Ashford Park
Gravel Extraction
Rehabilitation Strategy

23 November 2016

Revision Record:

Date of Revision	Version	Summary of Revision
November 2016	1	N/A – Version 1

CONTENTS

1.0 Introduction

1.1 Purpose

This Rehabilitation Strategy describes the following:

- The location and landscape context of the proposed quarry site;
- General principles of quarry rehabilitation applied to dry and wet extraction; and
- The processes and stages of the proposed rehabilitation works.

The purpose of rehabilitation is to maintain and enhance the significant indigenous vegetation retained as part of 'eco islands', provide rehabilitation planting to mitigate the loss of significant vegetation and ensure the final waterbody form created as a result of the gravel extraction activity will maintain water quality and enable the modified quarried landform to be successfully re-integrated into the Ōtaki floodplain landscape. This will enable natural systems to be established, including native riparian vegetation along waterbody margins to facilitate the ongoing ecological health of the waterbody.

This long-term vision can be expressed as follows:

> ***"To facilitate the successful rehabilitation of the site in a manner that accords with Winstone's Memorandum of Partnership with Nga Hapu O Otaki (see Appendix A) and will retain and enhance native species on islands and thriving native riparian vegetation along waterbody margins to maintain water quality and long term ecological health and successfully reintegrate quarried areas within the Ōtaki floodplain landscape"***

1.2 Background

By its very nature, the rehabilitation of extraction activity is a lengthy and sequential process. The nature of site modification is such that there will be a gradual transition across the site. The commencement of each subsequent stage of extraction activity will enable rehabilitation works within each preceding stage to occur. Such rehabilitation must be planned to ensure rehabilitation works undertaken will remain undisturbed and take account of any ongoing operational constraints.

It is difficult to develop a detailed plan for the site up to 20 years in advance of the completion of the project and prior to the end use being established. Notwithstanding this, a key element of the rehabilitation strategy is to ensure suitable site conditions are created, particularly along the margins of the waterbody, including landform modification and planting, which will deliver effective rehabilitation in a sequential and planned manner. Such measures will utilise overburden and associated rehabilitation material to maximise the establishment of native riparian vegetation along the margins of the waterbody and ensure its long term ecological health.

In recognition of the long term sequential nature of the project, the precise nature of rehabilitation to be implemented following extraction activity is best determined at the end of each stage of development and prior to the commencement of each subsequent stage. This enables a process of responding to site conditions and adapting rehabilitation to optimise effective outcomes which best facilitate the future end use of the site. The foundation concepts and general approaches applied will be continually based on widely accepted best practice implemented as each successive stage is rehabilitated.

This document seeks to establish the overriding objectives and approaches required for successful rehabilitation to facilitate the site's future use. The resultant strategy informs the more detailed measures to be employed during the development and sets out the processes and principles to be followed in stage plans prepared following defined areas of extraction. Such rehabilitation will also include pest plant and animal control, planting and protection and enhancement of significant vegetation detailed in separate plans to ensure that the resulting rehabilitation will meet best practice, such as GWRC's '*So you're thinking about a pond*' document.

In this document the term 'rehabilitation' is used rather than 'restoration'. Restoration implies returning the quarry to its former condition. The nature of a quarry operation is both destructive and extractive meaning that landform and landmass are removed and cannot be restored to their original form. In relation to the proposed Ashford Park extraction activities, the extraction below the water table will also result in the creation of a new waterbody. Despite this, landforms can be

created that are generally commensurate with broader landscape patterns and they can be engineered so that finished landforms are able to support and sustain ecological values which adapt to and enhance this environment.

2.0 Location and Context of Ashford Park

2.1 Location

The proposed extraction activity is located to the east of the existing Ōtaki Quarry between the Ōtaki River and the Ōtaki Maori Racing Club. The existing site is influenced by its use as a former horse stud farm, known as Ashford Park Stud. This includes horse paddocks enclosed by post and rail fencing with linear and specimen shelter tree planting, shallow water features and small remnants of indigenous forest. Occasional dwellings, auxiliary buildings and stables are also present, some of which have been adapted to accommodate alternate uses with others poorly maintained and contributing to an overall unkempt rural character. Low level grazing continues in some areas with sheep, cattle and horses with rough pasture and scrub in other areas. Most of this existing site character will be transformed during extraction activity.

The Ōtaki River is the most prominent river system in the Kāpiti District with distinct terraces, shifting gravel banks and wetland areas. Flood hazard control strategies influence parts of the river margins together with regenerating areas of riparian vegetation and podocarp forest. The river also supports seasonal habitat for fish and bird species and establishes an ecological corridor between the mountains and the sea passing to the south of the site. The Ōtaki Maori Racing Club is located along the northern boundary of the site and includes an open grass setting enclosed by shelter planting and large grandstands accessed off Te Roto Road. Rural lifestyle properties are also scattered throughout the area to the southeast of the Ōtaki Township and includes several dwellings along Te Roto Road and Rahui Road within the vicinity of the site.

2.2 Landscape Context

The site is part of the broader Ōtaki River floodplain which forms an extensive lowland plain extending between the Tararua foothills and the coast. Along the course of the river there is a sequence of river terraces stepping down to the river and these are a distinctive feature of this landscape.

Landforms throughout this area are typically underlain by marine sandstone, as is typical of all other lowland areas through the District. Here the ‘top rocks’ and soils are more obviously influenced by alluvial processes along the varying paths of rivers. To the east of SH1, alluvial processes dominate the landscape and are typified by a gradual sloping plain. The wide braided path of the river distinguishes this area and supports alluvial soil together with large grade gravels and distinct river terraces.

Following a significant period of milling (mainly totara), dairy farming, dry stock and intensive horticulture were established and these remain the predominant land use, setting up strong ‘lines’ in the landscape comprising of fences, shelter belts, irrigation races and drainage channels. The Chrystalls bend CWB extends along the margins of the Ōtaki River in the vicinity of the site and introduces recreation associations along the natural character and amenity values associated with the Ōtaki River.

2.3 Landscape Policy Context

A review of the existing landscape policy context relevant to quarry rehabilitation and within which the proposed impacts of extraction activity has been considered was set out in the Assessment of Landscape and Visual Effects included in Appendix F to the AEE accompanying the resource consent applications. In summary, the following key landscape outcomes are relevant:

- Identify and protect significant indigenous vegetation;
- Preserve natural character and amenity values associated with the Ōtaki River;
- Manage wider potential effects on landscape character within which the site forms a part;
- Manage potential visual effects on the available viewing audience;
- Manage potential effects on the rural character and the quality of the rural environment; and
- Recognise and promote safe cycleways, walkways and bridleways throughout the district including facilitating linkages to important amenities and services.

3.0 Factors Influencing Rehabilitation

Successful rehabilitation requires an understanding of the context and influences within which it will occur. This includes an understanding of the key environmental influences on future rehabilitation. As the site will be progressively rehabilitated, the lessons learned from earlier rehabilitation can be applied to later stages resulting in greater knowledge over time as to the most successful approaches to site rehabilitation.

A brief summary of the key influences relating to Ashford Park is set out below.

3.1 Geology and Soils

The underlying soils are consistent with alluvial gravels and comprise a series of Clayey Silty Gravel and Gravel and cobbles overlaid by topsoil.

3.2 Slope

The existing topography within the wider Ōtaki River floodplain slopes gradually from east to west from approximately 20 metres above sea level (masl) in the site's south-east corner and falling to approximately 15 masl in the site's north-west corner adjacent to Te Roto Road. The fall across the area where gravel extraction is proposed drops by approximately 3 vertical metres to an elevation of approximately 16.5 masl along the western edge of the proposed extraction area. The underlying topography through the site also reveals a series of gentle undulations associated with former river channels. Existing stopbanks associated with flood management of the Ōtaki River adjoin the site's southern and south-western boundaries and introduce more linear elements which frame the site with grass bunds typically formed at a slope of 1(V)/3(H).

Gravel extraction will entail removal of topsoil and underlying gravel from the existing flat site with slopes resulting from extraction typically laid back at 30^{o}. The proposed gravel extraction will include a process of benching the margins of the waterbody to facilitate a more gentle sequence of batters suited for riparian vegetation.

3.3 Vegetation and Ecology

The site is a modified agricultural landscape associated with the existing Ashford Farm Stud. Within the vicinity of the site, riparian planting has also been established along the margins of the Ōtaki River in association with flood plain management works.

The agricultural landscape is predominantly pasture enclosed by tree belt along boundaries and scattered tree groups and specimen trees. The taller tree belts comprise mature pine, poplar and macrocarpa with pockets of mature kohekohe and totara located in the central area of the site in the vicinity of existing buildings. The remaining trees along paddock boundaries predominantly comprise exotic shelter and specimen trees as well as areas of groundcover and scrub, including pest plants such as Tradescantia and blackberry along several paddock margins.

