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Wairoa River and Wastewater

A Big Picture Solution

B2A1

Prepared for

Wairoa District Council

Prepared by

LEI Environmental Impact

November 2017

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1 EXECUTIVE SUMMARY

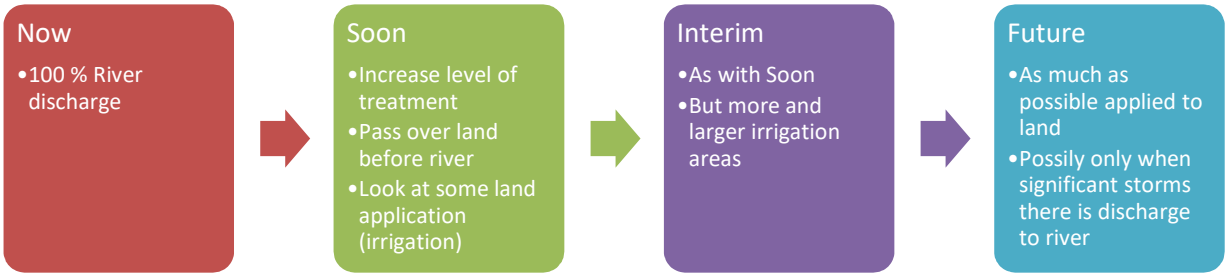
The Vision

This report presents a vision for the future for the way Wairoa manages its wastewater. It signals a long-term goal of removing wastewater discharges from the Wairoa River – and a commitment to improving river health not just related to wastewater – but in a holistic way. This includes implementing improvements not only for managing wastewater, but also opportunities for improving catchment water quality. Collectively this Vision can be achieved by the implementation of a Package.

It is intended that this report shows how cultural aspirations and community desires can be balanced with affordability to produce a sensible, affordable solution in the short term, whilst creating a commitment to continuous improvement that will ultimately see the end to the discharge of treated wastewater into the Wairoa River and the health of the river improved.

There are 'quick wins' that can be achieved in the short term, such as irrigating land close to the wastewater treatment plant on areas like the landfill plantation. There are other initiatives that can take place in the next 5 to 10 years to increase the irrigation area. There are yet more proposals that may take 10 years or longer to implement. And then there are things that we have not yet thought of that may appear in the future to be taken advantage of; with the key being a commitment to ensure that we are ready to take advantage of them when the opportunities present themselves.

The situation we find ourselves in has developed over more than 100 years. The Package presented in this report is not intended to be a 'quick fix'; but it is intended to signal the first step and a commitment to progress over the next 5, 10, 20 years to take every opportunity to achieve improvements and reduce the volume of wastewater entering the Wairoa River.



The Starting Point

The need to reconsent treated wastewater discharges from Wairoa District Council's current wastewater scheme for Wairoa in 2019 has resulted in the need to consider alternative locations and methods of discharge to the current river discharge. This report provides an opportunity to be used for discussion within the community to assist in deciding what action is needed to assist with improving the management of the current treated wastewater discharge and the collective management of land within the Wairoa River catchment.

The current treated water river discharge is **not considered acceptable by many** in the community, despite not having any significant measurable effects. The unacceptability relates to the notion of treated wastewater containing pathogens and contaminants entering an environment that is used by a large number of people within the community for recreation and food gathering.

The exact effects and impact of the discharge are likely being masked by the condition of the river as a whole; and in particular the negative impact from a range of upstream contributors to poor water quality. These include hill country erosion, run off from production land and various discharges from roading and urban areas. **The community would like to see water quality in their river improved.**

The Options

There are a range of alternative options to manage and discharge the treated wastewater, but many are technically challenged or are simply too expensive for the community to afford. Options considered have included continuing the existing discharge, modifying the existing discharge potentially with additional treatment, using an ocean outfall and various forms of land application.

These options need to be balanced against the level of investment required, and the potential improvements from investing an equivalent amount of financial resources in the larger catchment. For some wastewater upgrade options, a significant investment in treatment to improve wastewater quality will not improve the quality of water in the river; and the money would have been better spent on land management improvements and advice within the large catchment.

Further, there is the scope that treatment might involve options; being alternatives (one or another), successors over time (one then another) or complementary (both together). There is a need to decide on the minimum level of treatment, the costs and whether investment in treatment is proportionate to the improvement in Wairoa River water quality that would have resulted from the same funds been put into catchment improvements.

While **the need for wastewater management is a modern phenomenon that largely didn't exist 100 years ago**, there is a need to consider tikanga which as a minimum would see wastewater pass through and over Papatūānuku (land). Ideally it would be treated to drinking water standards and soaked into soils so as to entirely avoid discharging into any fresh water bodies or the ocean, but this notion is unrealistic and unaffordable to the Wairoa community at this time.

The Need for Steps

After receiving feedback from the Wairoa Wastewater Stakeholder Group, a concept for the treated wastewater discharge has been developed that provides for an affordable solution which is implemented over time in steps. Each step would incrementally lessen the impact on the Wairoa River, and in particular seeing over time a reduction in any treated wastewater discharge to the river.

The first step has two options. It provides for filtration and ultra violet light to remove pathogens before being discharged to the Wairoa River or for the pond treated wastewater to pass through and over land prior to entering the Wairoa River (high rate land passage). While this high rate land passage may not provide the ultimate solution to avoid any discharge to the Wairoa River, land passage is achieved. Further steps may see the two options combined and/or the irrigation of neighbouring land and any council owned land, with potential options including the plantation surrounding the landfill. Collectively these irrigation options will reduce the volumes of treated wastewater discharged to the river, but what gets to the river having a higher quality. The ideal goal of completely avoiding discharging to the river might be achieved in the long run if enough land becomes available and if a suitably sized storage pond is built.

How to Incorporate the Catchment

As noted earlier, the larger catchment is contributing contaminants to the Wairoa River which is undoubtedly adversely impacting on the river's mauri (life force). While the treated wastewater discharge is a source of contamination that the community would like addressed, so are the many other contributions being made by the wider catchment. Contributing to enhancement in catchment water quality would be further steps.

As part of the early steps in the 'Package', there is scope to use the high rate land passage concept to assist with drawing attention to the needed changes in the larger catchment. This includes the use of the high rate land passage to illustrate and educate the community about the catchment, with a physical model created within the high rate land passage structure to mimic the larger catchment. This model would allow the community to be engaged to create it, discuss what is important and for people to visit the high rate land passage site and see what the catchment looks like. This provides an opportunity for the community to understand the topography, land management limitations and vegetation effects that makes the Wairoa River catchment unique.

The Package

The early steps in making changes, being the installation of filtration and ultralight disinfection, or the creation of the high rate land passage including a catchment model, do not immediately meet the aspirations of the community of having a sustainable (economic, social, environmental and cultural) discharge that avoids the use of a river discharge. However, as technology and funds become available, there is scope for the initial system to be enhanced over time with additional steps. These include:

- education about water use and improvements to reticulation resulting in less water needing to be discharged;
- more affordable and more effective wastewater treatment technologies achieving further removal of contaminants; and
- the identification and implementation of alternative beneficial uses for water, including recycling, industrial use and irrigation.

These areas of enhancement and further steps, coupled with education and changes made to address the need to improve water quality in the greater catchment, can occur over time and at a rate that is affordable to a fiscally constrained community. Ultimately, such a programme would result in a far greater improvement in the river's water quality, and would be a wiser investment of funds and effort, than would be achieved by solely focussing on fixing Wairoa's wastewater discharge systems today.

This collection of works, referred to as '**The Package',** can be developed further and gradually implemented over time. The concept of multiple wastewater enhancement programmes being implemented over time, alongside enhancing management in the wider catchment, is represented in Figure 1.1 below.

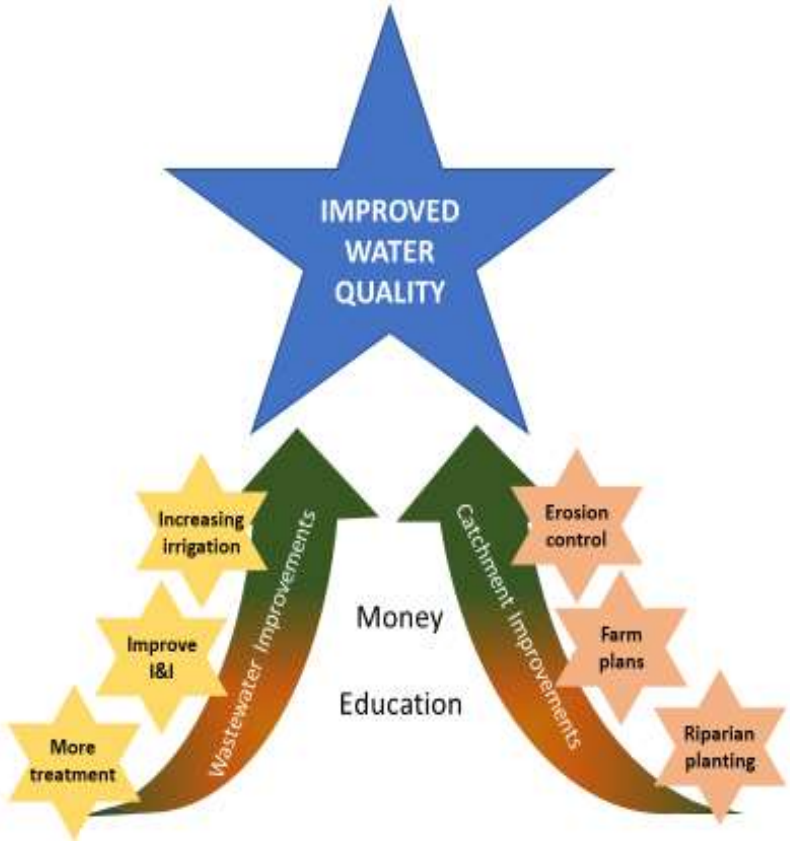


Figure 1.1: The Package

Costs

There are a number of already committed steps, including reticulation improvements to reduce wastewater flows. Further steps, including the resource consenting programme, have been costed at a very high level and could see a gradual increase in rates over time. This compares to alternatives which require ultimate solutions of ceasing the current river discharge immediately. Figure 1.2 below shows comparative scenarios of potential rating impacts for individual house connections for a) conservative package implemented over 30 years, b) more thorough package implemented over 30 years, and c) land only option implemented within the next three years.

