.</p>												
Spacing	Blanket plant at one-metre centres.												
Species list	<table> <tr> <td><i>Cordyline australis</i> (ti kouka/cabbage tree)</td> <td>5%</td> </tr> <tr> <td><i>Kunzea robusta</i> (kanuka)</td> <td>20%</td> </tr> <tr> <td><i>Leptospermum scoparium</i> (manuka)</td> <td>50%</td> </tr> <tr> <td><i>Melicytus ramiflorus</i> (mahoe)</td> <td>10%</td> </tr> <tr> <td><i>Phormium tenax</i> (harakeke/flax)</td> <td>10%</td> </tr> <tr> <td><i>Sophora microphylla</i> (kowhai)</td> <td>5%</td> </tr> </table>	<i>Cordyline australis</i> (ti kouka/cabbage tree)	5%	<i>Kunzea robusta</i> (kanuka)	20%	<i>Leptospermum scoparium</i> (manuka)	50%	<i>Melicytus ramiflorus</i> (mahoe)	10%	<i>Phormium tenax</i> (harakeke/flax)	10%	<i>Sophora microphylla</i> (kowhai)	5%
<i>Cordyline australis</i> (ti kouka/cabbage tree)	5%												
<i>Kunzea robusta</i> (kanuka)	20%												
<i>Leptospermum scoparium</i> (manuka)	50%												
<i>Melicytus ramiflorus</i> (mahoe)	10%												
<i>Phormium tenax</i> (harakeke/flax)	10%												
<i>Sophora microphylla</i> (kowhai)	5%												
Monitoring	<p>Annual photopoints and biennial vegetation quadrats.</p> <p>Twice annual pest plant surveillance checks.</p>												

Table 2: Outline of dryland planting

6.3.2 Dryland planting with tree restrictions

Explanation	<p>This planting will use mainly shrub species appropriate to the site, which will create a dense canopy cover to reduce the pest plant reinvasion.</p> <p>Existing <u>self established</u> trees can be left in these areas.</p>
Approx. size	Approximately 2,500m ² hectares.
Timing	<p>Planting to be done in winter 2018 (1 June – 31 August).</p> <p>This allows the site to be left for around 18 months to allow a high proportion of the residual pest plant seeds to germinate, which can then be controlled prior to planting.</p>
Spacing	Blanket plant at one-metre centres.

Species list	<i>Coprosma rhamnoides</i>	20%
	<i>Coprosma rigida</i>	20%
	<i>Muelhenbeckia complexa</i> (pohuehue)	10%
	<i>Veronica</i> aff. <i>bishopiana</i> (Hikurangi Swamp hebe)	30%
	<i>Veronica stricta</i> (koromiko)	20%
Monitoring	Annual photopoints and biennial vegetation quadrats.	
	Twice annual pest plant surveillance checks.	

Table 3: Outline of dryland planting in vehicle runoff zones

Need comments on the suitability of these species? Restrictions on growth form in vehicle runoff zones – stem cannot exceed 100mm diameter, cannot be dense bush like flax.

I included pohuehue, as it is already present at the site.

Andrew and Lisa – is there any problem with having the two hebe/veronica species together?

Alternatively – could use dryland sedges?, but needs to compete with privet etc. Also problem with plants suitability/ecosource availability from H Floodplain.



Diagram 7: Layout of dryland planting areas

6.3.3 Ephemeral wetland planting

Explanation	<p>Excavation works should to be carried out to create shallow ephemeral wetland habitat, made up of a series of dips and hollows along the existing drainage channel (section 6.5).</p> <p>A mix of large species (e.g. manuka, flax) with mixed sedges etc. to be used outside of the vehicle runoff zones.</p> <p>Sedges only to be planted in the vehicle runoff zones (approximately 250m² at the western end of the site).</p>																				
Approx. size	Dependant on the amount of excavation carried out. Potentially around 1,500 m ² (diagram 8).																				
Timing	<p>Excavation of the site in January-February 2017.</p> <p>Planting sedges in wet areas in autumn 2018 (April – May) when water levels are lower than in winter.</p> <p>Edge planting (trees and flax) may need to held until winter 2018 (June – August) along with dryland planting (depending on soil moisture).</p> <p>Allows the site to be left for around 18 months for residual pest plant seed germination, which can then be controlled prior to planting.</p>																				
Spacing	<p>Trees and flax can be planted along the edges and drier sections of the wetlands (avoiding the verge maintenance strip) at one-metre centres.</p> <p>Sedges can be cluster planted at 500mm centres depending on habitat suitability.</p>																				
	<p>Sedges (approx. 3,000 plants)</p> <table> <tr> <td><i>Baumea articulata</i></td> <td>10% (wetter areas)</td> </tr> <tr> <td><i>Carex lessoniana</i> (rautahi)</td> <td>30%</td> </tr> <tr> <td><i>Carex maorica</i></td> <td>30%</td> </tr> <tr> <td><i>Carex virgata</i> (purei)</td> <td>30%</td> </tr> </table> <p>Trees (approx. 1,000 plants)</p> <table> <tr> <td><i>Dacrycarpus dacrydioides</i> (kahikatea)</td> <td>5%</td> </tr> <tr> <td><i>Leptospermum scoparium</i> (manuka)</td> <td>30%</td> </tr> <tr> <td><i>Coprosma propinqua</i> (mingimingi)</td> <td>20%</td> </tr> <tr> <td><i>Coprosma tenuicaulis</i> (hukihuki/swamp coprosma)</td> <td>15%</td> </tr> <tr> <td><i>Phormium tenax</i> (harakeke/flax)</td> <td>20%</td> </tr> <tr> <td><i>Cordyline australis</i> (ti kouka/cabbage tree)</td> <td>10%</td> </tr> </table>	<i>Baumea articulata</i>	10% (wetter areas)	<i>Carex lessoniana</i> (rautahi)	30%	<i>Carex maorica</i>	30%	<i>Carex virgata</i> (purei)	30%	<i>Dacrycarpus dacrydioides</i> (kahikatea)	5%	<i>Leptospermum scoparium</i> (manuka)	30%	<i>Coprosma propinqua</i> (mingimingi)	20%	<i>Coprosma tenuicaulis</i> (hukihuki/swamp coprosma)	15%	<i>Phormium tenax</i> (harakeke/flax)	20%	<i>Cordyline australis</i> (ti kouka/cabbage tree)	10%
<i>Baumea articulata</i>	10% (wetter areas)																				
<i>Carex lessoniana</i> (rautahi)	30%																				
<i>Carex maorica</i>	30%																				
<i>Carex virgata</i> (purei)	30%																				
<i>Dacrycarpus dacrydioides</i> (kahikatea)	5%																				
<i>Leptospermum scoparium</i> (manuka)	30%																				
<i>Coprosma propinqua</i> (mingimingi)	20%																				
<i>Coprosma tenuicaulis</i> (hukihuki/swamp coprosma)	15%																				
<i>Phormium tenax</i> (harakeke/flax)	20%																				
<i>Cordyline australis</i> (ti kouka/cabbage tree)	10%																				
Monitoring	Annual photopoints and biennial vegetation quadrats.																				