Ecological consultants, Wildlands, has undertaken an assessment of the existing vegetation and habitats occurring within the site[1]. A summary of the findings set out within the ecological assessment are set out below:

3.3.1 Vegetation

Although the small remnants of indigenous forest comprise locally common species, the remnants do have significant ecological value due to their area and maturity; and the rarity of that combination of species, or vegetation type. No threatened or regionally uncommon species were recorded at the site.

3.3.2 Aquatic

There are no aquatic biodiversity values at the site.

3.3.3 Avifauna

Only common bird species were recorded at the site. Indigenous trees present at the site may provide seasonal habitat for mobile species, such as tui.

3.3.4 Herpetofauna

Remnant populations of non-threatened indigenous species could be present including common skink and various gecko species.

3.3.5 Invertebrates

No threatened or unusual species have been recorded from the site with existing habitats unlikely to support a high diversity of indigenous invertebrate species.

3.4 Climate

The predominant winds recorded in this area of the Kāpiti Coast are from the north-west and north-east with frequent winds also occurring from the south and south-east[2]. A wind rose illustrating wind direction for Otaki is included as **Figure 1:** Wind Direction for Otaki *(source: http://www.windfinder.com/windstatistics/otaki)*. The flat nature of the site surrounded by established shelter belts will likely reduce the effect of wind along the boundaries of the site with the potential for wind to build up across a larger open body of water.

The recent range of temperatures in the Kāpiti Coast range between 22^{o} and -2^{o}C in winter and 30^{o} and 4^{o}C in summer with rainfall slightly higher in autumn whilst remaining fairly consistent throughout the year (see **Figure *2***).

[1] Wildlands Consultants (2015) Ecological Assessment of a Proposed Gravel Quarry at Ōtaki.

[2] http://www.windfinder.com/windstatistics/otaki accessed 08/01/16

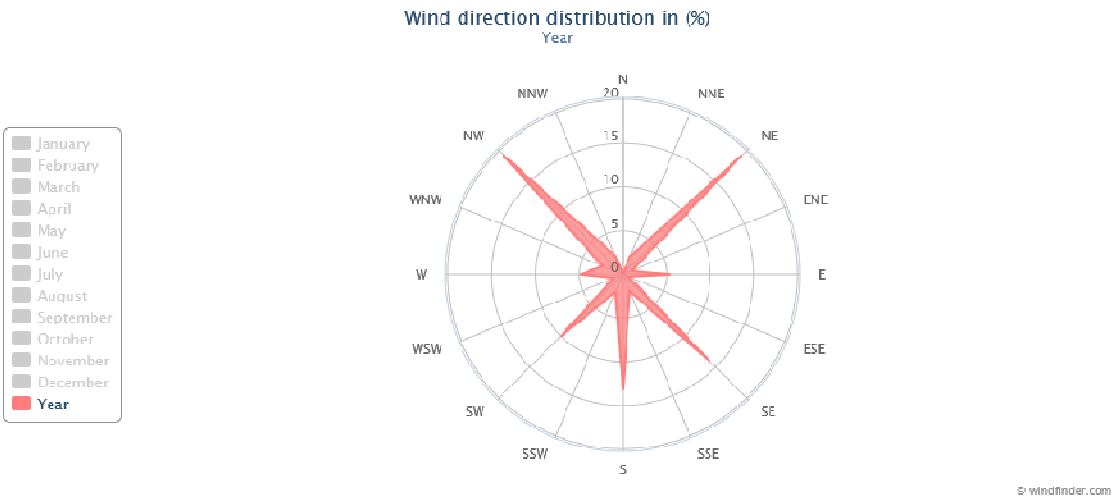

Figure 1: Wind Direction for Otaki (source: http://www.windfinder.com/windstatistics/otaki)

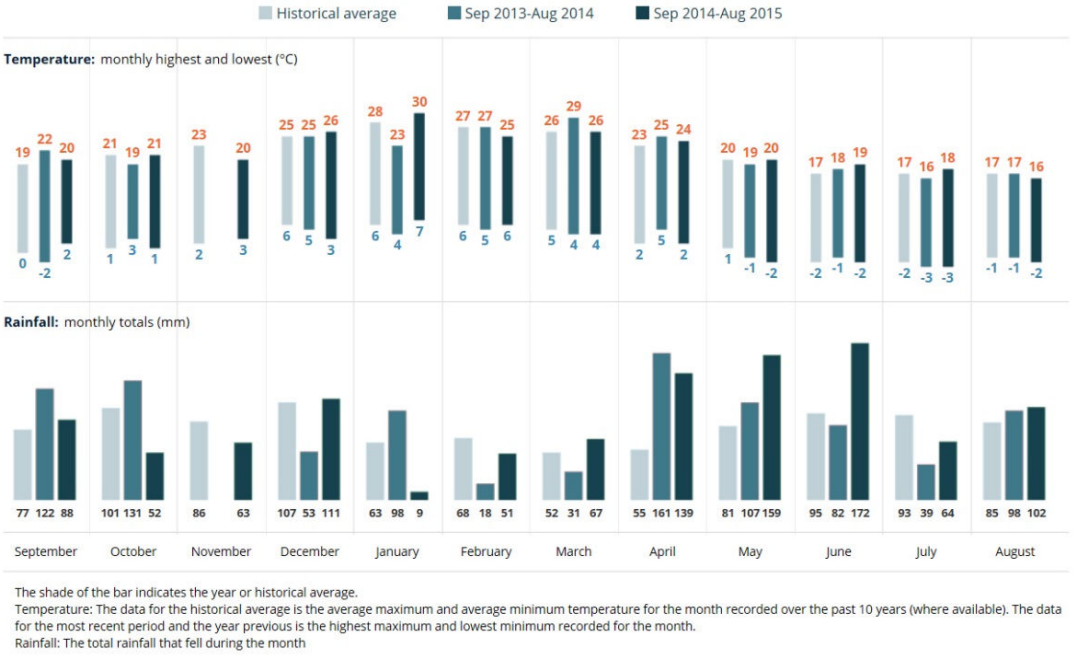

Figure 2: Average Kapiti - Horowhenua Temperature and Rainfall (source: Metservice)

3.5 Broad Design Considerations

There are numerous issues associated with the design of the resulting water body which must be addressed if it is to remain in good ecological 'health'. Such issues are outlined in **Table 1** below with the key design considerations identified for each. Ultimately, the maintenance of good water quality is critical for such activities to successfully (and safely) occur. Ecological considerations should therefore play a primary role in determining the final water body design and in deciding which activities are ultimately compatible without undermining its fundamental health.

***Table 1**: Surmising common issues faced in designing a waterbody and design considerations taking these issues into account.*

Common Issues	***Key Design Considerations***

Common Issues	*Key Design Considerations*
Safety (drowning risk & water quality)	Edge treatment, depth, vegetation/objects in water, contaminants & water quality factors
Weed infestations	Nutrient levels, imported plant pests, exotic/native plant balance, animal communities
Animal levels (fish, birds etc.).	Linked to habitat type & quality, public accessibility to habitat, nutrient & oxygen levels, animal numbers
Algal blooms	Marginal vegetation, light, oxygen, nutrient levels, water temperature & clarity
Insect infestations	Edge treatment/vegetation, water temperature & quality, predator species
Excessive sediment / sludge build-up	Flooding, vegetation, nutrient levels, erosion & run-off
Insufficient holding capacity / water source	Availability of groundwater recharge, extent of waterbody level fluctuations.
Waterfowl Pests	Discouraging destructive swans and geese by having less pasture along waterbody margins.
Nutrient status (low)	Buffering adjacent land use, planting and controlling pest species.

4.0 Rehabilitation Objectives

4.1 Overview

This document will influence the development of detailed plans which will outline the final form of the site following rehabilitation. Within this framework, staged plans will be used to specify rehabilitation procedures, maintenance of indigenous vegetation cover and monitoring to be undertaken as the quarrying activity proceeds. Rehabilitation works will be planned incrementally following each stage of extraction activity whilst responding to site conditions and ongoing extraction activity. On this basis the rehabilitation plan has a timeframe measured in decades with landform modification and revegetation undertaken following each stage of extraction works. Initial rehabilitation activity will be well advanced by the time the last stages of the quarry have been completed.

Because each quarry site is different, every rehabilitation programme requires adaptation in response to results achieved; that is, progressively refining details. This means that rehabilitation programmes usually include techniques to identify the most successful methods and approaches specific to that site to ensure l rehabilitation is optimised, both in terms of reducing time frames to achieve a successful outcome and reducing implementation costs. The strategy recommends one particular approach but it also describes how this could be refined or for other approaches to be adopted based on regular monitoring of results and outcomes. This enables the most efficient and effective measures to be used. This process of 'adaptive rehabilitation' is important because it improves certainty of anticipated outcome as experience from previous stages is acquired and re-applied to the site. Revegetation measures for each area will also vary according to the specific riparian context, exposure and substrate.