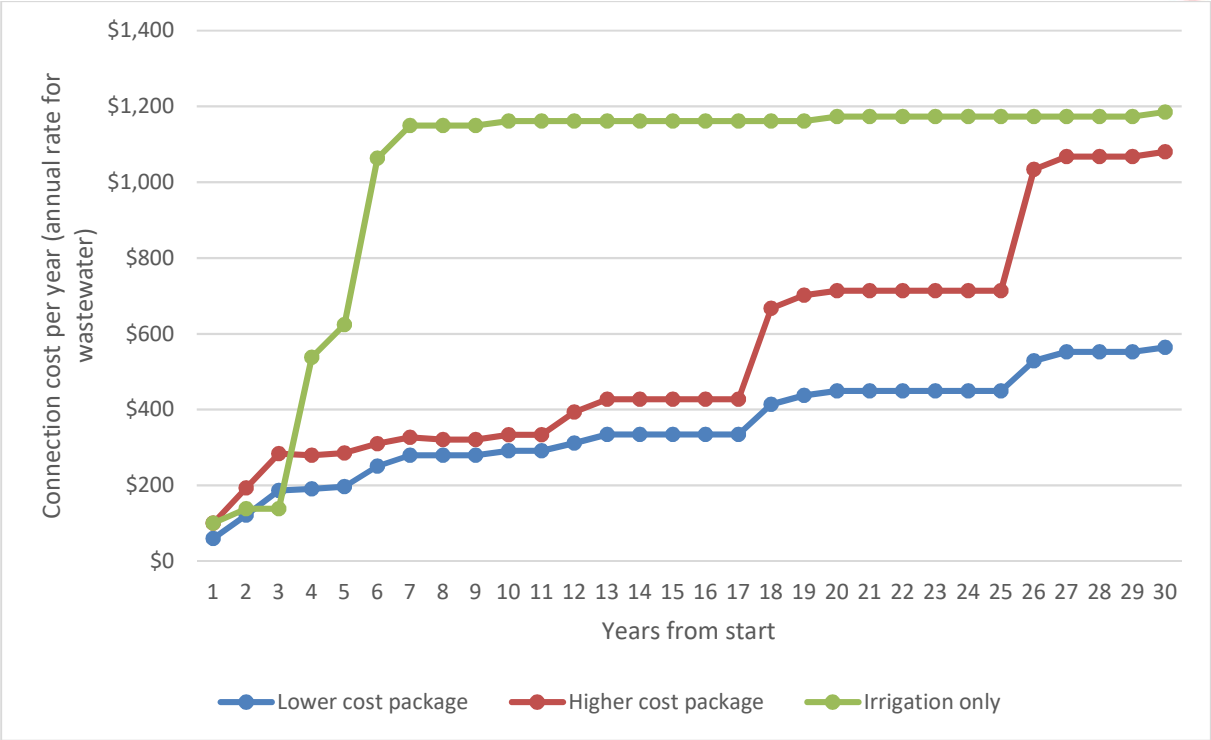


Figure 1.2: Annual Rate Cost Associated with Wastewater Packages

The Solution

A long term sustainable wastewater solution, requiring multiple angles to be considered, is needed for Wairoa. Opportunities and action to improve the mauri of the Wairoa River are also needed. Both objectives can work alongside each other, and potentially can be complementary when addressed as a **Package**. The Package recommended for consideration is high rate land passage followed by a 30-year implementation of gradual irrigation expansion.

It is worth remembering that it has taken more than 100 years for the river to reach its current condition; fixing it will not happen overnight.

2 INTRODUCTION

2.1 Background

The Wairoa wastewater discharge consent is due to expire in May 2019. An application to discharge treated wastewater to the environment needs to be made to the Hawke's Bay Regional Council (HBRC) by 30 November 2018. Wairoa District Council (WDC) staff have been working alongside advisors to develop options for a new discharge system, which has been informed with input from the Wairoa Wastewater Stakeholder Group and feedback received from the community.

It is also clear that the condition of the Wairoa River is not great, to the point that its condition caused by upstream sources of contaminants (silt, nutrients, and pathogens) is potentially masking any effects of the treated wastewater discharge that occurs shortly before the Wairoa River reaches the sea. The community would like to see improvements to the management and quality of water in the river.

While removal of treated wastewater from the Wairoa River is desirable from an environmental and cultural perspective, alternatives have technical limitations and are expensive; to the point where they are currently unaffordable for this small rural community. A solution is needed to allow the discharge of treated wastewater, and recognition is also needed of the current state of the river.

2.2 Scope

This report provides a summary of a package that brings together a series of treated wastewater options that can be enhanced over time as finances and technology allow; and at the same time create and contribute awareness of opportunities to improve the health of the Wairoa River catchment upstream of the urban Wairoa locality.

It is intended that this report is a starting point for discussion with the wider community where options can be enhanced and further developed.

3 PROCESS TO DATE AND OPTIONS

3.1 Information Informing the Process

The Wairoa Wastewater Consenting Project (the **Project**) was initiated in 2014 by the Wairoa District Council (WDC) to find a long term solution for the current wastewater discharge system. The journey to date has included several stages that will ultimately assist in formulating an application to be lodged to HBRC that represents the Best Practicable Option (BPO).

Over the course of the current year (2017), the focus has been to deliver technical reports and undertake consultation with the Wairoa community. A major part of consultation has been the involvement of the Wairoa Wastewater Stakeholder Group (the **Stakeholder Group**). This group has assisted council with identifying and formulating an acceptable means for the future management of Wairoa's wastewater and its discharge.

In August 2017 a hui-a-hapu and a public meeting were held to inform the community of this project and to gain feedback regarding what the community thought of the current discharge and what they would like done. The consensus from these meetings echoed the **Stakeholder Group**, being the removal of the wastewater discharge from the Wairoa River. Following close behind this message was a second message relating to the degraded state of the Wairoa River and the need for it to be improved. These positions on the state of the river and managing the wastewater discharge were cautioned by meeting attendees about the solutions needing to be affordable to the entire community.

3.2 Option Development

As a result of discussions with the community, in August a series of options were presented to the **Stakeholder Group**. Options included combinations of reticulation, treatment and discharge methods. Importantly, discharge methods included discharge to water, land or a combination of both. Each set of options was accompanied by a set of costs, and as would be expected there was significant variation, but costs ranged from less than $3 million to in excess of $20 million.

Costs could be grouped into three categories, being:

Cost		Range	Description
1)	low	less than $5 million	continuation of some form of river discharge
2)	Medium	5 to $15 million	a new ocean outfall or combinations of river discharge and land application
3)	High	greater than $15 million	land application utilising only irrigation

It is noted that an investment of $5 million equates to a rate increase of $200 per property for the next 30 years, and $10 million is a rate increase of $400 per property per year.

A key contributor to the high costs associated with the land discharge options is the area and storage infrastructure needed to accommodate year-round irrigation and wet weather storage.

Potentially 300 to 600 ha of land may be needed, depending on soil type and land use. Storage of up to 400,000 m^3 could also be necessary.

3.3 Refining the Options

With all options minimising environmental impacts and maintaining consistency with cultural values and community aspirations is critical, of which it is clear that ceasing the direct discharge of treated wastewater into the Wairoa River estuary is key. The consensus from the community is that the status quo with no additional treatment would not be considered favourably. Based on excluding unaffordable options at this time, and requiring some degree of further treatment, the following three options were identified as the most acceptable:

- 1a – Status Quo System With UV post-treatment prior to existing River Discharge
- 1b – High Rate Land Passage (HRLP) System and River Discharge
- 2 - Rapid Infiltration (RI) System and Coastal Discharge

Investigations undertaken to date (LEI, 2017:A7D1) suggest that the minimum acceptable and lowest cost option is to install a further treatment system at the outlet of the Wastewater Treatment Plant (WWTP) to kill pathogens prior to discharging via the existing pipeline and diffuser in Wairoa estuary (Option 1a). This would contribute to greater protection of public health through contact recreation and allow for recreation and seafood consumption. However, this level of treatment is not likely to be culturally acceptable if land passage options are not incorporated into the discharge system.

A key aspect of treatment required is acknowledgement and observance of tikanga. Aspects of tikanga as they relate to wastewater management are described in *Tangata Whenua Worldviews for Wastewater Management in Wairoa* (How, 2017:A4I2). It is clear that contact with Papatūānuku is required to achieve revitalisation of mauri in the treated wastewater, and hence the concept of discharge into a high rate land passage prior to the Wairoa River estuary is proposed (Option 1b). This level of land treatment is more culturally acceptable than a direct discharge to water without any land passage. It allows for a variety of soil and plant interactions, with some plant uptake of nutrients and water, over a longer timeframe than rapid infiltration systems. This option still requires discharge to the Wairoa River. Depending on the high rate land passage design and infiltration rates of the underlying soils, the percentage of treated wastewater that discharges to the river could be 85 – 99 % of the daily flow from the WWTP.

An option which sees an end to discharge into the Wairoa River (and the Wairoa Catchment) is the use of a coastal dune site for rapid infiltration. Installing rapid infiltration into the coastal dunes allows for land passage and ensures that the drainage of residual wastewater enters the sea as a diffuse underwater plume. This level of land passage is likely to be more culturally and recreationally acceptable than a discharge that is piped directly into the river or estuary, but the effectiveness of land treatment by rapid infiltration may be seen as less effective than high rate land passage.

Each of the three options has limitations. Doing more with the wastewater and consideration of alternatives requires more money that the community doesn't have. The most practical and affordable option to manage the current discharge would seem to be the adoption of the high rate land passage concept.

3.4 The Catchment Model

While the high rate land passage concept could be considered to be tokenism with regard to the revitalisation of the treated wastewater's mauri, a proposition has been made that the discharge structure could be used in such a way that it helps to identify and educate people about the health of the larger Wairoa River catchment. It is clear that the high rate land passage may not fully revitalise the water's mauri, but there is the opportunity to draw attention to what is happening in the larger catchment with gains being made as a whole that is greater than what could be achieved by managing just the urban wastewater. This can be achieved by using the high rate land passage discharge structure to replicate land forms and conditions in the catchment, and be used as an educational tool.

3.5 The Time Factor and Progressive Improvements

Any legally established discharge must be able to stand on its own, and have effects that are not considered to be adverse. This is not to say that effects will not be detectable, but they do not cause a more than minor detrimental impact. If, however, the discharger wants to, they may enhance and improve/reduce their impact over time. This means that if WDC operate a discharge now there is no reason why that discharge cannot be incrementally enhanced over time.

Should WDC choose to operate a high rate land passage and discharge to the Wairoa River, they can change this discharge over time by reducing the discharge, or even ceasing discharge to the river. To decrease the discharge the volume of water needs to be reduced, and/or alternative discharge options found. There may be also the option of maintaining a high rate land passage discharge but adding additional treatment over time such that the contaminant load discharged is less, and this may be acceptable.

There are a range of reticulation, treatment and alternative discharge options that could be considered and these are discussed in Sections 6 and 7 of this report. These options could be pursued over time and as funds allows. Such funds may come from increases in rates or external funding, such as the Ministry for the Environment.

4 THE PACKAGE

If improving the health of the Wairoa River requires the elimination of wastewater discharges it will not be a simple exercise and will take time. It will also involve many related activities and not just one solution; the tap cannot be turned off overnight.

A 'Package' is proposed to not only incorporate the final target of identifying a system(s) for wastewater discharge that is away from the Wairoa River, but also provide for improvements in the catchment as a whole. A key aspect of this package is education, whereby the wastewater discharge, and in particular the high rate land passage, can be used to inform the community and create discussion about the health of the Wairoa River and the opportunities for improvements.

Figure 4.1 shows how wastewater and catchment opportunities can work hand in hand over time to deliver an improvement in water quality.