Table 4: Outline of ephemeral wetland planting

This wetland species mix is based on those present at the site and in close by wetland areas. However, it is possible that once excavated, the site may not be suited to this range of species, depending on the soil types. If necessary, this species list may require changing to suit the conditions.



Diagram 8: Layout of ephemeral wetland excavation and planting areas

6.3.4 Damp drainage channels.

Explanation	<p>This planting will cover any remaining sections of the drainage channel in the southern remnant following the creation of the wetland (and outside of the 1.5-2 metre planting exclusion zone). The main area is expected to be the stretch of drain in-between the two wetland areas (diagram 8).</p> <p>If this section of drain falls within the planting exclusion zone, a new drain will be excavated further into the remanent, with the old section filled in. The reason is, that any drains without shading vegetation will provide habitat for the continuation and spread of the predatory gambusia.</p> <p>The main drain in the northern remnant is deeper than that in the south, running close to the northern boundary (fence line), and has some existing large indigenous tree cover. Therefore, this section of drain will be planted with the dryland tree mix to create further shade for black mudfish habitat (refer section 6.4).</p>
Approx. size	Potentially 500 m ² .
Timing	<p>Dry edge planting to be done in winter 2018 (June –August).</p> <p>Planting in the wet drains to be done in autumn 2018 (April – May).</p>
Spacing	<p>Plant sedges at 500mm centres depending on habitat suitability.</p> <p>Larger plants to be spaced at approximately one metre centres, taking into consideration the existing vegetation.</p>
Species list	<p>Dry edges</p> <p><i>Coprosma propinqua</i> (mingimingi) 5%</p> <p><i>Veronica</i> aff. <i>bishopiana</i> (Hikurangi Swamp hebe) 10%</p> <p><i>Leptospermum scoparium</i> (manuka) 70%</p> <p><i>Phormium tenax</i> (harakeke/flax) 10%</p> <p><i>Melicytus ramiflorus</i> (mahoe) 5%</p>
	<p>Damp areas - sedges</p> <p><i>Carex lessoniana</i> (rautahi) 15%[‡]</p> <p><i>Carex maorica</i> 15%</p> <p><i>Carex subdola</i> 15%</p> <p><i>Carex virgata</i> (purei) 15%</p> <p><i>Cyperus ustulatus</i> (giant umbrella sedge) 20%</p> <p><i>Carex gaudichaudiana</i> 15%</p>
Monitoring	Annual photopoints and biennial vegetation quadrats.

Table 5: Outline of damp drainage channel planting

Where possible, all revegetation plants will be ecosourced from the Hikurangi floodplain. If this is unachievable, then plants will be at least be from within the same gene pool as

* The ratio of sedge species will be dependant on the availability of seed from the site.

plants on the floodplain, i.e., from plants whose progeny have a reasonable chance of naturally occurring on the floodplain through the processes that disperse their seeds (e.g. upstream, upslope, upwind, bird dispersal etc.)

All plants being introduced to the site will be checked prior to arrival to be free of Argentine ants (*Linepithema humile*).

6.2 Pest plant control

The initial pest plant knock down across the site is programmed for December 2016 - February 2017 (prior to privet seeding).

Following the initial summer control, the site is to be run over again by the pest plant control contractors the following spring (October - November 2017) and then again in autumn March – April 2018) prior to the planting period in winter 2018 (June – August). By this time, the majority of germinating pest plants will hopefully have been removed from the site.

Ongoing regular post-planting surveillance and follow up control will be carried out at least twice yearly in spring and autumn for a period of no less than five years.

Pest plant control should follow the most suitable low impact methods available. While a list of control methods are included as Appendix 5 of this restoration plan, these methods are not intended to be regimented, and techniques may change over time based on future technology/innovation, specialist advice, and ideas and additional knowledge of those involved in the site management.

6.3 Rabbit control

Following the removal of the pest plants, regular monitoring of rabbit sign should be carried out using the Modified McLean Scale method for assessment (appendix A6.4).

The trigger point for control should be if sign reaches a 3 on the scale.

If this trigger point is reached, it is recommended that rabbit pindone be used as the main control method (appendix A6.4), with other methods such as shooting and fumigation considered if poisoning does not achieve the desired result.

6.4 Enhancement of mudfish habitat

The planting of dense vegetation in the wetlands and along the drainage channels will provide a level of shading which will benefit the mudfish population by cooling the water, providing an ongoing supply of debris and by reducing the habitat suitability for the predatory gambusia (gambusia prefer warm and open water).

Additional plant debris will be collected and added to the drains and wetlands as part of the restoration activities (e.g. flax, cabbage tree leaves, fern fronds etc.) to create substrate cover for mudfish, particularly as the waterbodies dry out over the summer season.

6.5 Excavation of the ephemeral wetland systems

Creation of the ephemeral wetland systems will involve the digging of a series of dips and hollows along/close to the footprint of the existing drainage channel in the southern remnant. The wetlands will be designed to be clear of the 1.5 – 2 metre road maintenance

plant exclusion zone. This will also require the infilling of some of the existing drain and the likely creation of a small shallow groundwater bund downstream (e.g. western end) of the newly created wetlands.

At this time, depending of the location of the existing drain between the two wetland areas (i.e. if it falls within the planting exclusion zone), the excavator will be used to create a new drain to the south (to allow planting), with the existing drain filled in with suitable low permeable material (e.g. thick clay).

As some of the excavation may also be under the electricity/telecommunication lines, work may need to follow Northpower requirements (e.g. smaller digger size, use of a spotter onsite to ensure machines stay clear of lines etc.). This will be determined closer to the time once contact has been made with Northpower.

6.7 Reintroduction of threatened plant species.

As *Veronica* aff. *bishopiana* and *Pittosporum obcordatum* are already present in sections of close by wetland and forest, enhancement of these populations will be the focus of threatened plant restoration effort.

Seed will be collected, starting summer 2016/17, to propagate both species. Once the plants have reached an appropriate size (at least pb5), they can be added to the site.

Given that *Juncus holoschoenus* var. *holoschoenus* was recorded from the Jordan Valley Shrubland PNAP survey (Manning 2001), but not from subsequent surveys (e.g. Clarkson *et al.* 2015), if local seed is available, the opportunity exists to reintroduce this species if deemed worthwhile.