4.2 Objectives

The proposed Rehabilitation Strategy will work in an integrated way with the proposed extraction activity over the duration of the quarrying. Rehabilitation works are integral to the operation of the quarry and will be implemented at the completion of each stage of extraction activity. It is, therefore, important that a sequential staging plan is adopted which can be adhered to over the duration of the works. Whilst timing of stage completion can adapt to fluctuations in demand, the sequence of extraction activity forms the basis upon which rehabilitation processes will occur.

The overriding rehabilitation principles as identified with the landscape strategy are set out below:

- Identify, protect and maintain core areas of significant vegetation and associated habitat in the long term;
- Design and manage the final waterbody form to maintain water quality and ecological health;
- Adopt a sequential staged extraction process which allows for progressive rehabilitation across the site;
- Monitoring and controlling pest plants and pest animal during operation and rehabilitation works;
- Create scalloped shorelines along the margins of the waterbody to improve habitat diversity with planting appropriate to the surrounding natural environment;
- Include a combination of edge treatments including vegetation, gravel beaches and hard edges that enhance amenity values and visual interest and provide protection from wave action;

- Ensure large areas of the waterbody are at least 3 metres deep to prevent the water getting too hot in summer;
- Identify, stockpile and manage overburden and top soil during each stage of extraction for subsequent use in rehabilitation of each stage;
- Form planted edges as gentle slopes to accommodate a sequence of native riparian vegetation in accordance with ecological recommendations (Wildlands, 2015); and
- Establish native riparian vegetation to achieve a minimum of 80% canopy cover after 5 years following completion of extraction activity (not restricting structures and activities associated with the waterbody's future use, such as jetties, boat ramps etc.)

4.3 Water Quality

The enclosed nature of water with input from clean water from the river filtered by the gravel within the waterbody means water quality cannot be maintained without a corresponding healthy ecosystem. An ecologically healthy (or oligotrophic) waterbody has clear cool water, low nutrient levels and large leaved aquatic plants.

An unhealthy waterbody usually contains cloudy or dark coloured water with high nutrient levels (mainly nitrogen and/or phosphate) and excessive algal growth. Algae subsequently dies and decomposes in a process which consumes oxygen. This leaves the waterbody in an anoxic (or eutrophic) state which is lethal to aquatic life and cannot easily be reversed.

To prevent this eutrophic state from occurring, nutrient levels within the waterbody need to be kept low; the waterbody needs to be kept cool and aquatic plants need to become established. There are a number of preventative measures that can be taken to ensure a healthy ecosystem is established and water quality is maintained (see **Table 2**).

Table 2 *Showing preventative measures that can be taken to ensure a healthy ecosystem is established and water quality is maintained*

Causes of Eutrophication	**Preventative measures**
Water body heating up speeding up algae growth	Depth of at least 3m in parts to prevent the waterbody from warming which increases bacteria growth.
Nutrient laden sediment inputs via surface run-off	Manage mowing, stock, fertiliser and compost near waterbody margins. Promote edge stability by having low gradient along waterbody margins Drainage from stockpiled topsoil needs to travel away from the created waterbody. Planting initially tough, low fertility nursery plants which do not need rich topsoil for survival. Rehabilitation planting initially concentrated on lower slopes to trap and filter out sediment and take up nutrients.
Ill functioning ecosystem with poor nutrient flow	Create irregular waterbody margins, increasing the amount of submerged/emerged vegetation up-taking nutrients from the water.
Nutrients concentrated within warmer top layer of waterbody which are then utilised with algae growth.	Promote stirring of the water (mixing and dilution of nutrients) with prevailing SE wind, by leaving gaps of taller vegetation on the SE and NW corners of the site.
Invasion of pest fish, through flooding of site and illegal introduction, which input faecal matter stir up bottom sediment and feed on riparian vegetation.	Yearly monitoring of pest fish species for the first 3 years following extraction completion.
Invasion of pest plants.	Yearly monitoring of pest plant species during establishment.
Waterfowl (largely swans and geese) colonising the waterbody inputting nutrient rich faecal matter.	Densely plant margins to encourage indigenous waterfowl and limit grass to deter problem game birds.

4.4 Timeframes

A key objective of the Rehabilitation Strategy is to ensure that rehabilitation works will occur sequentially in response to extraction works. Extraction will create a waterbody which increases in scale throughout the extraction period. The dynamics of ecological regeneration are largely influenced by the following:

- Riparian context;
- Erosion;
- Soils and micro-topography;
- Pest plants
- Pest animals
- Wind and wave action

The time frames required to achieve an effective cover of native vegetation following extraction activity must allow for:

- Discouraging key pest-plant and pest animal species and control those that occur.
- Overburden placement to create benches and riparian margins with suitable substrates for plant establishment;
- Creating and /or adding soil forming materials and/or organic soils to create suitable material for planting or natural regeneration;
- Planting appropriate riparian species and 'nursery' plants to facilitate revegetation of the waterbody margin; and

The goal for rehabilitation is to ensure a minimum of 80% of canopy cover is established in areas identified established as native riparian vegetation after 5 years following completion of extraction activity within the site.

5.0 Proposed Extraction Area and Staged Works

The full extent of the Proposed Extraction Area addressed within the Rehabilitation Strategy is illustrated in **Figure 3**. Extraction activity results in a waterbody being formed below the existing water table and a sequence of riparian margins relative to the final waterbody level formed within the site.

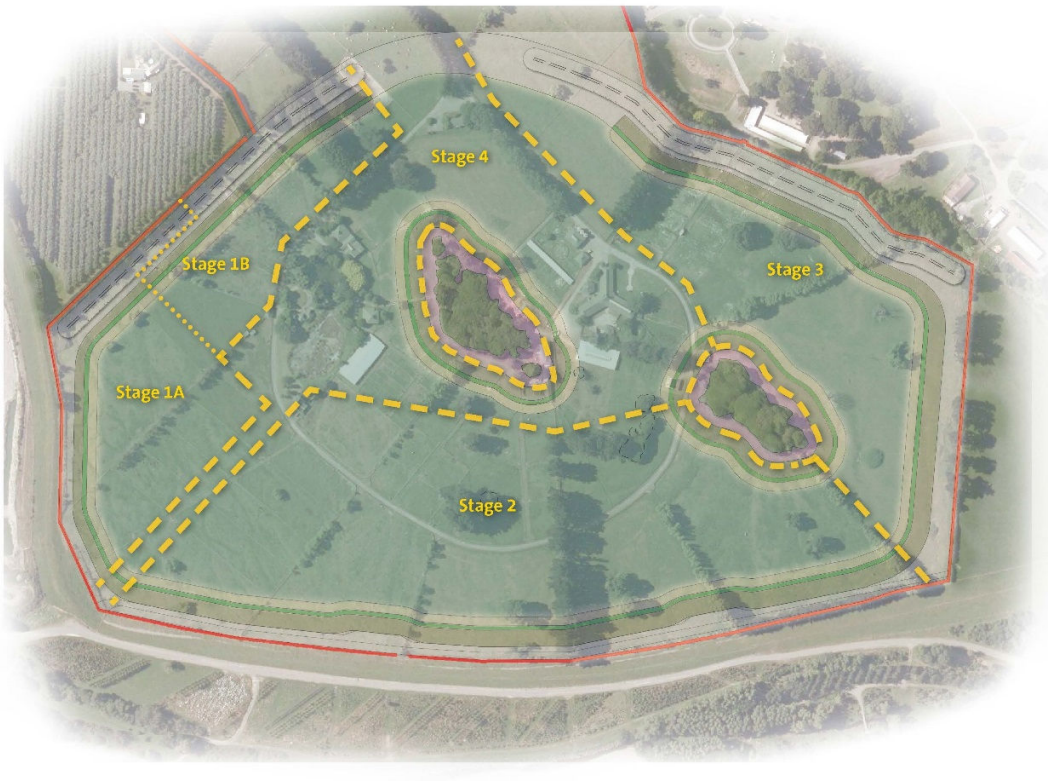

***Figure 3**: Proposed Stages of the extraction area within the rehabilitation strategy.*

Stages 1A and 1B of the extraction commences within the western area of the site and encompasses the creation of a 4 metre high noise bund running parallel with part of the western boundary. Stage 2 continues along the southern boundary towards the south-eastern corner and includes extraction along the southern edge of the proposed eastern island containing remnant native vegetation. During Stage 3, extraction continues parallel with the eastern and northern boundaries of the site and includes the creation of a noise bund with fence adjacent to the northern boundary and completion of the northern edge of the eastern most island containing remnant vegetation. Extraction culminates within the central area of the site during stage 4 and includes the completion of islands of remnant vegetation and removal of a temporary haul road connecting with the existing gravel processing plant.