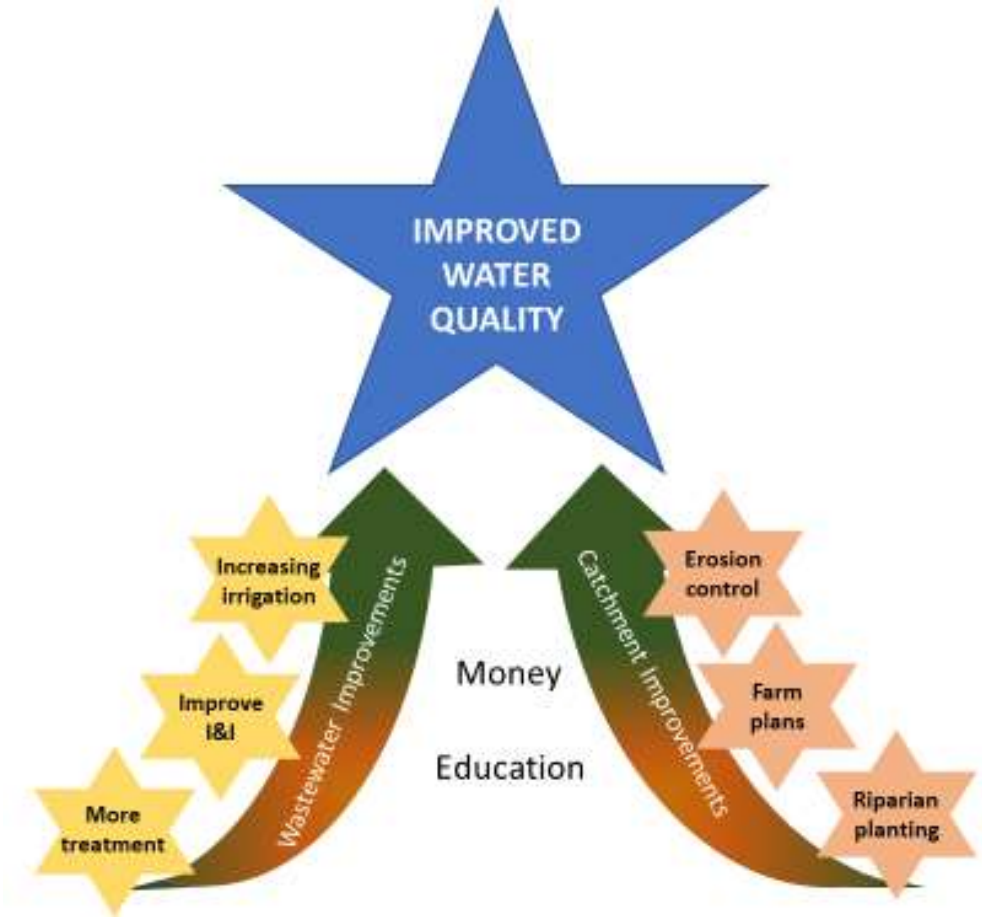


Figure 4.1: The Package

Improving water quality is an issue beyond the Wairoa River. New Zealand as a whole has multiple waterways like the Wairoa River which can be improved. And like these other rivers, the Wairoa River requires multiple activities and collaborative efforts in order for water quality is to be enhanced. The Package concept as it relates to improving water quality in the catchment and the part the wastewater system plays in contributing to improving water quality is illustrated in Figures 4.2 and 4.3.

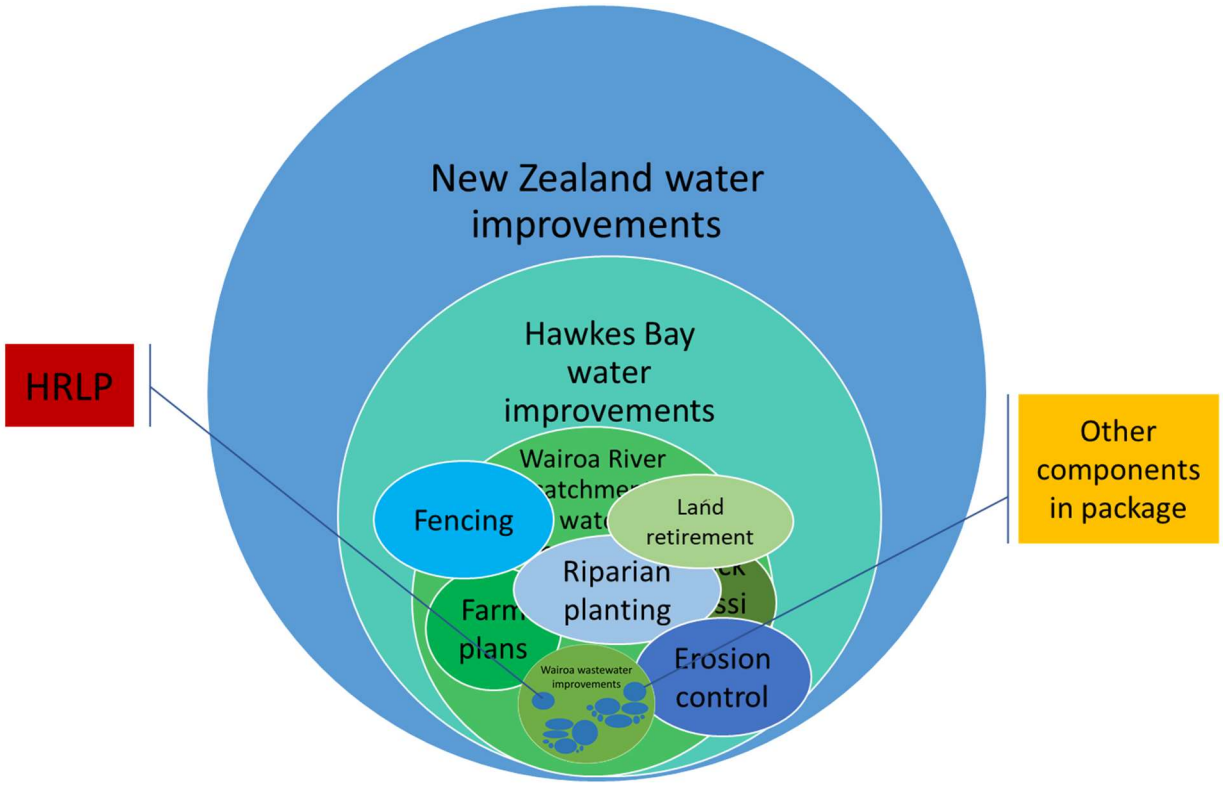


Figure 4.2: Improvements in Catchment Water Quality

Figure 4.3: Improvements in Impacts from Wastewater Discharges

5 LINKING THE DISCHARGE AND THE CATCHMENT

5.1 Overview

As stated in Section 3 above, the incorporation of a high rate land passage system into the current discharge system would be the most preferred option. Combined with filtration and UV disinfection, the high rate land passage provides for additional treatment prior to discharge to the Wairoa River. The sections below provide detail on the high rate land passage and how it can be linked to a better understanding of the Wairoa River catchment, and through education lead to improvements in the catchment water quality.

5.2 The High Rate Land Passage System

From a wastewater perspective, the purpose of the high rate land passage is to provide additional treatment, with the passage over and through land and vegetation having the potential to improve water quality. It also has the potential to provide for the revitalisation of the water's mauri as a result of again, passing over and through land.

Details of the high rate land passage option were presented in the report titled Preliminary Feasibility Assessments of Land Passage Options (LEI, 2017:A5D1). Key information is summarised below.

After consideration of land options in the area surrounding the existing treatment system, the location and geological features for land parcel 1.1.3 shown in Figure 5.1 below have been considered the most suitable for a high rate land passage for the Wairoa WWTP. It is located on the slope below the north-eastern end (and current outlet) of the WWTP above the low-lying flats, clear of any flood risk, and well back from most dwellings and the Wairoa River.

Figure 5.1 Aerial Photo of Proposed High Rate Land Passage Site and Locality

The land parcel is legally described as Part Lot 1 DP 3350 and is currently used as a paddock of a deer farm. The parcel is approximately 130 m long and at the widest point 70 m wide, and the whole area is about 0.75 ha. Its western boundary is the eastern side of the WWTP site and its northern boundary is a paper road which the current WWTP discharge pipe follows.

The soil in the area is classified as "Gisborne sandy loam", and the depth to a slowly permeable horizon is between 1.2 and 1.49 m. The permeability in this area is rated as moderate and the drainage as imperfect (drainage class 3) (HBRC, 2017). The surrounding area is comprised of Awamate silt loam which may be slightly less permeable.

The area has a gentle to moderate falling slope towards the east. Figure 5.2 shows that the western and eastern areas have a gentler slope of 0 to 12.8 degrees and the central area has a steeper slope of 12.8 to 21.4 degrees. Steep slopes or low-lying flats are typical features of the surrounding locality, so this land parcel is one of the most suitable areas near the WWTP.

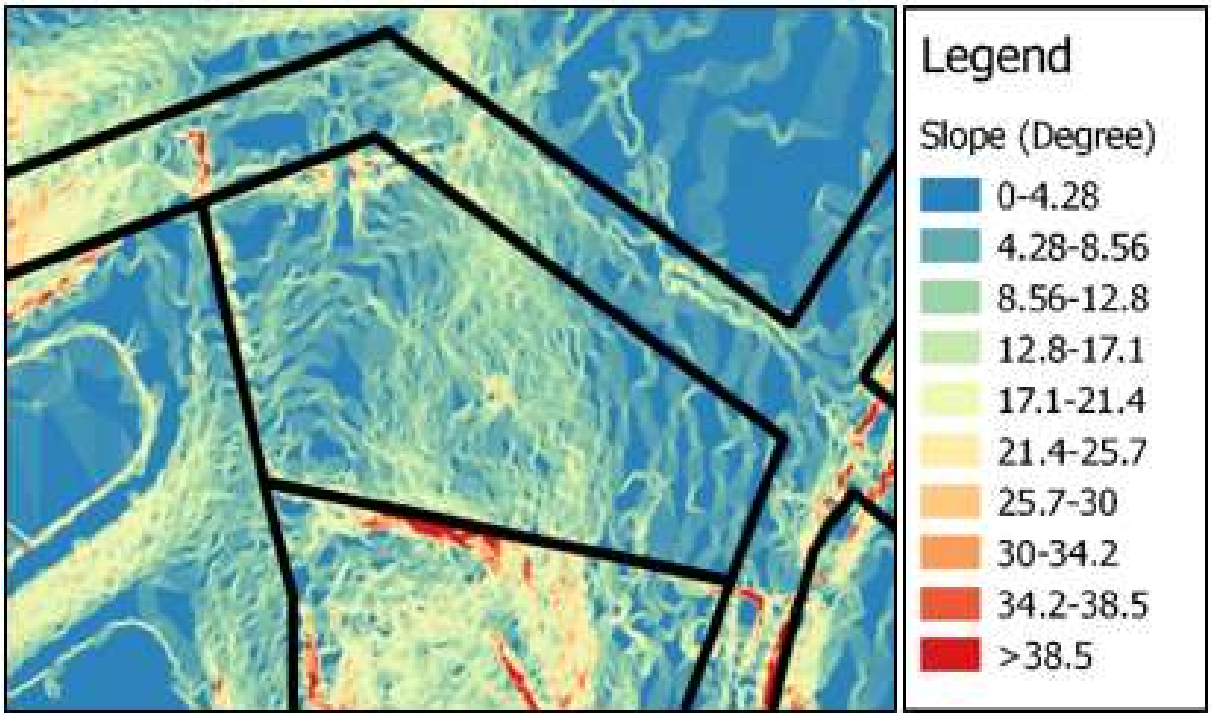


Figure 5.2: Slope of Proposed High Rate Land Passage Site

This site is outside of the Coastal Environment identified in the Wairoa District Plan (WDP) and the Hawke's Bay Regional Coastal Environment Plan (RCEP), so it avoids being subject to a large number of restrictive planning provisions. The Hawke's Bay Regional Resource Management Plan (RRMP) contains most of the relevant planning provisions controlling discharges and earthworks. It is privately owned land and also appears to be clear of archaeological and cultural significance.