Given that it is possibly a recent arrival from Australia in the process of establishing, but possibly now being outcompeted (source NZPCN website), should we pursue this sp?

It is envisioned that following the removal of pest plants and subsequent revegetation planting, the natural regeneration process will facilitate the self-reintroduction of a range of plant species from the surrounding landscape.

6.8 Assessment and upgrading of stock proof fences.

The fence along the northern boundary has recently been replaced, and is in good stock-proof condition [I need to recheck if this is the case for the entire length of the site.](#)

The fence along the southern boundary is in poor condition, and should not be considered to be stock proof. This fence will need to be upgraded or replaced before planting is carried out.

6.8 Management of areas outside of the planting zone.

In addition to the control of pest plants in the revegetation areas, additional control - particularly of Chinese privet, will be undertaken along the road edge for at least 200 metres either side of the remnants. This will help to create a buffer to limit the level of pest plant seed spread back into the revegetation plantings.

Where possible, within this 200-metre buffer, any sweet grass/glyceria and parrots feather growing in the drainage channels is to be sprayed (where access is possible).

An existing area of grass at the western end of the southern remnant, on the edge of the access way running into the adjacent paddock (diagram 7), is to be retained as grass to provide a parking/pull off area for visitors and vehicles associated with the ongoing management of the site.

7. Monitoring

Four monitoring methods are proposed for this site.

1. Photopoints.
2. Permanent vegetation quadrats.
3. Annual systematic pest plant and rabbit sign surveillance walks.
4. Freshwater fish trapping.

This ongoing monitoring offers the opportunity for joint collaboration between WDC (as land administrators) and the Ngati Hau Resource Management Unit (traditional kaitiaki), providing both scientific outcome and cultural indicators of restoration success.

The details of these monitoring methods are outlined in appendix 6.

8. References

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- Pivac, N. n.d. The ecological value of wetland fragments in the Hikurangi floodplain, as measured by black mudfish (*Neochanna diversus*). *Unpublished Thesis*: Unitec, Auckland.

Appendix 1 – Indigenous plant species lists

Indigenous vegetation listed by Clarkson <i>et al.</i> (2015)		
<i>Baumea articulata</i>	jointed baumea	
<i>Calystegia sepium</i>	akapohue, calystegia	
<i>Carex lessoniana</i>	cutty grass	
<i>Carex maorica</i>		
<i>Carex subdola</i>		Regionally Uncommon
<i>Carex virgata</i>	swamp sedge	
<i>Centella uniflora</i>	centella	
<i>Coprosma ×cunninghamii</i>		
<i>Coprosma areolata</i>	aruhe	
<i>Coprosma parviflora</i>	leafy coprosma	Regionally Uncommon
<i>Coprosma propinqua</i> var. <i>propinqua</i>	mingimingi	Regionally Uncommon
<i>Coprosma rhamnoides</i>		
<i>Coprosma rigida</i>		Regionally Uncommon
<i>Coprosma rotundifolia</i>	round-leaf coprosma	Regionally Uncommon
<i>Cordyline australis</i>	ti kouka/cabbage tree	
<i>Cyperus ustulatus</i>	giant umbrella sedge	
<i>Dacrycarpus dacrydioides</i>	kahikatea	
<i>Blechnum parrisiae</i>		
<i>Eleocharis acuta</i>	club rush	
<i>Eleocharis sphacelata</i>	bamboo spike sedge	
<i>Hydrocotyle pterocarpa</i>		
<i>Juncus edgariae</i>		
<i>Juncus prismatocarpus</i>	angled-fruit rush	
<i>Kunzea robusta</i>	kanuka	
<i>Leptospermum scoparium</i>	manuka	
<i>Melicytus micranthus</i>	small-leaved mahoe	
<i>Microtis unifolia</i>	common onion orchid	
<i>Muelhenbeckia complexa</i>	pohuehue	
<i>Myrsine divaricata</i>	weeping mapou	Regionally Uncommon
<i>Oplismenus hirtellus</i>	basket grass	
<i>Phormium tenax</i>	harakeke/flax	
<i>Pittosporum crassifolium</i>	karo	
<i>Podocarpus totara</i>	totara	
<i>Pteridium esculentum</i>	bracken	
<i>Ranunculus amphitrichus</i>	waoriki	
<i>Raphanus</i> sp.		
<i>Rubus australis</i>	bush lawyer	
<i>Thelymitra pauciflora</i>	sun orchid	
Additional indigenous species recorded by L. Forester & K. Hansen (NRC), A. Townsend & B. Herbert (DoC) and D. Wright (Ecology North) 20 May 2016.		
<i>Alternanthera nahui</i>	nahui	
<i>Blechnum molle</i>	mokemoke	At Risk–Naturally Uncommon
<i>Blechnum zeelandicum</i>		At Risk–Naturally Uncommon
<i>Coprosma propinqua</i> x <i>robusta</i>		
<i>Coprosma tenuicaulis</i>	swamp coprosma	Regionally Uncommon
<i>Haloragis erecta</i> subsp. <i>erecta</i>	shrubby haloragis	
<i>Hedycarya arborea</i>	porokaiwhiri/pigeonwood	

<i>Leucopogon fasciculatus</i>	mingimingi	
<i>Muelhenbeckia australis</i>	pohuehue	
<i>Myrsine australis</i>	mapou	
<i>Parsonsia</i> sp.	kaihua	