5.1 Landscape Strategy

The Landscape Strategy has been prepared in response to recommendations set out within the landscape and ecological assessments. This includes retaining and enhancing two separate islands of native vegetation within the waterbody and reinforcing an enclosure of screen vegetation around parts of the site boundary. The overall landscape strategy is illustrated below in **Figure 4**.

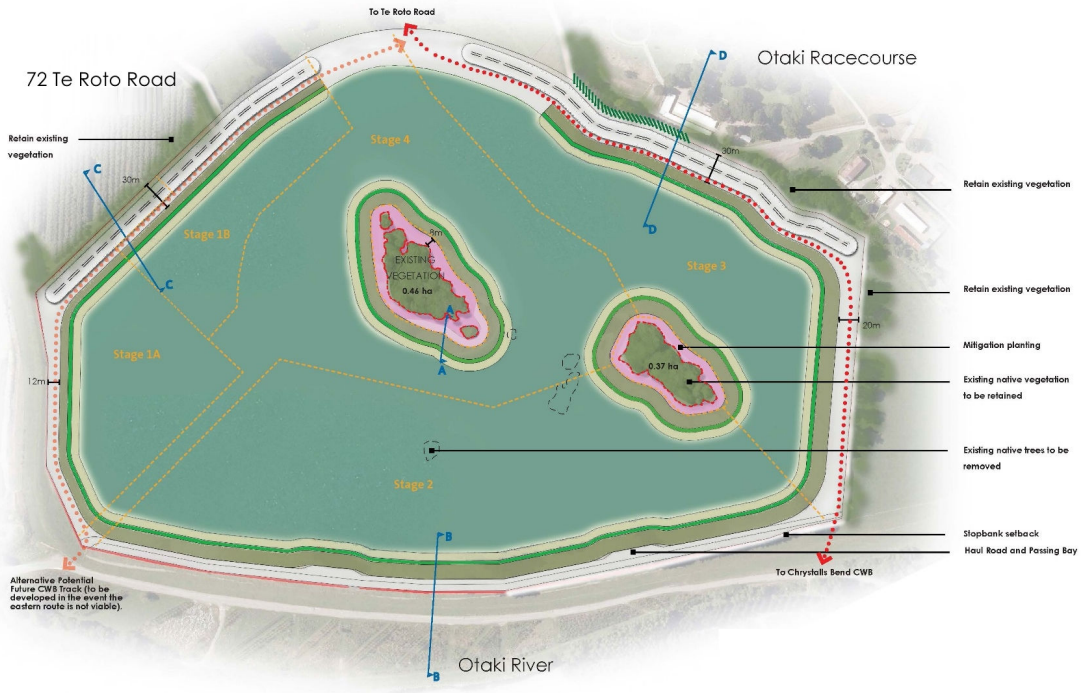

Figure 4: *The overall landscape strategy for waterbody rehabilitation following quarry extraction.*

Key Components of the Rehabilitation Strategy include:

Island Native Remnants
Two separate islands containing remnant kohekohe / totara forest which comprise of a total area of 0.82 hectares will be retained with the centre area of the waterbody.

Island Restoration Planting
In addition to the retention of remnant kohekohe and totara forest a total of 7,960m3 of restoration planting is proposed as part of ecological mitigation to compensate for vegetation loss in association with remnant vegetation retained on islands.

Riparian Vegetation
Riparian vegetation requires a sequence of planting along the margins of the waterbody to ensure the long term ecological health of the waterbody.

5.1.1 Riparian Planting

The treatment of riparian areas forms a key component of the rehabilitation strategy to ensure the long term ecological health of the waterbody. The riparian edge can be further divided into a sequence of wet and dry areas forming three integrated components as summarised below:

Riparian Dry Zone:
Riparian dry zones occupy the upper band of planting established along waterbody margins which are rarely inundated with water. The width of planting in these areas varied according to the distance between the water table and the existing ground level.

Emergent Zone
The emergent zone occurs above the water table along the margins of the waterbody edge of the water table and will partly be inundated with water. Water levels will fluctuate and planting will allow for this

Submerged Zone
The submerged zone occurs below the water table along the margins of the waterbody up to a depth of approximately 3 metres.

As happens naturally in ecological plant systems, between each zone will be an area of species overlap (called an ecotone), where the zones will blend with a gradual decrease of species from one zone, with a gradual increase of species of the next.

In accordance with the staged process of extraction, rehabilitation enables a sequence of rehabilitation to commence following the completion of each stage. **Table 3** below provides an estimate of the riparian area (taking into account topography) as a guide to the exposed surfaces that will form the overall focus of this Rehabilitation Strategy.

Table 3: *Indicative areas of riparian vegetation to be established within each stage.*

Stage	Riparian Dry Zone	Riparian Wet Zone	
		Emergent	Submerged
1	4,584m^2	2,214m^2	4,334m^2
2	12,638m^2	3,451m^2	6,920m^2
3	9,667m^2	2,929m^2	5,904m^2
4	6,582m^2	2,398m^2	5,170m^2
Total	**3.3 ha**	**1.1 ha**	**2.2 ha**

6.0 Rehabilitation Actions

6.1 Vegetation Protection

Remnants of native vegetation provide a vital role in biodiversity and ecological function, also providing shelter and habitat for birds which may encourage further natural seed dispersal. The protection of islands of significant vegetation also forms an integral component within this environment. Prior to the commencement of operations in each stage, the extent of quarry activities will be clearly understood and should include marking on the ground and fencing to prevent accidental removal.

Action:

1. Prior to commencement of extraction works in each stage, ensure that the limits of vegetation clearance are clearly known and understood to prevent vehicle access and unintended vegetation clearance or damage outside approved clearance areas.

6.2 Staging of Extraction Works

Rehabilitation planning that is integrated with extraction sequences will ensure that rehabilitation can commence in areas where extraction activity has concluded as early as possible to ensure the areas of significant vegetation to be retained are maintained and enhanced and the ecological health of the waterbody is maintained. It also ensures that rehabilitation effort is not wasted on areas which will be disturbed again later.

In accordance with consent conditions, before excavation within each stage is completed and before commencing of each subsequent stage of extraction activity (where applicable), a detailed Staged Rehabilitation Plan shall be prepared for the stage that has been extracted in accordance with the overall Rehabilitation Strategy to ensure the operation facilitates a progressive staged rehabilitation process. The detailed Stage Plan shall identify the following:

a. The final form of permanent lake margins to accommodate revegetation for that Stage;

b. timing of the proposed rehabilitation works taking into account operational constraints/requirements (for example, continued use of the haul roads and bunds) and how this will be achieved;

c. The volume of overburden and topsoil necessary to create permanent lake margins;

d. Species, plant numbers and timing of planting to occur;

e. Ongoing maintenance of planted areas to ensure establishment; and

f. Any work necessary to facilitate future recreation access through the site.

Action:

2. Ensure extraction activity adopts a sequential approach to rehabilitation that avoids or mitigates future disturbance of completed areas.

6.3 Vegetation and Soil Removal and Stockpiling

Vegetation and soil removal/stockpiling should occur sequentially at the start of each stage of extraction. Vegetation that is stripped from the site should be re-used in rehabilitation with excess removed from the site, with the exception of the larger native logs to be reserved and offered to Nga Hapū-o-Ōtaki. Larger trees should be stored whole with native branches carried to the forest remnants to facilitate protection of lizards. Chipped material should be stockpiled and applied as mulch to planted areas. The top 200 mm of topsoil forming the pre-quarried ground surface should be kept separate from the underlying overburden materials and subsoil, part of which should be retained for use in rehabilitation[3]. This is important for the successful re-use of the top layers as rehabilitation growth media for establishing effective vegetation cover. Inadequate identification of clean soil resources not only risks good soil becoming mixed with spoil or contaminated materials, thereby restricting or preventing its re-use, but may also result in the need to import soil, logs or mulch for planting and rehabilitation works and increase the cost of the project.

Topsoil stockpiles need to be in suitable locations within the quarry where they will not be subject to compaction by machinery. Such material also contains a higher level of nutrients which must be stored in an area or manner which prevents nutrient laden sediment run off from entering the waterbody and subsequently affecting water quality. Topsoil stockpiles should generally be no higher than 1.5 metres height (to prevent anoxic conditions forming within the stockpile core which depletes nutrient and beneficial microbial activity levels). Stockpiles should also be grassed to stabilise and reduce dust. The process of rehabilitation needs to ensure that any topsoil is stored for as short as time as possible to prevent deterioration. This will entail a coordinated programme of stripping, storage and re-spreading as required.

In addition to top layer and mulched vegetation there are un-saleable or low value quarry by-products such as overburden, grit and sludge, which can be used in the preparation of benching along the margins of the waterbody during rehabilitation. During extraction, a sufficient volume of overburden required for rehabilitation will need to be stockpiled to enable landform modification at the end of each stage of extraction. Internal stockpiles not to exceed 5 metres in height and be sited to minimise visibility from surrounding areas.