5.3 High Rate Land Passage System and River Discharge

Detailed below is a concept for what a high rate land passage system for Wairoa could look like.

After the wastewater has been treated in the current treatment ponds, and passed through the mechanical and biological processes within the ponds, it will pass through a new filtration and a UV disinfection process before it enters the high rate land passage. After passing through the high rate land passage the flow would then discharge into the river. Figure 5.3 provides a concept of this process.

Figure 5.3: High Rate Land Passage Treatment and Discharge Concept

This system will:

- Improve oxygen levels and reduce BOD content through aeration before entering the Wairoa River;
- Reduce the algae content of the wastewater and remove pathogens;
- Allow the water to pass through and over a series of land passage elements; and
- Discharge an improved wastewater at reduced daily volumes to the Wairoa River.

The objective of the filtration and UV system is primarily to reduce pathogen levels. However, the high rate land passage objectives need to be defined and the system's scale determined, especially as it relates to the requirements of the various components needed to revitalise the mauri of the treated water.

5.4 Using the High Rate Land Passage for Education

The high rate land passage can serve a secondary purpose of education to demonstrate to the community what happens within a water cycle and how land use (including wastewater discharges) impacts on the mauri of the awa. Specifically, a model can be created to show and educate the community about specific features in the larger river catchment and how these impact on water quality. Adopting this vision, it is proposed that a concept is employed whereby:

> *The high rate land passage will mimic the water cycle and demonstrate what happens in the larger Wairoa River catchment and utilise intrinsic features specific to land and waterways in the catchment to aid in the return of the mauri to the water passing through.*

Key features of this catchment model would include providing for:

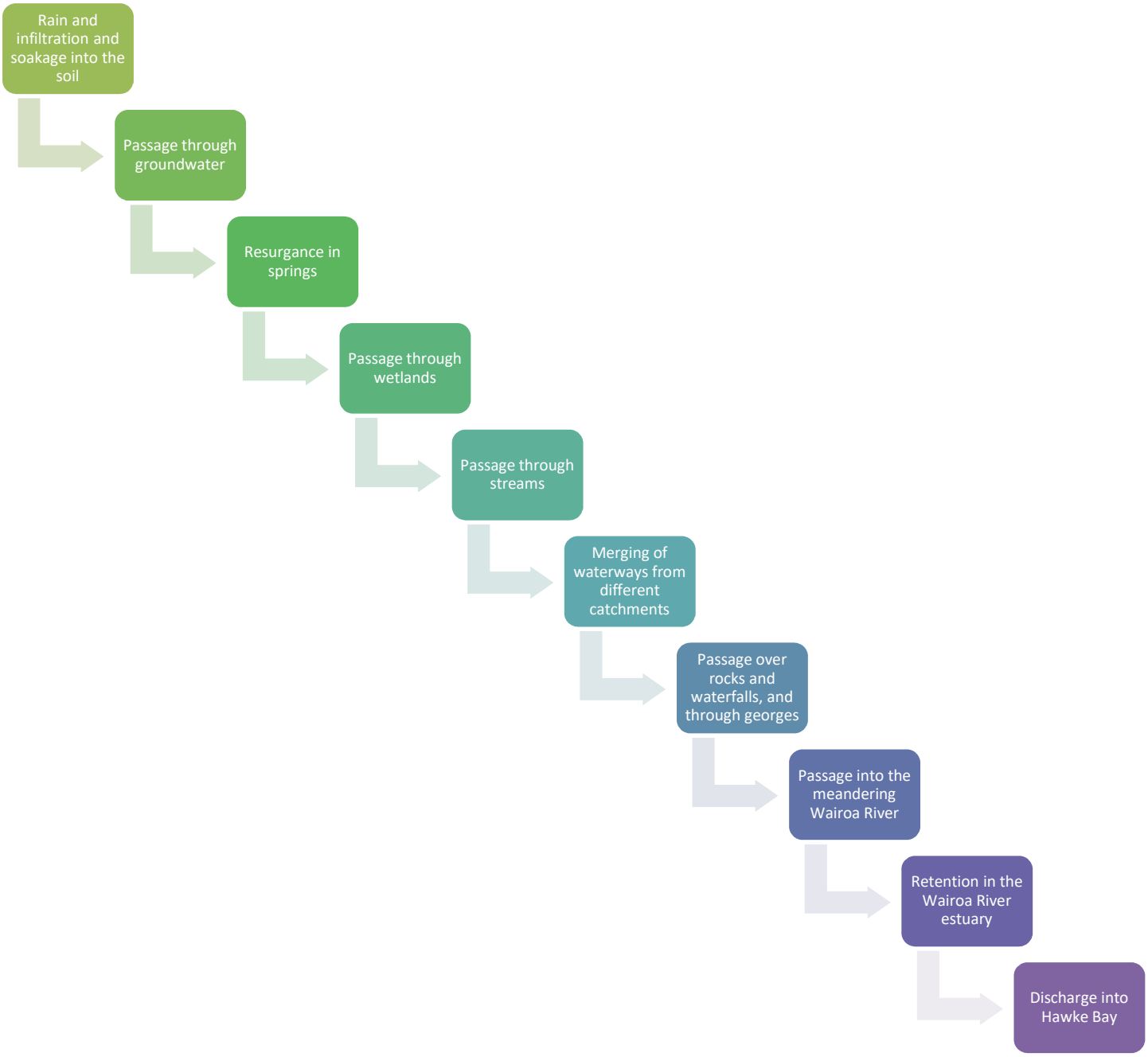


Figure 5.4: Key Features for the Wairoa High Rate Land Passage

The high rate land passage design and operation can incorporate elements of the Maori worldview of water's intimate connection between the deity's of Ranginui, Papatūānuku, and Tangaroa.

Representation of the awa (river), horanuku (landscape), geology and features of the wider catchment provide an opportunity for the passing wai to reconnect with the simulated catchment.

In drawing the attention to what is happening in a modelled catchment, the high rate land passage system can emulate the wide variety of natural watercourse flow conditions, from gentle seeping springs, through wetlands and small streams, merging into larger steep rivers with rapids and waterfalls and deep slow pools, passing through gorges, and finally meandering across floodplains.

In addition to providing a vegetation habitat, the high rate land passage system could become habitat for fish, eels (tuna), frogs and other reptiles, snails and insects, and birds.

Finally, it is noted that the process of the flow through a high rate land passage system is, amongst other things, to revitalise the mauri of the wai. In reality, as water passes down through the streams and tributaries of the Wairoa River the mauri is currently being diminished by various contaminants. Consequently, it could be considered that while contributing wastewater to the Wairoa River, the high rate land passage is doing so in a way that demonstrates and symbolises that mauri and ecosystem health could be restored in the Wairoa River.

In summary, the high rate land passage design is therefore considered to have more than one purpose. Not only will it be used to restore the mauri of the wai that cascades through its passages, but this design could also be used as a demonstration model to show the community what could be achieved on a grander scale with regards to improvements to the wider catchment.

5.5 What the High Rate Land Passage Could Look Like

There are a number of ways the above concept could be developed and constructed. Ideally it would be done using local materials of relevance and significance, with design and ideas representing important aspects and features of the larger Wairoa River catchment. There is also the opportunity that the community (and not just tangata whenua) could be involved in the project to develop and be responsible for various aspects of the design and construction. This could then serve as an education point with markers and notice boards along walkways highlighting the catchment features and features that assist with the enhancement and revitalisation of the river's mauri.

Figure 5.5 presents a design concept for the high rate land passage which is described in more detail below. It is repeated in Appendix A as a larger image with an alternative image presented in Appendix B.

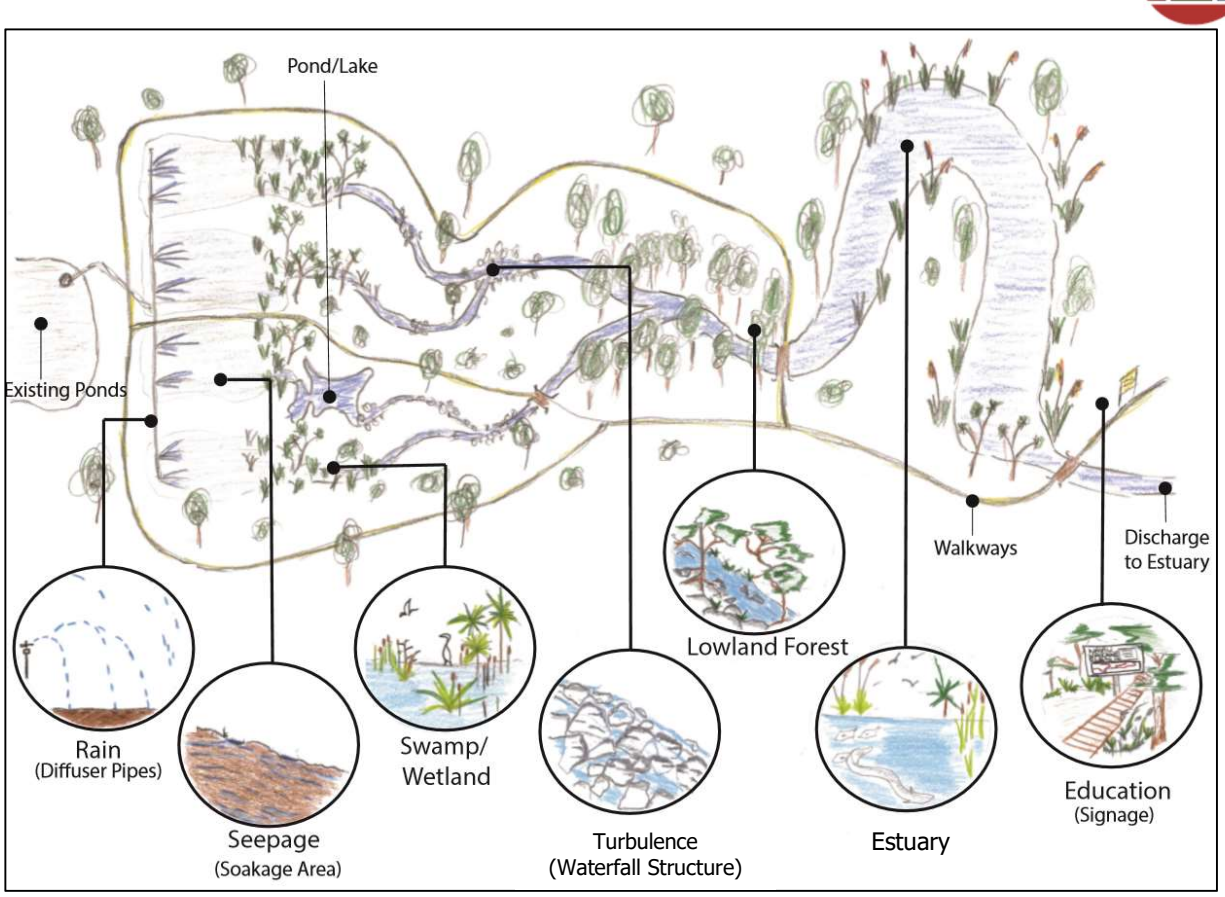


Figure 5.5: Design Concept Option for the High Rate Land Passage

The concept is to represent and mimic the natural water flows within the Wairoa River catchment and to incorporate these aspects with cultural values and a representation of the related interactions between the various Maori deity's. The proposed design is for the high rate land passage's waterways to be closely orientated to represent the catchments of the Wairoa River.