Appendix 2 – Exotic plant species lists

Exotic vegetation listed by Clarkson <i>et al.</i> (2015)	
<i>Agapanthus orientalis</i>	Agapanthus
<i>Alopecurus geniculatus</i>	Kneed foxtail
<i>Anthoxanthum odoratum</i>	Sweet vernal
<i>Briza minima</i>	Small quaking grass
<i>Bromus willdenowii</i>	Prairie grass
<i>Callitriche stagnalis</i>	Starwort
<i>Carex longii</i>	
<i>Carex ovalis</i>	Oval sedge
<i>Cortaderia selloana</i> *	Pampas grass
<i>Cyperus eragrostis</i>	Puketangata
<i>Dactylis glomerata</i>	Cocksfoot
<i>Epilobium ciliatum</i>	Tall willowherb
<i>Galium aparine</i>	Cleavers
<i>Galium palustre</i>	Marsh bedstraw
<i>Geranium dissectum</i>	Cut-leaved cranesbill
<i>Geranium robertianum</i>	Herb Robert
<i>Glyceria maxima</i>	Reed sweetgrass
<i>Hypochaeris radicata</i>	Catsear
<i>Landoltia punctata</i>	Purple-backed duckweed
<i>Leontodon taraxacoides</i>	Hairy hawkbit
<i>Leycesteria formosa</i>	
<i>Ligustrum sinense</i> ⁺	Chinese privet
<i>Lonicera japonica</i> *	Japanese honeysuckle
<i>Lotus pedunculatus</i>	Lotus
<i>Lotus suaveolens</i>	Hairy birdsfoot trefoil
<i>Ludwigia palustris</i>	Water purslane
<i>Malus ×domestica</i>	Apple
<i>Myriophyllum aquaticum</i> *	Parrot's feather
<i>Oenanthe pimpinelloides</i>	Parsley dropwort
<i>Paspalum urvillei</i>	Vasey grass
<i>Persicaria hydropiper</i>	
<i>Persicaria strigosa</i>	
<i>Polygonum strigosum</i>	
<i>Ranunculus repens</i>	Creeping buttercup
<i>Rosa rubiginosa</i>	sweet briar
<i>Rubus fruticosus</i>	Blackberry
<i>Rumex obtusifolius</i>	Broad-leaved dock
<i>Schedonorus arundinaceus</i>	Tall fescue
<i>Sonchus oleraceus</i>	Common sow thistle
<i>Ulex europaeus</i> ⁺	Gorse
<i>Vinca major</i>	Blue periwinkle
<i>Vulpia</i> sp.	
<i>Watsonia meriana</i>	Watsonia
Additional exotic species recorded by L. Forester & K. Hansen (NRC), A. Townsend & B. Herbert (DoC) and D. Wright (Ecology North) 20 May 2016.	
<i>Carex scoparia</i>	broom sedge
<i>Crocsmia x crocosmiiflora</i>	montbretia

<i>Daucus carota</i>	wild carrot
<i>Ehrharta erecta</i>	veldt grass
<i>Gladiolus undulatus</i>	gladiolus
<i>Juncus effusus</i>	leafless rush
<i>Pennisetum clandestinum</i>	kikuyu grass
<i>Phytolacca octandra</i>	inkweed
<i>Populus</i> sp.	poplar
<i>Pulicaria dysenterica</i>	fleabane
<i>Solanum mauritianum</i> *	woolly nightshade
<i>Solanum nigrum</i>	black nightshade
<i>Tradescantia flumenensis</i> *	tradescantia
<i>Yucca?</i> sp.	yucca

* Included in the National Pest Plant Accord

+ Included in the Northland Regional Council Pest Management Strategy

Appendix 3 – Fauna species lists

Bird species observations

Includes any bird observations include the road corridor and approximately fifty metres into the adjoining paddocks/pasture grassland.

Indigenous

Kahu/Australasian harrier	<i>Circus approximans</i>
Piwakawaka/fantail	<i>Rhipidura fuliginosa</i>
Pukeko	<i>Porphyrio melanotus</i>
Riroriro/grey warbler	<i>Greygone igata</i>
Silver eye	<i>Zosterops lateralis</i>
Tui	<i>Prothemadera novaeseelandiae</i>
Welcome swallow	<i>Hirundo neoxena</i>

Exotic

Blackbird	<i>Turdus merula</i>
Chaffinch	<i>Fringilla coelebs</i>
Common myna	<i>Acridotheres tristis</i>
Common starling	<i>Sturnus vulgaris</i>
Goldfinch	<i>Carduelis carduelis</i>
Greenfinch	<i>Carduelis chloris</i>
House sparrow	<i>Passer domesticus</i>
Mallard	<i>Anas platyrhynchos</i>
Pheasant	<i>Phasianus colchicus</i>
Skylark	<i>Alauda arvensis</i>
Song thrush	<i>Turdus philomelos</i>
Yellowhammer	<i>Emberiza citrinella</i>

Fish species (drainage channels)

Indigenous

Nil

Exotic/pest species

Plague minnow	<i>Gambusia affinis</i>	Both sides of road (3 sites)
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Invertebrate observations

Terrestrial/arboreal/aerial

Asian paper wasp	<i>Polistes chinensis</i>
Black headed jumping spider	<i>Trite planiceps</i>
Crane fly	Tipulidae
Damselfly	Zygoptera
Dragonfly	Anisoptera
Earth worm	Megascolecidae
Earwig	Forticulidae
Honey bee	<i>Apis mellifera</i>
Nurseryweb spider	<i>Dolomedes minor</i>
Orb web spider	Araneidae
Passion vine hopper	<i>Scolypopa australis</i>

Aquatic

Damselfly nymph	Zygoptera
Dragonfly nymph	Anisoptera
Water beetle	Dytiscidae
Water snail	<i>Potamopyrgus</i> sp.

Appendix 4 - Planting methodology

No planting will be undertaken for approximately 18 months following the initial pest plant control, to allow the germination and subsequent control of residual pest plant seeds.

Species mixes and spacing will follow the lists outlined in tables 2 – 5 for each specific habitat type, unless it is decided that these lists should be changed following the creation of the wetland habitat and clearance of the existing pest plant cover.

The actual plant numbers will be finalised once the physical size of each area/habitat type has been measured.

All plants listed in tables 2 – 5 will be revegetation grade size (e.g. 5.5cm tube etc.).

The planting of the dry sites is to be done in winter, when the soil moisture levels are generally highest (June - August).

The wetland plantings will be done in autumn (April – May), prior to the rise in water levels over the winter months.

Revegetation grade plants can be planted using the forestry cut method. Using a commercial grade planting spade, a cut is made in the ground, and spread apart by levering the spade back and forth wide enough to easily (without force) bury the plant to the top of the potting mix. The cut soil around the plant is then carefully closed and firmed with the foot.

For the future planting of larger (pb) grade plants (e.g. *Pittosporum obcordatum* and *Veronica* aff. *bishopiana*), plants will need to be placed in a hole approximately 1.5 times wider than the root ball, with the soil returned around the roots firmed with the ball of the foot.

All plants are to be well watered prior to planting.

All plants introduced to the site are to be checked to be free of Argentine ants before leaving the nursery where they are grown.

Appendix 5 - Pest plant control methods

For the purpose of ecological restoration, the initial pest plant control should cover at least the following species, which pose a direct threat to the establishment of plantings and the process of natural regeneration:

- Agapanthus (*Agapanthus orientalis*)
- Blackberry (*Rubus fruticosus*)
- Periwinkle (*Vinca major*)
- Chinese privet (*Ligustrum sinense*)
- Gorse (*Ulex europeaus*)
- Japanese honeysuckle (*Lonicera japonica*)
- Kikuyu grass (*Pennisetum clandestinum*)
- Leafless rush (*Juncus effusus*)
- Pampas grass (*Cortaderia selloana*)
- Parrot's feather (*Myriophyllum aquaticum*)
- Poplar (*Populus* sp.)
- Sweet grass/glyceria (*Glyceria maxima*)
- Tradescantia (*Tradescantia flumenensis*)
- Vasey grass (*Paspalum urvillei*)
- Woolly nightshade (*Solanum mauritianum*)
- Yucca (*Yucca?* sp.)