It is important that sufficient material is retained on site to facilitate rehabilitation at the completion of each stage. At the completion of Stage 4, material stockpiled in noise bunds can support subsequent landform modification along waterbody margins.

[3] With the exception of material from contaminated areas to be removed from the Site in accordance with consent conditions.

Action:

3. Store the larger native logs to be offered to Nga Hapū-o-Ōtaki. Lay branches from native trees in the forest remnants and chip and stockpile mulch for re-use as rehabilitation. Remove remaining areas of vegetation from the site.
4. Where practicable, separate the top 200 mm of surface soils from subsoil and underlying overburden and store separately.
5. Store topsoil material in such a way where nutrient laden sediment from stockpiles will not enter waterbody through surface runoff.
6. Ensure sufficient substrate and topsoil material is stored during operation to undertake landform modification as part of rehabilitation within completed areas.
7. Locate all stockpiled material within the site to minimise visibility from external areas and establish grass during operation to stabilise and minimise dust.

6.4 Riparian Margins - Landform Modification

Landform modification is part of the overall operation and will be implemented progressively as each stage of extraction activity is completed. Whilst the end use of the site is yet to be established, the final landform modification must ensure it enables native riparian vegetation which sustains a healthy ecosystem which enables native riparian vegetation to be self-sustaining and provide diverse habitat for native animals as well as support a range of future end uses.

The steep waterbody margins created following extraction are a limiting factor to successful establishment of healthy riparian habitats. Through the process of rehabilitation the slope gradients will be reduced by benching resulting in a relatively gently sloping edge which is capable of supporting a sequence of vegetation communities (see **Figure 4**). The lower bench to be formed at an average gradient of 1:8 and accommodate a variation in water depth up to 1.5 metres. This should typically allow for approximately 1/3 emergent and 2/3 submerged areas in response to the final water level. Above this, the remaining 'dry' waterbody margin should be formed at a gradient no steeper than 1:3 to reduce erosion and facilitate effective revegetation of dry tolerant low fertility species.

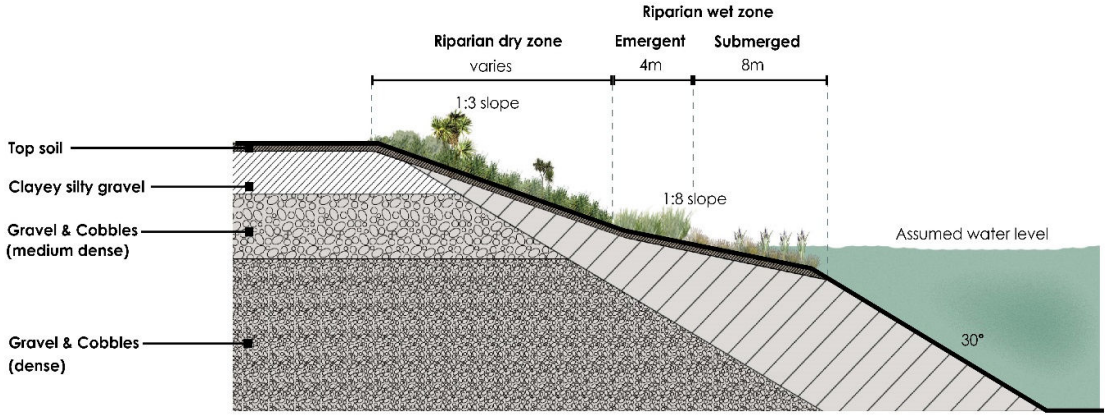

Figure 5: *Showing slope margins to be created in order to rehabilitate the edges of the waterbody*

In addition to forming gentler benching along the margins of the waterbody, the design of the edge needs to include irregular shaped convoluted margins, and shallows of differing depths (see **Figure 6**). Varying humps and hollows along benches will also promote the establishment of a richer diversity of habitats along the margins. These areas can be further enriched by creating small gravel banks and placing large exotic trees felled in the initial stages of land clearance (where possible) at points along the banks margins. This increases the diversity and extent of habitat available to edge plants and to future fauna (birds and insects). Planting should not restrict margins and structures which support complementary end uses of the site.

Figure 6: *Showing irregular convoluted waterbody margins which increase diversity and extent of habitat available.*

Action:

8. Ensure that the final landform will facilitate a sequence of native riparian vegetation communities and diverse range of physical habitats, both above (terrestrial) and below (aquatic) the waterbody.

6.5 Ground Preparation

Ground preparation is a key element of successful rehabilitation to achieve landform stability and support riparian planting which complements future uses within the site. With good planning, most material can be sourced from the site and does not need to rely on imported material. Observations and results through subsequent stages of rehabilitation will enable the best approach to be developed and refined.

The layering of a suitable substrate and growing medium needs to be determined for each of the delineated vegetation community zones relative to the water's edge (riparian dry zone, emergent and submerged) as well as the planting surrounding the remnant native vegetation on the islands (shown in **Figure 5**). The growing medium used will dictate the type of planting to be established. The substrate should be stabilised as each section of waterbody benching is completed to reduce erosion and runoff depositing sediment into the waterbody. Coarse aggregates, overburden and surface soils to be applied to waterbody margins as part of the rehabilitation process.

Use of topsoils sourced from within the site for rehabilitation purposes are expected to generate a high germination rate of exotic pasture and other species, at least initially. Some exotic weed species which are common along riparian areas including tree lupin (Lupines arboreus) are also likely to establish in some areas. However if managed correctly, this can be beneficial to rehabilitation goals in providing an initial nursery environment which improves the survival of desired mid-seral native vegetation. The presence of pest plants such as buddleia (*Buddleja davidii*), climbing asparagus (*Asparagus scandens*) and Banana passionfruit will need to be eradicated.

In the short term, hydroseeding or other alternatives such as straw mulch and grass seeding may also need to be employed to help stabilise lake margins, reduce runoff and erosion, bind soils to prevent dust problems and inhibit invasion by some pest plants. Providing suitable environmental conditions prevail, hydroseeding needs to be carried out very soon after completion of preparatory works and before batter slopes dry out. Coordinating the hydroseeding with creation of benches is important to ensure that this is completed during an appropriate planting season. Summer months should be avoided as hydroseeding is unlikely to be affective during dry periods.

This Rehabilitation Strategy seeks to make use of site sourced soil at Ashford Park in two key ways:

1. Establish stable benching along the margins of the waterbody; and

2. Support a sequence of fast-growing, dense native riparian vegetation which achieves 80% canopy cover in 5 years following completion of extraction.

Action:

9. Using available substrate, establish stable benching and slopes along waterbody margins following extraction activity.

6.6 Surface Run-off

Surface run-off needs to be considered within the final waterbody form to prevent scouring and erosion across benches and down slope faces and causing damage to rehabilitation works. Erosion and scouring of rehabilitated landforms may disrupt stable post-quarrying environments, affecting plant establishment and safety along lake margins in future years. Drainage paths incorporated within the margins of the waterbody must prevent nutrient laden sediment deposition into the waterbody and instead identify flow paths which allow the slow release of water filtered through dense riparian vegetation.

Action:

10. Ensure surface run-off is included as part of the landform modification process to prevent scouring and erosion of adjacent vegetation and rehabilitated landforms and run-off from catchment area does not carry sediment laden water into the waterbody body.

6.7 Noise Bunds

During the initial stages of operation, noise mitigation bunds up to 4 metres will be constructed along parts of the western and northern boundaries from material extracted from within the site. Such areas should use clearly differentiate between soil types used so that material can be appropriately reused in subsequent rehabilitation at the completion of stage 4 in combination with a functional benefit throughout the operational period. To stabilise noise bunds and to reduce dust during extraction noise bunds should be grassed immediately following their establishment and mown during operation.

Action:

11. Noise bunds to be grassed immediately following establishment to stabilise and minimise dust during extraction activity and maintain viability for subsequent reuse in rehabilitation works.

6.8 Island Rehabilitation

Two areas of remnant native vegetation will be retained within the centre of the site. The protection of this vegetation is necessary as these areas gradually become islands contained within a larger waterbody as extraction activity progresses. The retention and enhancement of islands of native vegetation forms a key mitigation measure and will help reinforce significant ecological values within the site. This work is to be detailed in a separate Ecological Island Plan required as suggested in the draft consent conditions.

Pest plants on the forest islands will also be controlled and all planted sites will be fenced from grazing stock prior to the creation of islands. Together with the pest animal control described in Section 7.0 these actions will result in the regeneration of a natural, indigenous seedling population, understory, sub-canopy and canopy with a diverse array of species. Without the threats posed by pests, these forest islands will thrive, providing enhanced habitat for indigenous birds and insects. In turn this will enhance connectivity for the forest remnants along the Ōtaki River riparian area.