This can be achieved by using a diffuser pipe to spray the wastewater onto sand and gravel beds at the high rate land passage inlet, replicating rain falling from Ranginui onto Papatūānuku in the mountain areas. Four separate channels represent the four main rivers in the Wairoa catchment (Waiau, Waikaretaheke, Ruakituri and Hangaroa Rivers) can then be used to convey water to the sea. Each of the river channels would have slightly different characteristics, for example:

- **Waiau River** has a fast-flowing channel with a rocky bottom and could be shaped like an eel to symbolise the significance for the two native species: the longfin tuna and the blind eel.

- **Waikaretaheke River** could be designed closely to the shape of Lake Waikaramoana just below the spring. The channel could include a waterfall feature designed like the Taheke Waterfall.

- **Hangaroa / Ruakituri River** could include big boulders in the stream and the Te Reinga Falls where the two rivers meet.

The final section of the constructed structure would represent the meandering lowland river and the estuary with its coastal lagoons (Whakamahi and Ngamotu).

To assist with the system's authenticity, the media and plants used in the high rate land passage can be sourced from the catchment of the respective river system.

In the journey from the rain simulation to the estuary there are six critical stages and include:

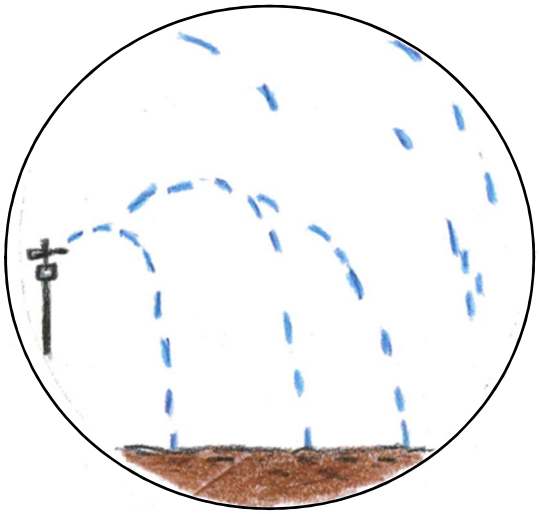
There is a seventh critical stage and that is education. This is required to bring together the various aspects of the structure and enable the story to be told of how the catchment was formed and works, landscape and geological features, and impacts on water that occur at various locations enroute from mountains to the sea.

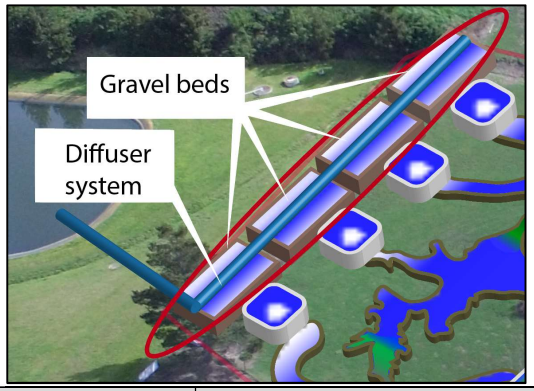
These stages are represented in Tables 5.1 to 5.6 below and includes a discussion as it relates to:

- Cultural aspects – which describe the processes within in each stage that relate to the relevant deity and transformation/transition processes as water moves through a catchment. The narration provided is limited in its context and understanding and should be significantly enhanced to represent the relevant deity and the physical features that provide the biotransformation for revitalisation of the flowing water's mauri. This should be undertaken by tangata whenua and hapu who have an association with whenua and the awa;
- Catchment aspects – what are the key features in the catchment and a description of the physical elements of each stage; and
- Treatment processes – being a description of what would happen to wastewater where the quality may be further enhanced. However, it should be noted that chemical and physical changes and transformation with a high rate land passage will be limited, especially if the water is well treated prior to entry.

Table 5.1: Rain

A spray system (diffuser) is used to simulate rain and allow the water to soak into the ground.

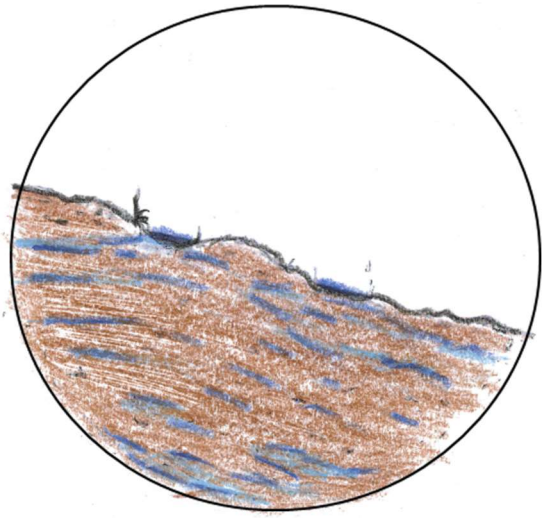


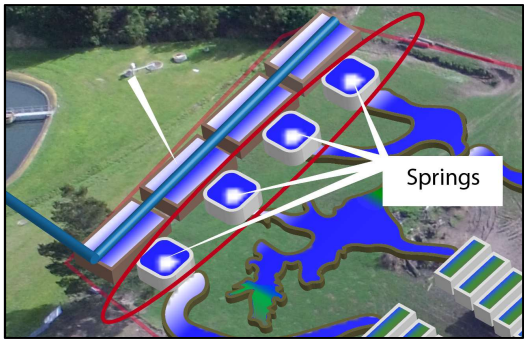


Cultural Aspects	Catchment Aspects	Treatment Processes
The tears of Ranginui represent the rain as a symbol of his sadness for his separation from Papatūānuku. The settling of his tears upon Papatūānuku represents the evaporation of rainfall as a symbol of her sadness. Both the rainfall and the evaporation is a symbol of the close bond between Ranginui and Papatūānuku. By mixing rainwater with air, the mauri of the water is enhanced due to its oxygen transfer process.	Rain falls in the mountainous headwaters of the river and soaks into the soils and sub-alpine vegetation. During storms, heavy rainfall flows across the land surface.	Aeration, vaporisation, and sunlight exposure all help to kill any residual pathogens. Volatilisation of ammonia and nitrogen transformation will occur. Soakage into the media and interaction with soil biota and plants enables nutrient and water uptake, pathogen and algae filtration, controlled drainage to groundwater, and nitrogen transformation.

Table 5.2: Seepage

Groundwater passage through the media and upwelling through media at a lower elevation, representing springs.

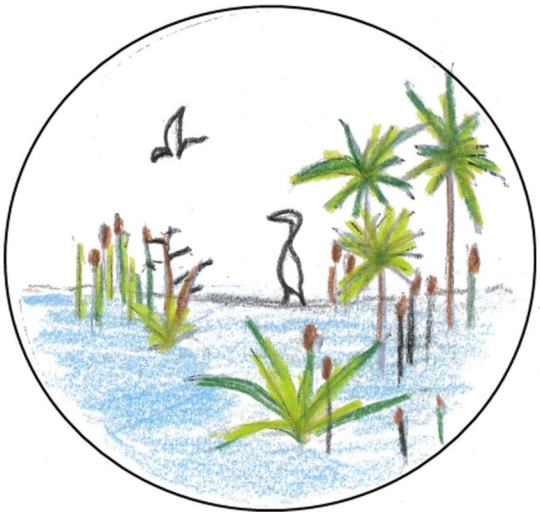


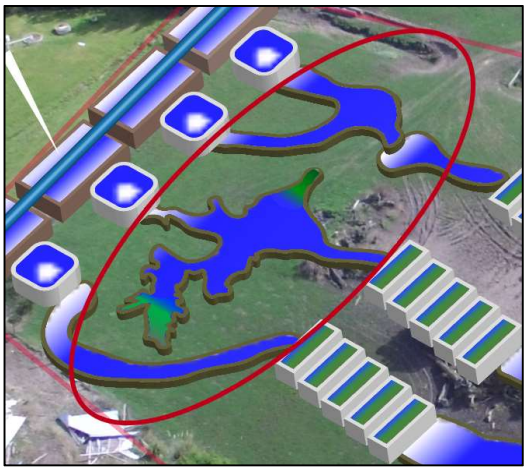


Cultural Aspects	Catchment Aspects	Treatment Processes
Papatūānuku absorbs the rainfall and nourishes the sub-alpine wetlands and bush. Te Urewera and key skyline or upland landmark deities occupy this area. Wainui is the guardian of fresh water. The water passes through Papatūānuku and returns to the world of light. This process revitalises the mauri of the water.	Rainfall soaks into the soils and percolates downhill to re-emerge by seepage and springs through rocks and soil (sourced from each catchment) to form sub-alpine wetlands or bogs. Wetland plants, mosses, and surrounding trees reflect the respective upland catchment characteristics.	Soakage through soil and upwelling through springs enables nutrient and water uptake, pathogen and algae filtration, drainage down to groundwater, and nitrogen transformation.

Table 5.3: Swamp/Wetland

The release from springs form sub-alpine wetland and bog areas through to lakes and streams.

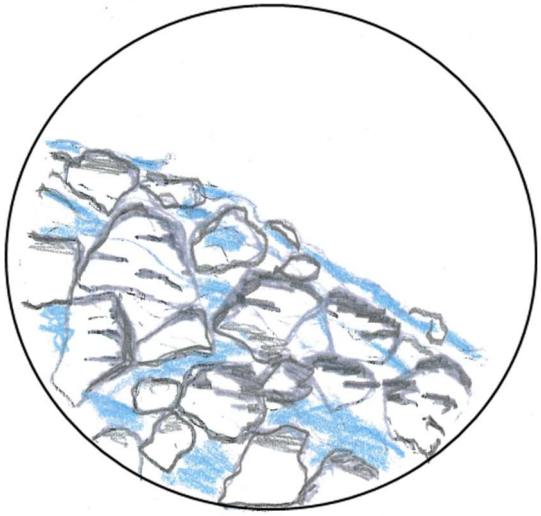


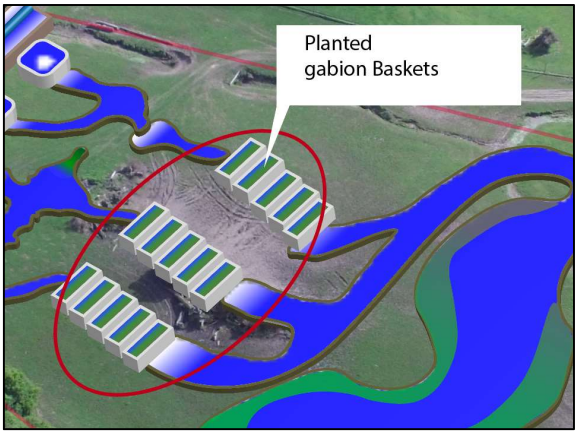


Cultural Aspects	Catchment Aspects	Treatment Processes
Tāne is the deity related to the forest, and Te Urewera and key skyline or upland landmark deities also occupy this area. Te Urewera headwaters start in the form of sub-alpine wetlands and bogs which feed into lakes and streams. Ground-water and surface water have intimate contact with Papatūānuku which provides mauri to the water. The water flow at the surface then nourishes the mauri of the sub-alpine wetlands and bush.	Springs feed sub-alpine wetlands or bogs. Wetland plants and surrounding trees reflect Te Urewera character and plants that are found in this zone. Soakage occurs through soil, surface flow over gravel, merging of spring seepage, and contact with riparian plants and trees.	Slow flow over and constant contact with soil and riparian plants enables nutrient and water uptake. There may be some drainage to groundwater which will provide for further filtration. The organic influence of the vegetation will provide for nitrogen transformation (denitrification).