Contractors carrying out spray work must hold the appropriate legal qualifications for herbicide use issued by WorkSafe New Zealand (i.e. Growsafe for application and Approved Handlers Certificate to purchase and transport some herbicides – for details refer to <http://www.growsafe.co.nz>). All operators must also wear the appropriate personal protection equipment suited for the job.

There are two commonly used approaches to pest plant control; species led and site led.

A species led approach targets individual species across a site, so that each species is controlled separately, usually in a hierarchical manner based on the level of threat, difficulty/ease of control/management of seed source etc.

A site led approach targets a range of species across an entire given area, where a site is often divided into sections with all pests targeted within each section in a systematic manner.

For the initial pest plant knockdown at this site, a mainly species led approach will be used - where appropriate, groups of species are be targeted together based on the type of control methods required (table A). Thus, all tree species that need to be cut down and the stump treated with herbicide, or foliar sprayed with sodium glyphosate are to be targeted together etc.

For this purpose the initial target species have been divided into eight management control type methods (table A).

The control of these groups should be done systematically. Given the narrow nature of the two remnants, a crew of pest control contractors can move along the management area in a line, covering the entire site.

The optimum timing for pest plant control is usually spring and autumn, when the plants are most active. However this can vary by species and by weather conditions. It is planned that the main control will be carried out from late spring to early autumn. In Northland blackberry should only be foliar sprayed in summer and autumn.

Foliar spraying is only to be undertaken on calm dry days.

The risk of spray drift damage to surrounding desirable species can be reduced by using an 'air induction' type nozzle (creates larger droplets) on the spray gear, and when practicable using a spray shield. Generally, work on windy days will be restricted to physical control (e.g. cutting vines in preparation for spraying, hand-pulling, or cutting and treating stumps).

To identify areas that have been sprayed, a commercial marker dye is to be added to the spray units as per the label instructions.

Particular care must be taken around areas of desirable indigenous habitat/vegetation. If the target pest plant is located amongst desirable species, all effort should be made to reduce the risk of damage to the non-target plants.

There will be regrowth/residual seed germination of the majority of pest species across the site the next few months following the control operation. Therefore follow up control will be carried following spring (October - November 2017) and then again in early autumn March - April 2018) prior to the planting period in autumn and winter 2018.

Ongoing pest plant surveillance

After the follow up control operation, regular monitoring and surveillance of control success, future pest plant invasion and the spread and impacts of non-targeted exotic vegetation identified in the ecological surveys (appendix 2) is to be undertaken twice annually (late spring and autumn). This will involve a quick systematic walk across the sites by a person or persons able to identify pest plants. This can be done using the grid system, or across the entire site at one time (will be dependant on the level of pest plant spread/occurrence).

During this walkover any pest plants identified are to be recorded and if appropriate/practical, their location marked with flagging tape for future control.

The identified pest plants should then be controlled as soon as possible, to reduce spread (e.g. seeding).

Table A: Targeted pest plants and control methods

Method 1	
Chinese privet	To be cleared as part of the initial pest plant control operation outlined in 6.1.
Woolly nightshade	Manual control by a team with saws etc., with the freshly cut stumps sprayed with a mix of 250ml/litre (50%) of sodium glyphosate.
Gorse	Mechanical control using a mulcher, followed by the spraying of the stumps with a mix of 250ml/litre (50%) of sodium glyphosate
Poplar	
	Small plants/seedlings: hand pull, or foliar spray with metsulfuron-methyl (5g/10 litre), with penetrant.
Method 2	
Japanese honeysuckle	The majority of these will be cut as part of the privet control operation.
Blackberry	Where reachable, and where there is low risk of overspray onto desirable species, the honeysuckle should be foliar sprayed prior to being disturbed/cut during the privet control. Use either metsulfuron-methyl (5g/10L), or triclopyr or picloram (label rates), with penetrant (1ml/litre)
	For any remaining small infestations: cut and scrape stem close to ground, treat stump immediately with 250ml/litre (25%) of sodium glyphosate administered in a small spray bottle.
	Larger infestations outside of the privet control areas: use the foliar spray method. Take particular care to avoid overspray or drift. The vines should be pulled off the surrounding desirable vegetation before spraying (if necessary cut the vines back to reduce the potential spray contact with the surrounding desirable vegetation).
	Blackberry should only be sprayed in summer and autumn, when the plants are actively growing.
Method 3	
Pampas	Foliar spray with a strong mix (20ml/litre) of sodium glyphosate, with penetrant (1ml/litre).
Periwinkle	
	If pampas is growing amongst desirable vegetation, foliar spray with 15ml/litre of haloxyfop (grass selective herbicide) with crop oil.
Method 4	
Tradescantia	Spray with triclopyr (6ml/litre), with penetrant (1ml/litre).
	Take particular care to avoid overspray or drift.

Method 5	
Kikuyu grass Vasey grass Soft rush	<p>Where spray can be applied with low risk to surrounding desirable vegetation, spray with sodium glyphosate (10ml/litre), with penetrant.</p> <p>For the grasses in sensitive areas use haloxyfop (10ml/litre) with crop oil (grass selective).</p> <p>Another option for plants amongst desirable vegetation (particularly for the soft rush) is to apply spray with a spray shield (and air induction nozzle), which can cover the target plant and reduce contact with the surrounding plants.</p>
Method 6	
Agapanthus Yucca [#]	<p>Dig out smaller plants and dispose of all pieces away from the site (e.g. transfer station or burn).</p> <p>Foliar spray with a mix of 4g metsulfuron + 200ml glyphosate with 10 ml penetrant per 10 litres of water.</p>
Method 7	
Parrots feather	<p>It may not be feasible to eradicate the parrot's feather from the site (and buffer). However, where possible, spray control should be carried out in summer when the water levels in the drainage channels are low.</p> <p>Foliar spray with sodium glyphosate (10ml/litre), with penetrant. Repeat every 3 - 5 weeks until the end of summer or water levels rise to a point of making it difficult to apply herbicide.</p>
Method 8	
Sweet grass	<p>Carry out control when the water levels in the drainage channels are low (e.g. summer).</p> <p>Where spray can be applied with low risk to surrounding desirable vegetation, spray with sodium glyphosate (10ml/litre), with penetrant.</p> <p>In sensitive areas use haloxyfop (7.5ml/litre), with crop oil.</p>

[#] A couple of plants are located amongst garden waste dumped along the access way at the southeastern end of the site (adjacent to the grassed pull off area)

Appendix 6 – Monitoring methods

A6.1 Photopoints

To be done annually (October).