Planting to restore the forest tree species that will be lost during extraction will be undertaken in canopy gaps and within an eight metre wide buffer strip around the margins of the islands (see **Figure 4**). This is proposed to occur throughout the gravel extraction operation and includes riparian margins formed during Stages 2, 3 and 4. Once completed, this will enable planting an area of 4,920 m^2 on the western island and 3,040 m^2 on the eastern island. Plants to include eco-sourced kohekohe, tītoki, and tōtara together with a mix of other species that commonly occur in similar forest remnants (see **Table 4**).

Revegetation planting is quite different to what would be carried out under a 'normal' horticultural planting regime; in principle it is more akin to forestry planting. In addition, each site will have unique features and combinations of soil, slope,

moisture, sun and wind. On all areas that are planted as part of island enhancement, the following practices to be adopted:

- Planting needs to be well planned so that the appropriate vegetation communities are planted at the right time. Usually a two year lead time is required to enable sufficient quantities of appropriate locally sourced plant species to be propagated;
- Species will be sourced from local plant populations to ensure that they are ecologically compatible and suitable for the environs (i.e eco-sourced);
- All plants will be suitably acclimatised to local conditions prior to planting. If plants are propagated outside the Wellington district this may involve bringing them to a suitable holding area or nursery several months before they are planted;
- Small grade plants will be used (i.e. up to PB3 or 1L grade) because they will acclimatise and establish more readily than larger grades;
- Areas to be planted may need to be spot sprayed with a contact herbicide or openings to reduce local competition for light and resources as part of site preparation prior to any planting works;
- If necessary plants will receive locally applied fertiliser (e.g. fertiliser tab and be marked with a stake to facilitate identification in the future;
- Where planting sites are devoid of any woody vegetation, plants are densely planted (i.e. 1.0 m centres) with the objective of attaining 'canopy closure' as quickly as possible (i.e. the sooner plants coalesce from pest plants and other unwanted plants). Where planting sites are within established native nurse crops, plantings are at low density (i.e 3.0 m centres) using key pioneer species, given that survival rates are typically much greater than open ground plantings; and
- Plants are generally planted in a coherent pattern that is easy to locate in the future during follow up maintenance work and so that the level of plant survival can be easily determined.

On an exposed site, maintenance work will initially involve replacing dead plants ('blanking') and cutting back / removing unwanted and competing species. Infill planting may also be required at years 1, 2 and 3 to ensure mitigation planting becomes established. Where planting is undertaken, maintenance will be programmed and costed for at least the first three years after planting; after that plants will likely be well established and self-sustaining. An appropriate mechanism is also required to ensure the islands re protected in the longer term such as a QEII covenant (or similar).

Restoration plant species proposed in association with island enhancement, as identified in Wildlands Assessment[4], are listed in **Table 4**. All of these species are present within the surrounding landscape and can be sourced locally from naturally occurring populations to provide material for propagation.

Table 4 *Plant Selection for Restoration Planting (Wildlands, 2015)*

Scientific Name	**Common Name**
Alectryon excelsus	Tītoki
Beilschmedia tawa	Tawa
Brachyglottis repanda	Rangiora
Coprosma areolata	Thin leaved coprosma
Coprosma crassifolia	
Coprosma rhamnoides	
Coprosma rotundifolia	
Dicksonia squarrosa	Whekī
Dodonea voscosa	Akeake
Doxysylum spectabilie	Kohekohe
Elaeocarpus dentatus	Hinau

[4] Wildlands (July 2015), Ecological Assessment of a Proposed Gravel Extraction at Otaki.

Geniostoma ligustrifolium	Hangehange
Hedycarya arborea	Porokaiwhiri, pigeonwood
Knightia excelsa	Rewarewa
Lophomyrtus bullata	Ramarama
Lophomyrtus obcordata	Rōhutu
Melicope ternata	Wharangi
Melicope simplex	Poataniwha
Melicytus ramiflorus	Māhoe
Microlaena stipoides	Bush rice grass
Myoporum laetum	Ngaio
Myrsine australis	Māpou
Neomyrtus pedunculata	Rōhutu
Nestegis lanceolata	White maire
Nestegis montana	Narrow leaved maire
Olearia rani var. *colorata*	Heketara
Pennantia corymbosa	Kaikomako
Piper excelsum	Kawakawa
Pittosporum eugenoides	Tarata, lemonwood
Pittosporum tenuifolium	Kōhūhū, black matipo
Podocarpus totara	Tōtara
Pseudopanax crassifolius	Horoeka
Streblus heterophyllus	Tūrepo, small leaved milk tree

Action:

12. Island rehabilitation should be detailed in a separate plan which includes specifications associated with vegetation protection, landform modification, planting as well as a monitoring and maintenance programme.
13. Facilitate provision for future ongoing protection of the Ecological Islands once fully established.

6.9 Riparian Planting

Riparian vegetation is required around the islands of native vegetation and around the perimeter of the created waterbody. The goal for rehabilitating these areas is to ensure native riparian vegetation achieves a minimum of 80% canopy cover after 5 years following completion of gravel extraction within the site. As set out in the long term vision, the purpose of revegetation is: *"To facilitate the successful rehabilitation of quarried areas in a manner that will retain and enhance native species on islands and thriving native riparian vegetation along waterbody margins to maintain water quality and long term ecological health"*. This will also enable the extracted area to become re-integrate into the surrounding restored areas of the Ōtaki floodplain.

The key drivers for revegetation design can be summarised as follows:

- To maintain water quality within the waterbody body to ensure a healthy (in function and structure) native ecological system;
- To plant appropriate eco-sourced species suited to site conditions; and
- To assimilate the quarried site within the larger Ōtaki floodplain landscape.

The Rehabilitation Strategy provides a framework for refining rehabilitation works and plant schedules over time and requires that planting plans be adapted for each subsequent stage of rehabilitation (as they become available). This allows knowledge to be gathered and applied throughout the rehabilitation process so that ground preparation and planting can be refined to deliver the most effective outcome. This also and allows managers to accurately predict the future performance of native vegetation cover being established to achieve as full coverage on the site as feasible.

Riparian planting is required to encourage consistent, fast and high quality native vegetation cover over the rehabilitated waterbody margins. The approach taken should allow for one planting event per stage to establish pioneer species suited to the riparian habitat and followed by infill planting comprising of early seral plant species advancing towards a suitable

climax community. The management of pest plants and pest animals during operation forms a key element to enhance the success of planting.

During the initial stages of rehabilitation, there is scope to test differing site preparation treatments to optimise the adaptive management process throughout rehabilitation works. Following ground preparation outlined in Section 6.5, different soil conditions can also be tested to ensure a higher degree of plant survival. The restoration plantings nearby of the Otaki River margins and the oxbow at Chrystalls Bend and the success and growth rates of those plantings are also a useful tool to illustrate what planting methods and species have been successfully adopted within nearby restored areas.

6.9.1 Riparian Wet Zones

Riparian wet zones occupy the lower margins of the waterbody and include both seasonally and permanently inundated wetland areas. Planting within the riparian wet zone is required to respond to the final level of the waterbody and will comprise predominantly of sedges and rushes followed by enrichment planting. Plant species which are appropriate to the riparian wet zone areas are set out in **Table 5,** separated into emergent (above the water line) and submerged (below the water line) areas.

The nature of quarrying activity below the water table will mean that the resultant waterbody will experience significant periods of turbidity during adjoining extraction activity. This will result in a dynamic turbid environment within which light frequently cannot penetrate below the water surface. Planting undertaken within riparian wet zones, including areas permanently inundated, should therefore extend no deeper than the ability for plants to remain above the water surface and gain enough light to survive. True aquatic plants which are entirely submerged can only be added after stage 4 works are complete and sediment has settled out of the water column.

The establishment of riparian wet zone planting will require a suitable growing medium which accommodates plants whilst preventing nutrients being lost and deposited within the waterbody. Within submerged areas, this may require containers or cages accommodating initial areas of planting to enable it to become established. In addition, erosion along the edge of the waterbody, particularly the south western margin facing the predominant wind, will need structures such as fallen trees, or boulders in place to prevent waves from eroding the bank preventing plant establishment. Testing the effectiveness of these structures needs to be included during the early stages of rehabilitation and adapted throughout the rehabilitation process.

Planting within the riparian wet zone should generally be undertaken in mid-late summer when the waterbody level is likely at its lowest level under the supervision of a suitably qualified ecologist or landscape architect. Plants will then have time to establish before becoming increasingly inundated during the following autumn / winter period. Over time, planting which is undertaken within the emergent area and extending into the margins of the submerged zones is expected to colonise the submerged shelf, therefore limiting the need to undertake subsequent infill planting in these areas.