Table 5.4: Turbulence

From the headwaters of the individual streams there will be rapids and waterfalls in gorges as they descend the upper part of the catchment to merge into larger streams and rivers.

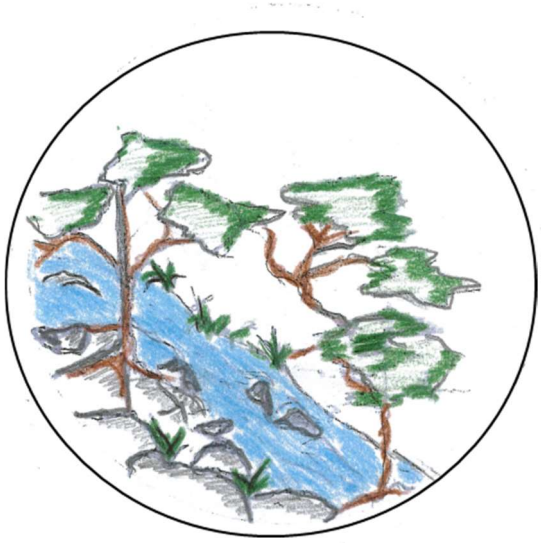




Cultural Aspects	Catchment Aspects	Treatment Processes
Waterfalls have individual character and spiritual and cultural significance. Taheke and Te Reinga Falls are key examples. Each river draws its identity from its waterfalls and similar characteristics such as steep gorges and rapids. The mixing of water with air transfers oxygen and mauri into the water. Splashing against and flowing over rocks provides close contact with Papatūānuku.	Each stream and river is turbulent and swiftly flowing and in places cascades over steep rapids and waterfalls. The special character of each river will be reflected in overall layout, rocks, and plants. Cascading structures representing the Taheke and Te Reinga Falls will feature here.	Soil soakage, aeration, algae on stream beds, and contact with riparian plants enables nutrient and water uptake, drainage to groundwater, and nitrogen transformation. The turbulence allows for any degradable organic matter from the treatment process to be further reduced. It also provides for UV treatment of pathogens, and potentially volatilisation of ammonia to some limited extent.

Table 5.5: Lowland Forests

Each river flows through meandering channels across the lowlands which were once densely forested.



Cultural Aspects	Catchment Aspects	Treatment Processes
Tāne resided here, within the tall podocarp forests and the understorey tree ferns and bush. This was an important area for birds, lizards, and abundant food sources and other resources for Maori. It was an important navigation route to Te Urewera. Mauri is exchanged as water supports the forest and its inhabitants. Contact with Papatūānuku and soakage of water into soils also occurs in slower flowing areas.	Each river has its own character of gorges, open valleys, gentler gradient, vegetation cover, and tight or broad curves. Water flow is generally less turbulent and slower moving on the surface due to the gentler gradient. The terrestrial and aquatic habitats were richly diverse and abundant.	The slower flow areas allow for nutrient uptake by plants and aquatic life, and for soakage into the soils. Some transformation of nitrogen also occurs.

Table 5.6: Estuary

As the Wairoa River flows through the estuary it has a meandering form and has lagoons immediately prior to where the river mouth meets Hawke Bay.

Cultural Aspects	Catchment Aspects	Treatment Processes
Papatūānuku meets and mixes with Tangaroa in this inter-tidal zone, and mauri exchanges between the two deities and environments. Slow water movement is also important. Two taniwha, Tapuwae and Te Maaha, form the gravel bars on each side of the river mouth. This area has a rich and lengthy history of human occupation. There has historically been an abundance of kai from and adjacent to the estuary and in the sea.	Special character of the estuary will be reflected in shape, soil, and surrounding plants. The slow meandering nature of this part of the catchment is critical. Tidal nature and variety of habitats are also important features. The tidal sequence of the estuary can be reflected in the capture and release of the treated water in synch with the actual estuary cycle. To reflect the aspect of food gathering, the created structure could be stocked with tuna.	A pond with variable water levels, and contact with riparian plants, enables nutrient and water uptake, further oxygenation, evaporation, UV treatment of pathogens. There may be some additional nitrogen transformation.

Table 5.7: Education

Telling the story of the catchment, alongside the story of the high rate land passage system and community efforts to improve the health of the Wairoa River.

Cultural Aspects	Catchment Aspects	Treatment Processes
Education of tamariki and mokopuna is a strongly held Maori value. It is important for future generations to learn from kaumatua their ancestry and tikanga Maori. It is important to transfer the knowledge of how to care for their environment and maintain healthy mauri, and balanced tapu and noa.	Each catchment has a story to tell, and many different aspects can be educational. There are stories to be told about Maori creation history, ecological history, physical development, and human history. The water quality changes and challenges for the wider catchment can also be explained with restoration projects as examples of work to clean up the river.	The treatment processes can be described in some detail at each stage of the high rate land passage in order to improve public understanding of how wastewater is treated. It can also link to the wider catchment nutrient inputs and transformations.

Water accumulating in the lower pond (represented by the lagoons) during each day will discharge into the Wairoa estuary through the existing or modified discharge pipeline and diffuser during night-time out-going tides. The pond's fill and empty cycle could be seen to represent the rise and fall of the tide.

When the wastewater is not discharging to the estuary, a pump will be used to circulate the wastewater from the wetland back up to the high rate land passage diffuser inlet so that the wastewater within the high rate land passage is always flowing like a natural waterway. This will help to maintain a base flow. It will also represent (if passed through the sprinklers provided) evaporation from the waterways with its return to the mountains in the form of rainfall and the source of the individual rivers.

6 BRINGING TOGETHER THE PACKAGE

6.1 One Solution or Many – Wastewater Options

Community wastewater discharge is usually provided for by one solution. While there may be a number of improvements to that system over time (such as additional treatment), typically all water passes through one discharge point.

The proposed package of work is divided into two aspects: pre-discharge and post-discharge. These are described below.

6.1.1 Pre-discharge

Reticulation renewals and upgrades will continue to be implemented as determined by WDC in consultation with their community via Annual and Long-Term Plans. These programmes are necessary to replace the aging and faulty reticulation which has allowed significant volumes of groundwater and stormwater to enter the reticulation in recent years. These additional volumes of water not only require pumping to the WWTP and treatment by the WWTP, but they are also the primary cause of storage exceedances at the WWTP and pump station overflows during storm events. These in turn can contribute to resource consent breaches by forcing the discharge to the estuary to occur outside of the consented night-time falling tide conditions and/or unconsented pump station and manhole overflows to land and waterways.

In addition to reticulation works, WDC will need to monitor the performance of the WWTP as high wastewater flows reduce treatment efficiency. While the current level of treatment is considered to be having no detrimental adverse impact at the point of discharge, there may be a point in future where changes of treatment technology are desirable. Should this eventuate, it will be important to ensure that any proposed changes to the treatment system will not adversely affect the high rate land passage system, but will also be compatible with and necessary for any future land discharge system. It is important to avoid investing in any treatment plant technology or infrastructure that may become redundant when a longer-term discharge options are implemented. It is noted that, regardless of the discharge mechanism, UV disinfection is likely to be required, and this would include filtration in order to be assured of the UV system's effectiveness against pathogens.

6.1.2 Post-discharge

It is clear that there is a community preference to have no treated water discharge to the Wairoa River. While options can be considered, and implemented, such as irrigation, these will not occur immediately and see the removal of 100 % of the flow. This means that the current discharge system has to be used in some form, and as suggested in previous sections, a high rate land passage will contribute to further treatment and land passage prior to discharge into the river.

This focus could be considered a short-term solution. Longer-term non-river options should be incorporated into the larger package to allow for phasing out of discharging to water and ideally changing to an all land discharge system. Adjusting to a land only system requires a significant financial contribution towards infrastructure. Additionally, having land available to irrigate and a very large storage pond to manage winter flows will be the most crucial elements in the success of ceasing the current discharge to water. It doesn't however, exclude the

potential for a partial cessation of the river discharge, particularly during lower flow summer periods.

6.2 Phasing Over Time

Due to the high costs that will be encountered for infrastructure and possible land purchase or lease, any irrigation of wastewater to land will be a gradual process over a 30 year (potentially longer) period. This is a process whereby the land required needs to be identified, acquired and if necessary adequate storage provided for periods where irrigation is not recommended (i.e. during rainfall events and when soil moisture levels are high and cannot tolerate additional irrigation).

It is also important to avoid investing in any infrastructure that may become redundant when a longer-term land discharge system is implemented. Ideally the high rate land passage should be designed so that it becomes an integral part of the treatment and discharge system regardless of the final location of the discharge, whether it is to the estuary or onto farm land.

The acquisition of land, if land application is desired and affordable by the community, will take time, WDC and the community will need to actively seek out and motivate rural landowners to initiate wastewater irrigation schemes on nearby rural land. There is the potential that if promoted with benefits land owners may be willing participants and users of the wastewater for irrigation.

Should a larger package be agreed with the community prior to lodging consent for the needed continuation of the existing discharge needs, there will be a requirement to ensure that future undertakings are committed to by WDC. This will undoubtedly require monitoring of progress against specific milestones and deadlines to ensure a larger package is delivered on.

6.3 Catchment Improvements

During the process of identifying a best practicable option for wastewater discharge, the vision to improve the health of the Wairoa River has been a clear objective. If the focus was solely on removing the wastewater discharge from the river, this would not address all issues with the river health. The Wairoa River is heavily influenced by the geology of the surrounding land, being a variety of mudstone, siltstone and sandstone layers, together forming fine silt particles that create a turbid river when sediment enters the waterways. This issue is exacerbated where bare earth is able to erode, and then land management influences the potential for further erosion.

The Wairoa River Catchment is the Hawke's Bay region's largest with an area of 3,563 square kilometres. The land-use in the catchment is mostly farming, predominantly hill country sheep and beef farming. Forestry is the second largest land-use. The catchment includes the majority of the Wairoa district as well as having a significant land holding (much of the Hangaroa sub-catchment) in the Gisborne District.

If changes are to be made within the river catchment there are five key areas that can be considered: Oversight and Governance, Planning and Prioritisation, Whole Farm Planning, Implementation and Works, and Auditing and Reporting. These five areas can be implemented

across the region or on a sub-catchment basis. If applied at a sub-catchment level there could be a specific focus, dependent on the topography and main land management or waterway issues within those catchments.