A total of four photopoints have been set up across the site on 17 October 2016. At one point, an additional photo was taken in a different direction to gain a wider range of views of the site. In total there are 5 photos across the site.

At each photopoint records were made of the:

- Location
- Date
- Time
- Weather conditions
- Camera type and settings
 - Zoom
 - Focus
 - Shutter speed
- Camera position
 - Compass bearing
 - Tripod height
- GPS Co-ordinates

Usually the camera position would be marked with a waratah stake with an attached numbered orange plastic identification tag for ease of location in the future. However, as the sites are located on the road edge, it was decided not to use waratahs (for safety and potential interference to road edge maintenance machinery). Therefore in the future photopoints will need to be identified using the co-ordinates and any features identified for each point.

The purpose of photopoints is to provide a replicable photograph of a set area, which can be used over time to compare and monitor changes to that area (e.g. growth of plantings, level of natural habitat regeneration and reductions in pest plants).

The original photos were taken using a Canon EOS 7d MkII (crop frame) digital SLR camera with a 28mm-350mm zoom lens on a monopod.

These photopoints should be replicated annually as close as possible to the same date (17 October).

Copies of the photos are included below.

Position of photopoints



Location	Photopoint 1
Date	17 October 2016
Time	13.40
Weather conditions	Sun/cloud – light south westerly
Zoom	50mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	100° (magnetic)
Tripod height	1700mm
GPS Co-ordinates	E1712924 N6058702
Site characteristics	Taken from edge of gravel accessway on southern side of road



PP1

Location	Photopoint 2
Date	17 October 2016
Time	13.48
Weather conditions	Sun/cloud – light south westerly
Zoom	50mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	104° (magnetic)
Tripod height	1600mm
GPS Co-ordinates	E1713042 N6058692
Site characteristics	Approximately 120 east of PP1 on northern side of road in small pull off area.



PP2

Location	Photopoint 2A
Date	17 October 2016
Time	13.50
Weather conditions	Sun/cloud – light south westerly
Zoom	50mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	173° (magnetic)
Tripod height	1600mm
GPS Co-ordinates	E1713042 N6058692
Site characteristics	Approximately 120 east of PP1 on northern side of road in small pull off area.



PP2A

Location	Photopoint 3
Date	17 October 2016
Time	13.55
Weather conditions	Sun/cloud – light south westerly
Zoom	50mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	286° (magnetic)
Tripod height	1720mm
GPS Co-ordinates	E1713258 N6058512
Site characteristics	Taken from edge of gravel accessway on southwestern side of road



PP3

Location	Photopoint 4
Date	17 October 2016
Time	14.02
Weather conditions	Sun/cloud – light south westerly
Zoom	50mm
Focus	Infinity
Shutter speed	250/second
Compass bearing	290° (magnetic)
Tripod height	1700mm
GPS Co-ordinates	E1713258 N6058512
Site characteristics	Taken from edge of gravel accessway on northeastern side of road



PP4

A6.2 Vegetation quadrats

To be repeated every second year.

A series of vegetation quadrats are to be set up across the site following the removal of the current dense privet canopy, to measure the level of growth, natural regeneration and pest plant control success across the site.

It is planned that four 10m x 10m quadrats will be set up (where the remnants/planting areas are wide enough). The quadrats will be positioned to cover both dryland and wetland habitats.

The quadrats are to be marked with wooden survey posts. Additionally, the northeastern corner of each quadrat will be recorded by GPS.

Once measured, a string line is to be run to each corner to mark the extent of the quadrat. Only plants rooted within the quadrat are to be included in the survey.

Vegetation within the quadrats will be divided into four height tiers;

- Groundcover – all vegetation lower than 500mm in height,
- Understory – all vegetation between 0.5 – 4 metres in height,
- Canopy – all vegetation above 4 metres forming an obvious canopy,
- Emergent – all individual trees greater than 4 metres in height above the predominant canopy.

Due to the potential long-term diversity of the groundcover, this tier is measured by giving each species an individual score, where;

- 1 = <10% cover
- 2 = 10-30% cover
- 3 = 31-50% cover
- 4 = 51-70% cover
- 5 = 71-90% cover
- 6 = >90% cover

The understory, canopy and emergent tiers are to be given a percentage cover ranking (i.e. the percentage cover of each species across the horizontal plane within each tier). This should be done by two recorders undertaking a visual estimate of cover within each tier.

While this method has the potential for biases through variation in the estimates of cover by different individuals, it should be sufficiently accurate to measure general changes to vegetative structure over time.

At each quadrat records are to be made of the:

- Location
- Date
- Wind direction
- Wind speed (based on the Beaufort Scale)
- Cloud cover (measured in a percentage out of eight)
- GPS recording of the northeastern corner of the quadrat (NZTM)
- Example of quadrat recording

Example of a vegetation quadrat record

Survey date 31 October 2016
Wind direction SE
Speed (Beaufort Scale) 1
Cloud cover 4/8
GPS (NE cnr) E1710994
 N6057876

Groundcover	Score
Open ground	1
mixed pasture	3
<i>Blechnum parrisiae</i>	1
<i>Carex</i> sp.	1
<i>Coprosma propinqua</i>	1
<i>Cyperus eragrostis</i>	1
<i>Kunzea robusta</i>	1
<i>Ligustrum sinense</i>	3
<i>Myrsine divaricata</i>	2
<i>Oplismenus hirtellus</i>	1
<i>Ranunculus</i> sp.	1
<i>Rubus fruticosus</i>	1
Sub-canopy (0.5-4m)	% cover
Open	20
<i>Myrsine divaricata</i>	20
<i>Ligustrum sinense</i>	15
<i>Kunzea robusta</i>	5
<i>Podocarpus totara</i>	25
<i>Muelhenbeckia australis</i>	5
<i>Coprosma rhamnoides</i>	5
<i>Melicytus micranthus</i>	5
Canopy (>4 m)	
Open	75
<i>Podocarpus totara</i>	25
Emergent (>4 m above canopy)	
Open	95
<i>Cordyline australis</i>	5

Key to groundcover score

1 <10%
 2 10-30%
 3 31-50%
 4 51-70%
 5 71-90%
 6 >90%

A6.3 Freshwater fish surveys

To be repeated in winter every second year (August 2017, 2019 etc.).

A total of ten trapping positions were set through the drains on both sides of the road by David Wright (Ecology North).