Planting needs to be well planned so that the appropriate vegetation communities are planted at the right time. Usually a two year lead time is required to enable sufficient quantities of appropriate locally sourced plant species to be propagated. The following practice should be followed:

- Species to be sourced from local plant populations to ensure that they are ecologically compatible and suitable for the environs (i.e eco-sourced);
- All plants to be suitably acclimatised to local conditions prior to planting. If plants are propagated outside the Wellington Ecological District this may involve bringing them to a suitable holding area or nursery several months for hardening off and acclimatising before they are planted. Any holding area will need to ensure that wetland plants remain in a moist environment which prevents potential damage from drying out during transportation and prior to planting;
- Small grade plants will generally be used (i.e. up to PB3 or 1litre grade) because they will acclimatise and establish more readily than larger grades;
- Plants should be densely planted (i.e. 0.75 m centres) with the objective of attaining ‘canopy closure’ as quickly as possible (i.e. the sooner plants coalesce to exclude weeds); and

- Plants are generally planted in a coherent pattern that is easy to locate in the future during follow up maintenance work and so that the level of plant survival can be easily determined; and

Planting established within the wet zone should be selected from the following list:

Table 5: Plant Selection for Wet Zone Areas

Scientific Name	Common Name	Emergent	Submerged
Austroderia toetoe	Toetoe	✓	
Carex buchananii	Buchanans sedge	✓	
Carex lessoniana	Spreading swamp sedge	✓	
Carex maorica	Maōri sedge	✓	✓
Carex secta	Pūrei	✓	✓
Carex virgata	Pūkio	✓	✓
Eleocharis acuta	Sharp spike sedge		✓
Eleocharis gracilis	Slender spike sedge		✓
Eleocharis sphacelata	Kutakuta		✓
Isolepis prolifera		✓	
Juncus australis	Leafless rush, wīwī	✓	
Juncus pallidus	Giant rush	✓	
Juncus planifolius	Grass leaved rush	✓	
Juncus sarophorus	Fan-flowered rush	✓	
Luzula picta var. *picta*		✓	
Machaerina tenax		✓	
Melicytus ramiflorus	Māhoe	✓	
Phormium tenax	Swamp flax	✓	✓
Schoenoplectus tabernaemontani	Kuāwa		✓
Schoenus maschalinus	Dwarf bog rush	✓	✓
Sparganium subglobosum	Mārū		✓
Typha orientalis	Raupō		✓
Coprosma robusta	Karumu	✓	
Coprosma tenuicaulis	Swamp coprosma	✓	

6.9.2 Riparian Dry Zones

The upper margins of the waterbody require dry tolerant species recognising that these riparian areas are rarely inundated with water. In addition, each site will have distinctive attributes and combinations of soil, slope, moisture, sun and wind which will influence growing conditions. It is also functionally important that erosion and runoff is minimised in this area to prevent excessive nutrients being deposited along margins and within the waterbody. This may initially require hydroseeding to bind more nutrient rich topsoils where employed.

During the initial stages of rehabilitation, a combination of passive rehabilitation entailing direct seeding and active rehabilitation applying direct planting are recommended. This will help inform optimum plant establishment across the site during subsequent stages.

6.9.2.1 Direct seeding

Passive rehabilitation generally takes longer to establish than more active planting methods, however given the long term sequential process through which rehabilitation will occur, this can provide a relatively cheap and effective supplement to hand planting techniques. Understanding the process and timeframes associated with passive rehabilitation will also provide a useful baseline to measure against alternate more intensive methods of revegetation.

The process of direct seeding requires initial ground preparation as set out in Section 6.5. Seed should be dispersed across scarified bare ground and can include layering. Species employed should typically comprise hardy, dry tolerant species which naturally establish in recently disturbed nutrient deficient soils. Manuka branches can also be used to support a microclimate that limits competing plant growth. As with any planting project, usually a two year lead time is required to enable sufficient quantities of appropriate locally sourced seed to be made available as identified in **Table 6**.

Once seeding is undertaken, management will be necessary during establishment in order to ensure a trajectory to the desired endpoint (native vegetation community of 80% cover in 5 years after extraction completion) is achieved. Pasture grasses and other agricultural weeds will likely establish rapidly and before any of the desirable native riparian vegetation and sometimes is not conducive to the establishment of native plants. During establishment, native seedlings will need to be identified and released to enable native vegetation to become established. Ecological weeds and animal pests will also need to be managed during establishment in accordance with a pest plant and animal plan. A person with proven ecological/horticultural expertise will be required to oversee this work.

Direct seeding should be timed to occur within autumn or spring planting seasons and follow the initial scarification of the ground to ensure a micro-habitat is present for a diversity of seedlings and spores to establish. Annual monitoring and maintenance will be necessary following seeding to prevent competing plants suppressing the establishment of desirable species. As noted above this is likely to require additional management compared with direct planting methods. Direct planting may be required in areas which direct seeding results in limited success.

6.9.2.2 Direct planting

Direct planting can provide more rapid establishment of revegetation and limit management. Planting needs to occur within a suitable growing minimum which should include a minimum of 300mm topsoil following ground preparation as identified in Section 6.6. Compared with direct seeding techniques, the use of more nutrient rich soils should be followed by hydroseeding with grass or similar alternative to bind soils and minimise runoff entering the waterbody.

Areas to be planted should be spot sprayed with a contact herbicide to reduce local competition for light from other colonising nursery species as part of site preparation prior to planting. Small grade plants should be used (i.e. up to PB3 or 1litre grade) because they will acclimatise and establish more readily than larger grades. Plants should also receive locally applied fertiliser (e.g. fertiliser tab or slow-release granules) and the areas of planting marked on site with painted stakes to facilitate identification for future maintenance. Plants should be densely planted (i.e. 1.0 m centres) with the objective of attaining 'canopy closure' as quickly as possible (i.e. the sooner plants coalesce to exclude weeds).

Areas of planting need to be well planned so that the right vegetation communities are planted at the right time (generally from the beginning of June to the end of August). Appropriate species can be drawn from **Table 6** below:

Table 6: Plant Selection for Riparian Dry Zone (Wildlands, 2015)

Scientific Name	Common Name	Suitable for Direct Seeding
Coprosma areolata	Thin leaved coprosma	
Coprosma crassifolia		
Coprosma repens	Taupata	
Coprosma rhamnoides		
Coprosma rotundifolia		
Dodonea voscosa	Akeake	
Doxysylum spectabilie	Kohekohe	
Elaeocarpus dentatus	Hinau	
Geniostoma ligustrifolium	Hangehange	
Hedycarya arborea	Porokaiwhiri, pigeonwood	
Knightia excelsa	Rewarewa	
Leptospermum scoparium	Manuka	
Lophomyrtus bullata	Ramarama	
Lophomyrtus obcordata	Rōhutu	
Melicope ternata	Wharangi	
Melicope simplex	Poataniwha	
Melicytus ramiflorus	Māhoe	
Metrosideros robusta	Northern Rata	
Microlaena stipoides	Bush rice grass	
Myoporum laetum	Ngaio	
Myrsine australis	Māpou	
Neomyrtus pedunculata	Rōhutu	

Scientific Name	Common Name	Suitable for Direct Seeding
Nestegis cunninghamii	Black Maire	
Nestegis lanceolata	White maire	
Nestegis montana	Narrow leaved maire	
Olearia rani var. *colorata*	Heketara	?
Ozothamnus leptophyllus	Tauhini	?
Pennantia corymbosa	Kaikomako	
Piper excelsum	Kawakawa	
Pittosporum eugenoides	Tarata, lemonwood	
Pittosporum tenuifolium	Kōhūhū, black matipo	?
Podocarpus totara	Tōtara	
Pseudopanax crassifolius	Horoeka	
Streblus heterophyllus	Tūrepo, small leaved milk tree	

Action:

14. Apply a combination of passive and active revegetation technique to optimise rehabilitation outcomes.
15. Monitor rehabilitation to inform future rehabilitation, including planting programmes.

6.10 Pest Control

All revegetation work requires some maintenance; plants will most likely need to be 'released' from competing unwanted species, particularly those that are considered ecological weeds, such as invasive woody weeds, smothering grasses or climbing vines. Pest animals can also compromise the success of rehabilitation works, such as animals identified as problems within the current Ashford Park site including rats (Rattus spp.), brushtail possums, mice, mustelids and hedgehogs (Wildlands, 2015). Once established, the creation of a large waterbody also introduces potential for waterfowl and fish species to disrupt a functioning ecosystem and may need to be considered as part of the future management of the site as its future use is established.

6.10.1 Pest animals

Given the creation of two vegetated islands within a created waterbody, it is highly practicable to effectively control and eradicate mammalian predators. This will result in greatly enhanced habitat for forest birds such as kereru and tui, and also wetland birds such as bittern and crake, once riparian habitat is established along their periphery.