Improving the health and stability of the Wairoa River catchment will involve a financial contribution, not only from the community of Wairoa, who will already be contributing to an improvement to the wastewater discharge system, but the entire district of Wairoa will need to be financially involved. Further funding will see more projects taken on board with a faster turnaround to completion.

6.4 Delivering the Package

The package of works can be broken down into the following groupings:

- Wastewater reticulation;
- Wastewater treatment;
- Wastewater discharge; and
- Catchment works.

Specific actions that can or are being implemented are described in Table 6.1 below. The table identifies specific items and actions along with a description of the action. Approximate cost ranges for specific items have been identified, along with a likelihood of the item being undertaken. **Committed** implies that works have been allocated in current financial planning or general undertakings. **Essential** is considered to be works that need to happen to allow a sustainable wastewater system within the catchment to be developed, and **desirable** are more aspirational activities.

Table 6.2 provides an implementation summary based on the likely time to implement the above actions.

Table 6.1: Package description, timing, costs and certainty. (red = committed >90% likely to occur; orange = essential 60% likely to occur; yellow = desirable >10% likely to occur)

	Item		Description	Time	Cost	Certainty
Wastewater Reticulation	House	Remove illegal Connections	Stormwater connections connected to wastewater reticulation are removed and diverted to minimise I&I contribution	year 1 to year 5		
	Reticulation	Investigations	Research and modelling of reticulation system to encounter what is the best solution for the particular system	Year 1 to year 5		
		Relining	Lining of pipes	Year 1 to year 30		
		Replacement	Replacing asbestos pipes and older leaky pipes	Year 1 to year 30	**$4.75 M to $20 M**	
		Pressure Lines	Upgrading sections of the reticulation system with pressure lines instead of gravity feed	Year 5 to year 15		
		New Mains	Areas of the reticulation system that need new mains added to avoid increasing loads on already existing systems	Year 10 to year 15		
	Pump Stations	Replacement	Replacing pump station pumps	Year 1 to year 10		
		Rising Main Upgrade	Upgrading systems that are no longer coping with the flow rates	Year 1 to year 10		
Wastewater Treatment	Treatment	Desludging	Removing pond sludge build up to allow for increased storage area	Year 5, 10 , 15, 20 (every 5 years)	**$100 K to $500 K**	
		Flow Meter Upgrade	Replacing the current monitoring system and calibrate to the current flow rates	Year 2		
		UV Treatment	Adding UV treatment to the pond treatment system to decrease pathogen loading rates	Year 2	**$250 K to $400 K**	
	High Rate Land Passage	Physical Works - Construction	Constructing the approved design, gabion baskets, rock features, water features	Year 2 to Year 3		
		Planting	planting out the high rate land passage site with appropriate plant species	Year 2 to Year 3	**$2.65 M to $5.56 M**	
		Educational Signs	Erecting educational signs to show the passage of wastewater from the treatment plant to discharge as a means of education in relation to wastewater nutrient removal and catchment improvement	Year 3		
Wastewater Discharge	Outfall Pipe	System Upgrade	Upgrading of the outfall pipe to minimise blockages and unconsented overflows	Year 2 to Year 3	**$300 to $1 M**	
	Irrigation					
	Area 1 - Mucalo Property	Construction	Installation of infrastructure pipes and pumps across the Mucalo property. This will see piping from the treatment plant to the hill tops and flats of the associated areas	Year 5		
		Maintenance/Use	Monitoring soil moisture and groundwater levels regularly, soil moisture should be checked before irrigation begins each session; irrigation maintenance of piping, nozzles and pump.	Year 6 onwards		
	Area 2 - Landfill Forestry	Construction	Installation of infrastructure pipes and pumps across forestry site. This will be an additional connection from the Mucalo property.	Year 10		
		Maintenance/Use	Monitoring soil moisture and groundwater levels regularly, soil moisture should be checked before irrigation begins each session; irrigation maintenance of piping, nozzles and pump.	Year 11 onwards		
	Area 3 - Mucalo Neighbouring Property	Construction	Installation of infrastructure pipes and additional pumps. These will be connected onto existing piping from the Mucalo property.	year 15	**$16.5 M to $34 M**	
		Maintenance/Use	Monitoring soil moisture and groundwater levels regularly, soil moisture should be checked before irrigation begins each session; irrigation maintenance of piping, nozzles and pump.	year 16 onwards		
	Area 4	Construction	Installation of infrastructure pipes and additional pumps if required, dependent on location from existing irrigation	Year 20		
		Maintenance/Use	Monitoring soil moisture and groundwater levels regularly, soil moisture should be checked before irrigation begins each session; irrigation maintenance of piping, nozzles and pump.	Year 21 onwards		
	Area 5	Construction	Installation of infrastructure pipes and additional pumps if required, dependent on location from existing irrigation	Year 25		
		Maintenance/Use	Monitoring soil moisture and groundwater levels regularly, soil moisture should be checked before irrigation begins each session; irrigation maintenance of piping, nozzles and pump.	Year 26 onwards		
	Oversight & Governance	Governance	Manage governance oversight and maintain relationships with existing governance structures (i.e. Regional Council)	Year 3 onwards		
		Management	Technical advisory team, strategic and operational management, support of catchment projects	Year 3 onwards		
	Planning & Prioritisation	Research and Planning	Analyse historic field data, research and audit to fit into prioritisation and planning processes	Year 3 to Year 4		
		Works and Catchment Allocation	Plan individual and catchment programmes/targets	Year 4		
	Whole Farm Plan	Engagement	Engagement with individual farmers in target sub-catchments to determine farm layout and target areas for works.	Year 4 onwards		
		Whole Farm Plan	Process of farm planning, farmer interview, mapping, nutrient budget, targeting 100 farms per year	Year 4 onwards	**Up to $45 M**	
		Works Programme	Agree on works programme and timing with farmer	Year 4 onwards		
	Implementation and Works	Incentives and grant payments	Funding grants applied for to assist with ratepayers' contribution, should include central government and other organisations (i.e. industry support, trusts, marae, tourism initiatives)	Year 3 onwards (dependent on grant period)		
		Physical Works	Carry out physical works according to agreed plans (i.e pole planting, riparian zoning, land retirement) aim for 2,500 ha per year of works	Year 5 onwards		
	Audit and Report	Audit and monitoring	Auditing of works undertaken on a regular basis (i.e. yearly)	Year5 onwards		
		Reporting	Annual reports completed to account for works undertaken	Year 3 onwards		

Table 6.2: Package plan over 30 years

			0 years (2017/18)	1 years (2018/19)	2 years (2019/20)	5 years (2024)	10 years (2029)	15 years (2034)	20 years + (2039)	25 years + (2044)	30 years + (2049)
Wastewater Reticulation	House Reticulation	Remove illegal connections									
		Investigations									
		Relining									
		Replacement									
		Pressure Lines									
		New Mains									
		Replacement									
		Rising Main Upgrade									
Wastewater Treatment	Treatment Plant										
		Desludging									
		Flow Meter Upgrade									
		Treatment - UV treatment									
	High Rate Land Passage										
		Consent									
		Physical Works - Construction									
		Planting									
		Educational Signs									
		Operation/ maintenance									
Wastewater Discharge	Outfall Pipe	system upgrade									
	Irrigation										
	Area 1 - Mucalo Property	Construction									
		Use/maintenance									
	Area 2 - Landfill Forestry	Construction									
		Use/maintenance									
	Area 3 - Mucalo Neighbouring Property	Construction									
		Use/maintenance									
	Area 4	Construction									
		Use/maintenance									
	Area 5	Construction									
		Use/maintenance									
Catchment Works		Oversight & Governance									
		Planning & Prioritisation									
		Whole Farm Plan									
		Implementation and Works									
		Audit and Report									

6.5 What Does The Package Cost

The delivery of the above Package comes at a cost to the community, being an increase in rates to cover the Package. The reality is any changes to the current system will result in rate increases, with options pursuing 100 % discharge to land being very expensive (if in fact 100 % land application is actually feasible). If targeting 100 % discharge to land is essential then there are two options: 1) the costs being incurred now, or 2) costs incurred gradually over time. There is the scope for the increases to be moderated by developing lower cost options with the help of the community.

Figure 6.1 below provides an indicative idea of three potential costs scenarios over a 30 year period for:

- the gradual implementation of a Package using an initial land passage treatment system with more irrigation gradually introduced over time;
- again the gradual implementation of a Package, but a more costly route for establishing irrigation whereby council are responsible for greater costs, such as land purchase; and
- the adoption of a 100 % land application/irrigation programme at an early stage.

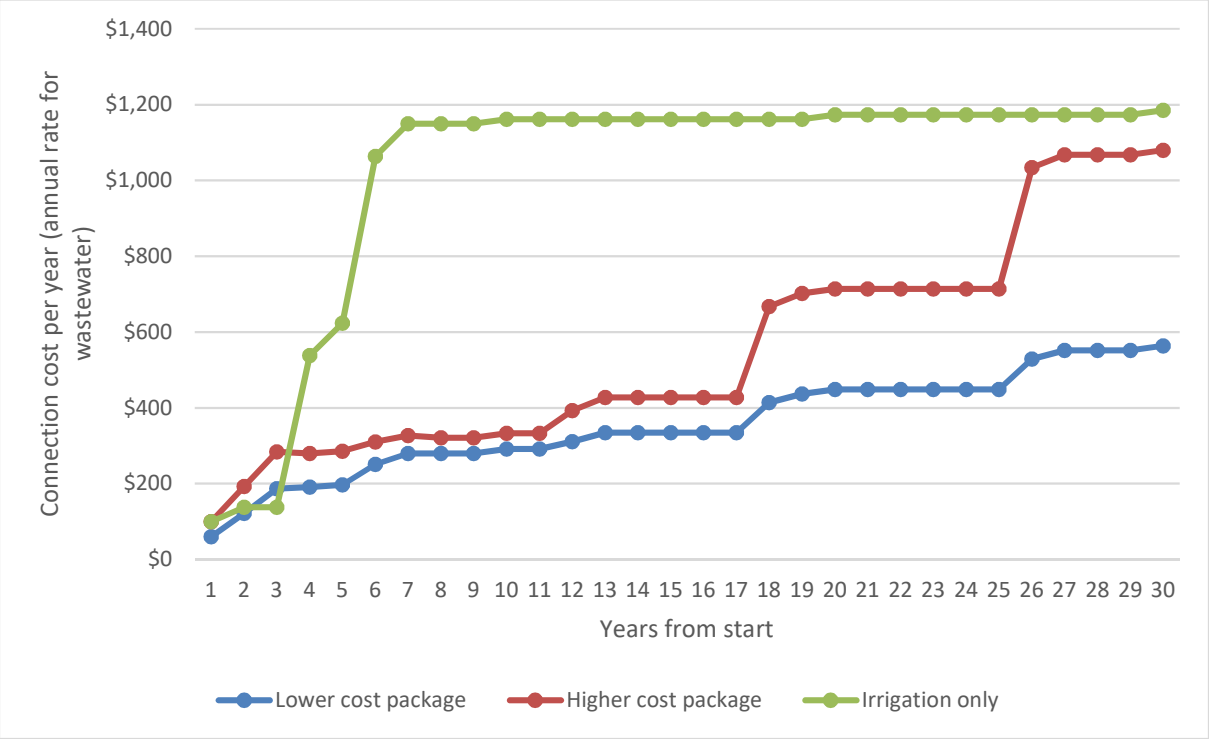


Figure 6.1: Annual Rate Cost Associated with Wastewater Package

The costs are the annual rate resulting from the capital work activities in that year being spread over the subsequent 30 year period, with operating costs in that year also added.