Each trap position was numbered (refer to aerial photo on page 46).

Care was taken to ensure that a small amount of the top of the trap was left protruding from the water to allow captured fish access to air (as the drains can have low levels of dissolved oxygen). The traps were tied to emergent and bankside vegetation so as to avoid movement and sinking of the traps. In most cases the water depth was sufficient to allow the placement of the trap, however some sites required digging to increase water depth.

Along the drains, ten 3mm Gee Minnow traps were set for one night, baited with a teaspoon of vegemite in a small camera film canister with a single 3-4mm hole in the end to allow the vegemite to slowly run out.

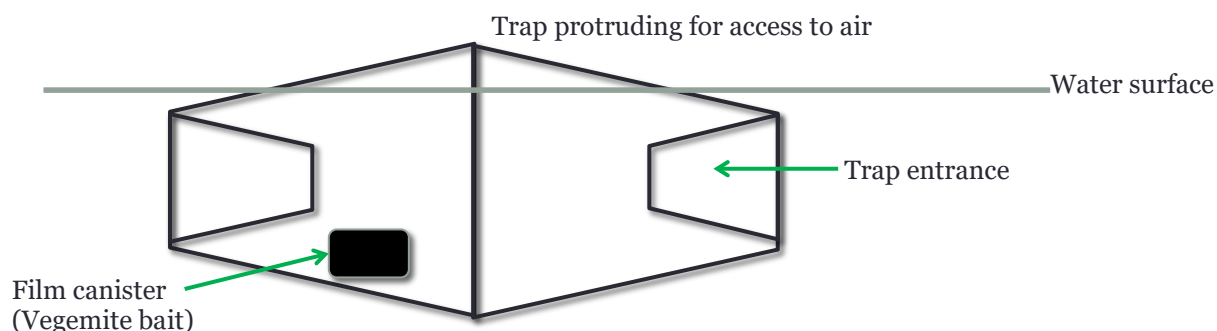
Traps were laid out in the afternoon, then checked and emptied early the following morning.

All fish and invertebrate species caught in the traps were recorded. Any indigenous fish were to be measured (length) and released as soon as possible in the same place as capture (none caught).

Numbers of the introduced pest fish species *Gambusia* were counted, in one case where the number of fish was high, the number was recorded greater than twenty (JVF 1).

The future fish monitoring will expand to include some more of the existing wetland/sedgeland habitat identified in diagram 6 (page 15). This will either require more traps than were used in the 2016 survey, or the spreading of the survey over more nights (moving the traps around the site).

Example of trap setting



Position of fish traps



Results of fish survey

Site	Fish	Inverts	Comment/additional obs.
<i>Southern side of Jordan Valley Road</i>			
JVF 1	Gambusia >20	Snail	Weedy/open – <i>Persicaria</i>
JVF 2		Snail	Weedy/open – <i>Persicaria/Lonicera</i>
JVF 3		Snail, damselfly	Weedy/open – <i>Lonicera/Rubus</i>
JVF 4		Snail	Edge of dense <i>Baumea articulata</i>
JVF 5		Snail, damselfly	Weedy/open – <i>Lonicera/Rubus/Carex</i>
JVF 6		Snail, beetle	Weedy/open – <i>Lonicera/Rubus/Carex</i>
<i>Northern side of Jordan Valley Road</i>			
JVF 7	Gambusia x 7	Snail	Shaded <i>Ligustrum/Persicaria</i>
JVF 8		Snail	Shaded <i>Ligustrum</i>
JVF 9		Snail	Shaded <i>Ligustrum/Lemna</i>
JVF 10	Gambusia x 1	Snail	Shaded <i>Ligustrum</i>

A6.4 Rabbit monitoring and control

The control of rabbits should be triggered will be if sign reaches a 3 on the Modified McLean Scale.

Scale (Maximum allowable limit)	Rabbit infestation
1	No sign seen. No rabbits seen.
2	Very infrequent sign present. Unlikely to see rabbits.
3	Sign infrequent with faecal pellet heaps more than 10 metres apart. Odd rabbits may be seen.
4	Sign frequent with some faecal pellet heaps more than 5 metres but less than 10 metres apart. Groups of rabbits may be seen.
5	Sign very frequent with faecal pellet heaps less than 5 metres apart in pockets. Rabbits spreading.
6	Sign very frequent with faecal pellet heaps often less than 5 metres apart over the whole area. Rabbits may be seen over the whole area.
7	Sign very frequent with 2–3 faecal pellet heaps often less than 5 metres apart over the whole area. Rabbits may be seen in large numbers over the whole area.
8	Sign very frequent with 3 or more faecal pellet heaps often less than 5 metres apart over the whole area. Rabbits likely to be seen in large numbers over the whole area.

Modified McLean Scale (adapted from Otago Regional Council RPMS)

If control is necessary, it will be done using rabbit pindone toxin. Baits will be laid out weekly for a month using the spitting method, where sods of earth are turned over using a grubber, with a small handful of pellet baits added to the spit and left for a few nights. The turning over of the soil attracts rabbits, and makes the disposal of the unused baits easy (by kicking the sod back into the hole). The spits will be laid across the site, particularly where obvious rabbit sign is observed, with baits left for three to four rain free nights.

Signage is to be put in place, stating:

- That pindone is being used across the site.
- That it is toxic to humans and animals.
- The method of delivery.
- The length of time that the pindone will be left in place.
- The contact details (name and phone number) of the person responsible.

Appendix 7 – Jordan Valley Shrubland restoration time line

Task	Year 1 2017				Year 2 2018				Year 3 2019				Year 4 2020				Year 5 2021			
	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr
Pest plant control																				
Initial pest plant control	■																			
On-going pest plant control				■		■		■		■		■		■		■		■		→
Rabbit control *	■				■				■											
Planting																				
Ephemeral wetland and drain planting						■														
Dryland planting							■													
Planting maintenance								■		■		■		■		*		*		*
Plant replacement *										■	■									
Planting <i>P. obcordatum</i> & <i>V. aff. bishopiana</i>										■										
Excavation of wetlands (& drain)	■																			
Upgrade fence	■																			
Monitoring																				
Permanent vegetation quadrats	■								■								■			→
Photopoints				■				■				■				■				→
Fish surveys							■							■						→
Pest plant surveillance (walk over site)				■		■		■		■		■		■		■		■		→
Annual monitoring summary					■				■				■				■			→
Lizard survey	■																			

* these tasks will be dependant on monitoring results (e.g. assessing natural regeneration around the oxbow edges, plant loss from planting areas etc.)