Guiding principles for pest animal control and eradication were identified within the Ecological Assessment supporting the application[5]. This recommends that the pest animal control and eradication plan will include but not be limited to the following:

a. Details of the suitably qualified and experienced person(s) who will be implementing the plan;

b. Design for a survey for pest animals using standard protocols which may include, but not be limited to, chew tags, traps and tracking tunnels;

c. Recommendations arising from the survey including which species will be controlled and to what level, and which can be eradicated;

d. Details of methods for the control and eradication of pest animals;

e. Timeframes associated with the control and eradication programme;

f. Details of any post-control monitoring to confirm control levels; and

g. Details of likely reinvasion scenarios and recommendations for any on-going monitoring or control.

The implementation of the pest animal and eradication control plan may require several years of repeat control before pest animal numbers reach recommended levels. Protection of islands of remnant native vegetation with reinforcement

[5] Ibid, Appendix 8

planting provide a key element of mitigation. Pest management undertaken in relation to the islands may also need to be detailed in a future management plan once established to ensure ongoing protection.

Monitoring and control of pest animals within the riparian margins will also need to occur where pest animals (such as rabbits or geese) are causing damage to the riparian plantings. Mammalian predator control on these areas will also help to alleviate invasion by swimming to the forest islands.

6.10.2 Pest plants

During the establishment of native riparian vegetation, management of pest plants will form a key element of work to ensure the objective of achieving a successful canopy cover. This will entail releasing plants from competing pioneer species during plant establishment alongside eradication of ecological weeds to be controlled under statutory documents (e.g. Regional Pest Management Strategy).

For direct planting of fast growing species, releasing may only be necessary in the first year or establishment, but slower growing species and direct seeding may require releasing for up to 3 years. Where direct seeding is used, management should also recognise that native seeds may take some time to germinate when the right conditions prevail and often not during the first year.

In addition to active weed management, mulching involves spreading loose, readily permeable material, such as wet straw and sawdust around newly planted shrubs to protect the roots and trap moisture. Mulching should only be done when soil is moist. This can control weed growth as well as reducing loss of moisture from soil helping to keep shrubs alive during a dry summer or drought.

Action:

16. Prepare a pest animal eradication and control plan prior to commencing extraction activity.
17. Release native planting from competing pioneer species during establishment to enhance the success of native riparian vegetation.
18. Control the establishment of ecological weeds during rehabilitation works.

6.11 Animal habitat rehabilitation

When excavation has ceased and rehabilitation of the area is near complete, some faunal species introductions can be made, either as additional enhancement, or as an adaptive management tool to issues that may arise from rehabilitation (if required). Given that the waterbody has been newly created and lacking in competitive pest species this is an ideal opportunity to easily introduce native fauna, thereby creating an intact and functioning ecosystem. This will also depend on the end use of the site and may need DoC and MPI permits.

6.11.1 Fish

In addition to tadpole of species, native fish will feed off the insect population which will develop within the riparian vegetation. Banded Kokopu, and common bully are two species which may be suitable for relocation into the created waterbody once riparian vegetation is established.

Native eel species, will with time colonise the waterbody, during floods and the wet winter months, travelling overland from nearby waterways.

6.11.2 Freshwater Mussels

Another species found naturally within New Zealand freshwater waterbody systems are the New Zealand freshwater mussel or Kakahi – Echyridella menziesi. Kakahi are filter feeders and are now classified as threatened. The mussel has a

parasitic larval stage in which they live on the gills of a galaxid fish. This reliance means that kakahi must be introduced with established populations of native galaxids. Such introduction should be considered in consultation with DoC and MPI.

6.11.3 Birds

Birds are expected to colonise themselves within the rehabilitated area once habitat is established and pest animals controlled. Investigation into encouraging colonisation of specific birds may be achieved by creating desired habitat by growing bird food plants and creating shingle banks, for example creating unvegetated shingle banks on the leeward side of the islands for banded dotterel, raupo swards for bittern laying logs at the shoreline and semi submerged large trees as shag roosts.

Action:

19. Investigate animal habitat restoration and introductions as integral component of rehabilitation and long term ecological health.

7.0 Monitoring and Review

7.1 Monitoring background

On-going annual monitoring will be essential so that:

- Trends can be recognised early and optimised (e.g. recognising more favourable micro-sites or the most successful plant species for revegetation);
- Pest problems (plant and animal) can be dealt to when signs are first observed (e.g. pulled seedlings while still young); and
- The effects of changeable climatic conditions can be managed (e.g. delaying planting in drought years).

During establishment, monitoring should consider key aspects of the project to ensure successful rehabilitation outcomes. This shall encompass erosion, water quality, and pest management

Monitoring and appropriate management responses will form part of the rehabilitation documentation. Whilst some management measures need to be in place at the outset, for others monitoring will be required to decide what action needs to be taken and when during the establishment. This may be simply a matter of refining the rehabilitation method used or it may require more significant alteration of the method and timing of subsequent rehabilitation works. Site management will be tailored to progress from year to year. Monitoring programme must be simple, concise, easily repeatable and where possible able to be carried out by suitably trained staff and volunteers.

During establishment, monitoring inspection would result in an annual report that covers:

- Identification of successes of past and previous year;
- Identification of deficiencies or inadequacies including water quality, pest plants and animals;
- Identification of erosion resulting from wave action within the waterbody;
- Identification of opportunities to remedy identified issues; and
- The programme for the coming year.

Comprehensive record keeping will be important and allow the accumulation of knowledge. This will result in increased efficiency and reduced costs over the life of the rehabilitation project. Progress photographs, including aerial photography and photographs taken from key vantage points looking towards the site can be a valuable monitoring tool.

7.2 Monitoring programme

Monitoring and associated site management will include the following:

- Extent of areas rehabilitated;
- Observations of finished landform stability, including erosion along lake margins and small-scale slumping that may affect revegetation success.
- If monitoring of plant growth shows patchy plant survival or slower than anticipated growth rates, monitoring of soil fertility to inform needs for fertilisers;
- Signs of animal pest damage to revegetation areas as a trigger for undertaking pest control;
- Incidence and persistence of invasive plant pests, particularly those required to be controlled under statutory documents (e.g. Regional Pest Management Strategy) or those deemed to present a risk of to the success of revegetation areas; and
- Survival and growth rates of planted trees and shrubs to direct infilling planting and future planting programmes towards species most likely to survive.

7.3 Methods

A monitoring programme will be developed in more detail for each stage of extraction activity. Monitoring methodologies are likely to include such methods as:

- Walk-over observations of features with checklists;
- Permanent photo-points or aerial photographs to track visual progress towards rehabilitation objectives; and
- Water quality sampling and laboratory analysis to assess temperature and nutrient composition.

8.0 Management Action Summary

1. Prior to commencement of extraction works in each stage, ensure that the limits of vegetation clearance are clearly known and understood to prevent vehicle access and unintended vegetation clearance or damage outside approved clearance areas.
2. Ensure extraction activity adopts a sequential approach to rehabilitation that avoids or mitigates future disturbance of completed areas.
3. Store the larger native logs to be offered to Nga Hapū-o-Ōtaki. Lay branches from native trees in the forest remnants and chip and stockpile mulch for re-use as rehabilitation. Remove remaining areas of vegetation from the site.
4. Where practicable, separate the top 200 mm of surface soils and mulched vegetation from subsoil and underlying overburden and store separately.
5. Store topsoil material in such a way where nutrient laden sediment from stockpiles will not enter waterbody through surface runoff.
6. Ensure sufficient substrate and topsoil material is stored during operation to undertake landform modification as part of rehabilitation within completed areas.
7. Locate all stockpiled material within the site to minimise visibility from external areas and establish grass or suitable alternative during operation to stabilise and minimise dust.
8. Ensure that the final landform will facilitate a sequence of native riparian vegetation communities and diverse range of physical habitats, both above (terrestrial) and below (aquatic) the waterbody.
9. Using available substrate, establish stable benching and slopes along waterbody margins following extraction activity.
10. Ensure surface run-off is included as part of the landform modification process to prevent scouring and erosion of adjacent vegetation and rehabilitated landforms and run-off from catchment area does not carry sediment laden water into the waterbody body.
11. Noise bunds to be grassed immediately following establishment to stabilise and minimise dust during extraction activity and maintain viability for subsequent reuse in rehabilitation works.
12. Island enhancement should be detailed in a separate plan which includes specifications associated with vegetation protection, landform modification, planting as well as a monitoring and maintenance programme.
13. Facilitate provision for future ongoing protection of the Ecological Islands once fully established.
14. Apply a combination of passive and active revegetation technique to optimise rehabilitation outcomes.
15. Monitor rehabilitation to inform future rehabilitation, including planting programmes.
16. Prepare a pest animal eradication and control plan prior to commencing extraction activity.
17. Release native planting from competing pioneer species during establishment to enhance the success of native riparian vegetation.
18. Control the establishment of ecological weeds during rehabilitation works.
19. Investigate animal habitat restoration and introductions as integral component of rehabilitation and long term ecological health.

APPENDIX 1 - Memorandum of Partnership with Nga Hapu O Otaki