The Packages described above do not include existing programmed works, including expenditure on reticulation upgrades. They do however, include an estimation of annual operating costs.

Where a river discharge is maintained, at least in the initial years, a contribution to establishing catchment management programmes is included in the costs. However, where the land

application package is commenced at an early stage there is no contribution to any catchment programme.

A summary of the total 30 year costs is presented in Table 6.3 below.

Table 6.3: 30 year costs for Alternative Wastewater Packages

		Lower cost package	Higher cost package	Irrigation only
Wastewater Reticulation		**$ -**	**$ -**	**$ -**
	Consenting	**$ 1,500,000**	**$ 2,500,000**	**$ 2,500,000**
Treatment Plant	Desludging	$ 1,200,000	$ 1,200,000	$ 1,200,000
	Flow Meter Upgrade	$ 75,000	$ 150,000	$ 150,000
	Treatment - UV treatment	$ 250,000	$ 500,000	$ 500,000
	Treatment Plant Total	**$ 1,525,000**	**$ 1,850,000**	**$ 1,850,000**
Wastewater Treatment	High Rate Land Passage			
	Physical Works - Construction	$ 1,000,000	$ 1,400,000	$ -
	Planting	$ 300,000	$ 500,000	$ -
	Educational Signs	$ 100,000	$ 150,000	$ -
	Operation/ maintenance	$ 2,100,000	$ 2,800,000	$ -
	High Rate Land Passage Total	**$ 3,500,000**	**$ 4,850,000**	**$ -**
Discharge	**Outfall Pipe - system upgrade**	**$ 350,000**	**$ 500,000**	**$ -**
	Irrigation			
	Area 1			
	Construction	$ 250,000	$ 250,000	$ 10,000,000
	Use/maintenance	$ 520,000	$ 520,000	$ 3,900,000
	Area 2			
	Construction	$ 1,500,000	$ 750,000	$ 11,000,000
	Use/maintenance	$ 1,380,000	$ 960,000	$ 3,600,000
	Area 3			
	Construction	$ 500,000	$ 1,500,000	$ -
	Use/maintenance	$ 720,000	$ 1,080,000	$ -
	Area 4			
	Construction	$ 2,000,000	$ 6,000,000	$ -
	Use/maintenance	$ 480,000	$ 720,000	$ -
	Area 5			
	Construction	$ 2,000,000	$ 8,000,000	$ -
	Use/maintenance	$ 160,000	$ 240,000	$ -
	Irrigation Total	**$ 9,510,000**	**$ 20,020,000**	**$ 28,500,000**
Catchment works	Oversight & Governance	$ 430,000	$ 520,000	$ -
	Planning & Prioritisation	$ -	$ -	$ -
	Whole Farm Plan	$ -	$ -	$ -
	Implementation and Works	$ -	$ -	$ -
	Audit and Report	$ -	$ -	$ -
	Catchment Total	**$ 430,000**	**$ 520,000**	**$ -**
	Total current value investment	**$ 16,815,000**	**$ 30,240,000**	**$ 32,850,000**

7 FUNDING OPTIONS

The assistance of funding with a wider wastewater package will assist with achieving goals quicker, more money upfront will allow for a quicker set up with the aim of achieving removal of wastewater entering the Wairoa River sooner. The reality of setting up such a catchment programme is that it needs to be affordable and work within budget constraints of its funders (district rate payers, central government, industry groups, and charitable or environmental organisations). Many volunteer hours and donated goods (construction materials and plants) or cash are often key elements in successful programmes of this nature. Buy-in is crucial in the form of local communities working to improve their own backyards to achieve wider community benefits and pride or mana.

Using the Sustainable Land Use Initiative (SLUI) run by Horizons Regional Council as an example, this can show an estimate to what costs are involved within a similar catchment project. Since implementation in 2007 through to the most recent operational report of 2014/15, works have been carried out on 19,800 ha of land in the Horizons region. This has included pole planting, afforestation, riparian planting, and retirement of land. A 10-year cost of this project has been estimated at $84M with year 1 costing $1.5M (Cooper, 2014).

Funding for the SLUI project was generated from Horizons rate payers, farmer contributions and MPI funding.

There are also other central government funding opportunities, such as the Ministry for the Environment's Freshwater Improvement Fund. This had allocated $100 million over a four year period for a range of projects that were to enhance water quality. The recent change in government will also no doubt create other funding options.

8 REFERENCES

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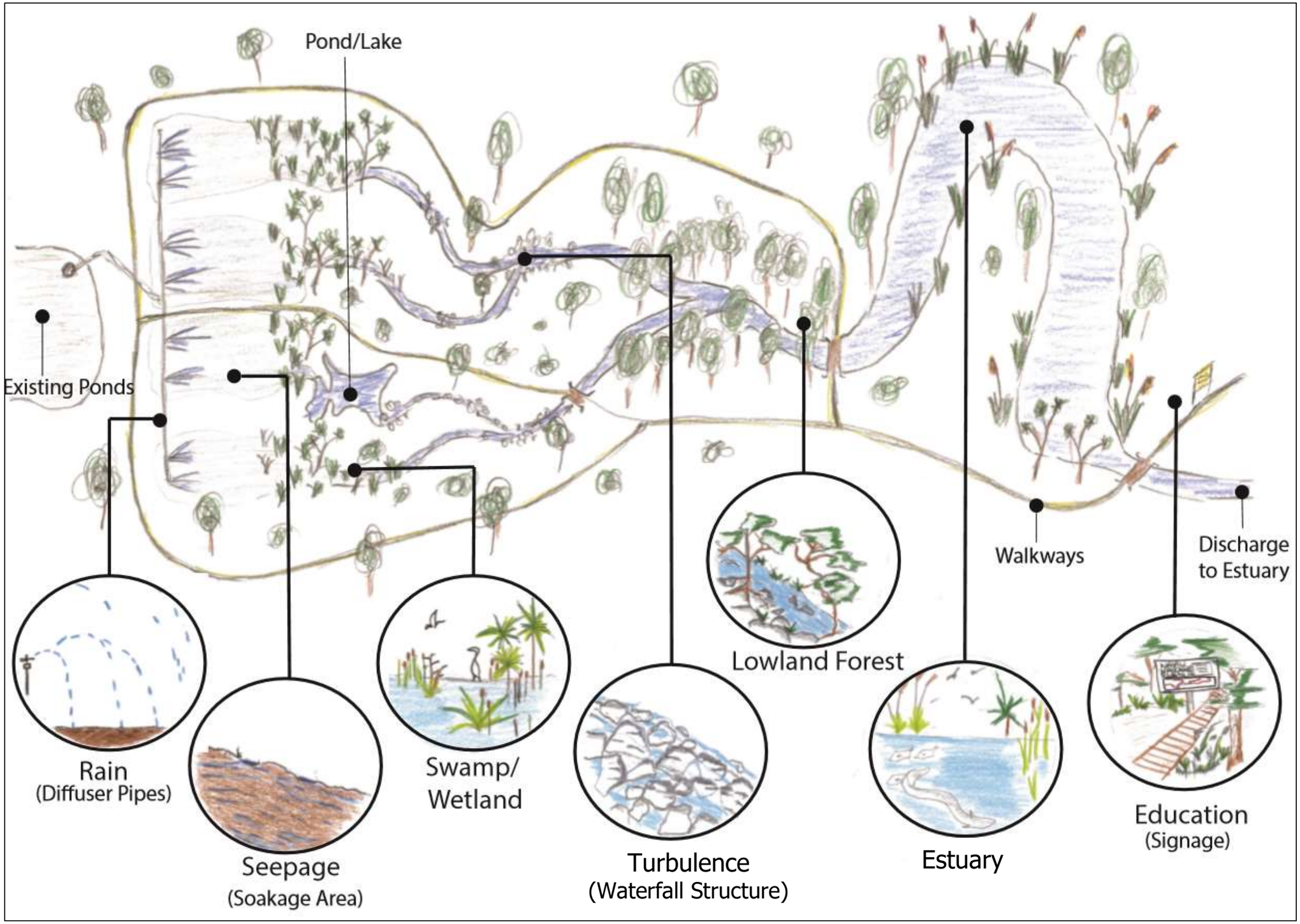
9 APPENDICES

Appendix A Figures

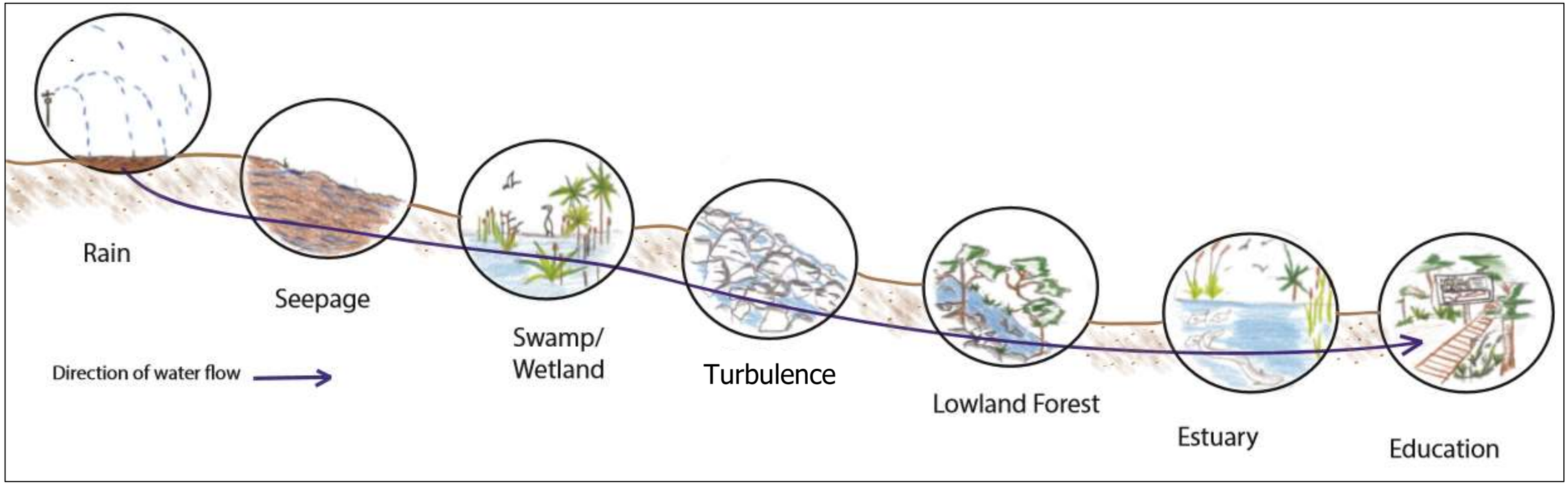
APPENDIX A

Figures

Appendix A.1: Design Concept - Plan



Appendix A.2: Design Concept – Section



Appendix B: Design Concept - Alternate