→ indicates task may need to continue (based on monitoring/surveillance results and budget considerations)

Appendix 8 - Work plan budget approximations

Year 1 (2017) – clearing pest plants from site – excavating wetlands

Action	Details	Timing	Approx. cost
Initial pest plant control	Use of contractors and mulching machines.	Summer	\$10,000
Follow up pest plant control	Follow up control across site (dependant on surveillance/monitoring results).	Spring & autumn	\$2,000
Rabbit control	Dependant on surveillance	Summer	\$250
Upgrade fence	Based on the replacement of the southern boundary fence.		\$1,000
Excavation of wetlands & drains	Use of digger and truck for spoil removal. Road traffic control and potential spotter for work under electrical lines.	Summer	\$8,000
Monitoring & surveillance	Repeat photopoints, pest plant walkovers etc. Write results summary.	Ongoing	\$900
Project management	40 hours for project management.	Ongoing	\$3,000
		Total	\$25,150

Year 2 (2018) – planting site and maintaining pest plant control

Action	Details	Timing	Approx. cost
Planting labour	265 person hours x \$35	April – August	\$9,275
Plant transport/incidentals			\$1,500
Plant purchase	25,000 mixed plants for dryland and wetland revegetation	April - August	\$30,000
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$2,400
Rabbit control	Dependant on surveillance	Summer	\$250
Monitoring	Repeat photopoints and fish surveys, pest plant surveillance walkovers. Write result summary.	Ongoing	\$1,100
Planting project management	70 hours for planting supervision and project mngt.	Ongoing	\$5,250
		Total	\$49,775

Year 3 (2019) – site maintenance & adding *P. obcordatum* & *V. aff. bishopiana*

Action	Details	Timing	Approx. cost
Threatened plant purchase	Purchase of 100 pb5 <i>Pit. obcordatum</i> and 100 <i>Ver. aff. bishopiana</i>	June - August	\$1,100
Planting labour	16 person hours x \$35	June – August	\$560
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$2,000
Replacement plant purchase	Estimated on 5% replacement	April - August	\$1,500
Replacement planting labour	20 person hours x \$35	April – August	\$700
Plant transport/incidentals			\$1,000
Rabbit control	Dependant on surveillance	Summer	\$250
Monitoring	Repeat photopoints and quadrats, pest plant surveillance walkovers. Write result summary.	Ongoing	\$1,100
Project management	50 hours for project management.	Ongoing	\$3,750
		Total	\$11,960

Year 4 (2020) – site maintenance and monitoring

Action	Details	Timing	Approx. cost
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$1,000
Monitoring	Repeat photopoints and fish surveys, pest plant surveillance walkovers. Write result summary.	Ongoing	\$1,100
Project management	10 hours for project management.	Ongoing	\$750
		Total	\$2,850

Year 5 (2021) – site maintenance and monitoring

Action	Details	Timing	Approx. cost
Follow up pest plant control & planting maintenance	Follow up control across site and release of planting areas.	Spring & Autumn	\$1,000
Monitoring	Repeat photopoints and quadrats, pest plant surveillance walkovers. Write result summary.	Ongoing	\$1,100
Project management	10 hours for project management.	Ongoing	\$750
		Total	\$2,850

Appendix 9 – Task checklist

Year 1 (2016/17)

Task	Description	Timing	Completed (tick when complete)
Initial photopoints	Carry out first set of photopoints	Spring 2016	✓
Lizard survey	Undertake one off lizard survey when high temperatures higher	Summer 2016	
Initial pest plant control	Control of pest plants, particularly: Chinese privet across site	Summer 2017	
Upgrade fences	Assess and upgrade stock fence on southern boundary	Summer 2017	
Excavation of wetlands	Plan and carry out excavation in wetlands & drains	Summer 2017	
Assess rabbit population	Carryout surveillance for rabbit sign. If necessary, control by use of pindone toxin	Summer 2017	
Initial vegetation monitoring quadrats	Mark out permanent vegetation quadrats once initial pest plant control work done	Summer 2017	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Spring 2017	
Follow up photopoints	Repeat photopoints	Spring 2017	
Additional pest plant control	Dependant on outcomes of surveillance	Spring 2017	
Write monitoring summary		Spring 2017	

Year 2 (2018)

Task	Description	Timing	Completed
Assess rabbit population	Carryout surveillance for rabbit sign. If necessary, control by use of pindone toxin	Summer 2018	
Wetland & drain planting	Plant sedges etc. in wetlands and drains	Autumn 2018	
Dryland planting	Plant remainder of areas with dryland mixes	Winter 2018	
Fish monitoring	Fish trapping as monitoring	Winter 2018 (August)	
Maintenance of plantings	Carry out maintenance (e.g. releasing) around plantings	Spring 2018	
Follow up photopoints	Repeat photopoints	Spring 2018	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Autumn & spring 2018	
Additional pest plant control	Dependant on surveillance results	Autumn & spring 2018	
Write monitoring summary		Spring 2018	

Year 3 (2019)

Task	Description	Timing	Completed
Assess rabbit population	Carryout surveillance for rabbit sign. If necessary, control by use of pindone toxin	Summer 2019	
Vegetation quadrats	Repeat vegetation monitoring quadrats from year 1	Summer 2019	
Carry out replacement planting	If necessary, replace plants across site	Autumn & winter 2019	
Plant threatened species	Plant <i>Pit. obcordatum</i> & <i>Ver. aff. bishopiana</i>	Winter 2019	
Maintenance of plantings	Carry out maintenance (e.g. releasing) around plantings	Autumn & spring 2019	
Follow up photopoints	Repeat photopoints	Spring 2019	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Autumn & spring 2019	
Additional pest plant control	Dependant on surveillance results	Autumn & spring 2019	
Write monitoring summary		Spring 2019	

Year 4 (2020)

Task	Description	Timing	Completed
Fish monitoring	Fish trapping as monitoring	Winter 2020	
Follow up photopoints	Repeat photopoints	Spring 2020	
Maintenance of plantings	Carry out maintenance (e.g. releasing) around plantings	Autumn & spring 2020	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Autumn & spring 2020	
Additional pest plant control	Dependant on surveillance results	Autumn & spring 2020	
Write monitoring summary		Spring 2020	

Year 5 (2021)

Task	Description	Timing	Completed
Vegetation quadrats	Repeat vegetation monitoring quadrats from year 1	Summer 2021	
Follow up photopoints	Repeat photopoints	Spring 2021	
Maintenance of plantings	Carry out maintenance (e.g. releasing) around plantings	Autumn & spring 2021	
Pest plant surveillance	Walk over site identifying the need for pest plant control	Autumn & spring 2021	
Additional pest plant control	Dependant on surveillance results	Autumn & spring 2021	
Write monitoring summary		Spring 2021	