Freshwater ecosystems of Tiritiri Matangi

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Executive Summary

A survey of all freshwater streams and dams on Tiritiri Matangi Island was carried out over the period 12 – 14 November 2014 in order to characterise the ecology of the freshwater habitats on the island and to provide recommendations as to improvements that could be made to enhance these.

Results showed that the only permanent freshwater habitats were contained within a number of artificial dams located around the island, with the stream systems being characterised by their intermittent nature, having isolated pools and a general lack of flow during the period of the survey.

The fish fauna captured was limited to two native species, shortfin eel (*Anguilla australis*) and banded kokopu (*Galaxias fasciatus*), which were found in a total of three dams. These species are noted for their ability to climb in-stream obstacles while migrating upstream, which is the likely reason why they are the only species to be detected on the island.

The main issues affecting freshwater ecosystems on Tiritiri Matangi are due to the short, steep nature of the catchments present. This causes streams to only flow intermittently and results in reduced connectivity for native fish to migrate upstream into the permanent habitats that are present behind the dams.

Due to the topography of the island restricting the amount of freshwater habitat available, there are limited options for improving the current state of freshwater ecosystems on Tiritiri Matangi. However, a number of recommendations are made in order to improve fish passage into two of the dams by modifying their spillway structures, and the potential for translocating black mudfish, a threatened native species, to the island is also explored.

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1. Introduction

1.1 Background

Surrey Environmental Ltd was contracted by the Supporters of Tiritiri Matangi to undertake a freshwater survey of Tiritiri Matangi, the purpose of which was to evaluate the freshwater environments present on the island with regards to their ecological value and to carry out a stocktake of the fish species that inhabit these habitats.

Over the period 12-14 November 2014 all permanent freshwater habitats on the island were surveyed, using a combination of traps, nets and spotlighting, and qualitative assessments made of the ecological value of these habitats.

This report presents the results of the fieldwork that was carried out and provides recommendations for ways in which the freshwater biodiversity of Tiritiri Matangi may be maintained and improved in the future.

1.2 Fish migration and stream connectivity

Many of New Zealand's native freshwater fish have a diadromous life-cycle, meaning that a portion of their life history is spent at sea. For the galaxiid or 'whitebait' species, which include banded kokopu, this involves the eggs hatching in the freshwater environment and the larvae being washed out to sea, where they develop over a period of weeks into translucent whitebait. The whitebait then migrate back into freshwater habitats, where they develop their pigmentation and spend the remainder of their adult lives.

Eels have a different life history in that they migrate into the Pacific Ocean once mature, where they spawn and die. The larvae then drift back to New Zealand on ocean currents and the juvenile eels migrate upstream into freshwater habitats, where they develop into adults.

Despite the differences in life histories between eels and galaxiids, the key aspect for both is the requirement for upstream and downstream migration between the freshwater environment and the ocean. For this reason maintaining the connections between freshwater catchments and the sea is crucial for maintaining populations of these fish.

Because Tiritiri Matangi is a small island, any freshwater fish present will be diadromous, with recruits coming from within a Hauraki Gulf population fed from catchments on the mainland. Therefore the issue of stream connectivity is critical in determining the amount of habitat that is available on the island for fish to occupy and for maintaining permanent fish populations.

Stream connectivity can be affected by both man-made and natural factors. Man-made factors include in-stream structures such as culverts, weirs and dams that present a physical barrier to fish migrating upstream, while natural barriers may include waterfalls, fast-flowing chutes and intermittent streams that only hold water infrequently during periods of high rainfall.

The degree to which fish are able to bypass in-stream obstacles also differs between species. Some, such as inanga (*Galaxias maculatus*), are relatively poor swimmers and are unable to migrate upstream past areas of concentrated high flows or over fairly small in-stream obstacles. Others, such as eels (*Anguilla* sp.) and banded kokopu (*Galaxias maculatus*), have the ability to climb vertical surfaces by utilising damp areas with low flow at the margins of streams and rivers.

This means that 'climbing' species are able to penetrate much further inland and over a variety of obstacles that would be impassable to species with weaker swimming abilities.

Despite their impressive ability to scale vertical surfaces, 'climbing' species are unable to migrate past man-made structures that incorporate overhanging lips, as often found on weirs and 'perched' culverts. Obstacles such as these will often require additional engineering solutions in order to make them passable to migrating fish.

2. Methodology

The purpose of this survey was to gather information on the type and extent of the freshwater habitats present on Tiritiri Matangi and to carry out a stocktake of the fish species that inhabit these.

All dams on the island that hold permanent water were surveyed using both fyke nets and Gee minnow traps, which were left overnight and retrieved the following morning.

The fykes were set perpendicular to the shoreline, with the leader attached by a stake to the shore so that fish were directed into the net mouth, while Gee minnow traps were suspended parallel to the shore in areas of cover that were likely to be suitable habitat for small fish.

All fish captured were identified to species, measured, and then immediately returned to the water.

Fyke nets are designed to catch larger fish and are particularly effective at capturing eels, while the unbaited Gee minnow traps with 5mm mesh targeted smaller fish (see
Figure 1 &
Figure 2).

Spotlighting was also carried out at night on a number of dams and streams in an effort to detect fish. Because most native fish are nocturnal, spotlighting is often a more effective technique for surveying than netting or trapping, especially in waterways that are too small or shallow to allow the effective use of nets. All fish seen while spotlighting were identified to species and an estimated length was recorded.

The locations of all nets and traps were marked using a Garmin GPS, as were any other notable features, including the location of fish found while spotlighting.

In addition to surveying for fish, water quality measurements were also taken at all dams using a YSI Professional Plus multiparameter meter. This was used to record water temperature, pH, dissolved oxygen levels and conductivity for each site.

The approximate surface area for each dam was calculated using aerial photos accessed using the Auckland Council GIS Viewer (http://maps.aucklandcouncil.govt.nz/aucklandcouncilviewer/).

In addition to the dams, all catchments on Tiritiri Matangi were surveyed to determine the extent of any permanent streams. The value of habitat in these areas was also assessed.

Notes were also taken of the quality of the habitat at each site and of any possible improvements that could be made to increase the ecological values. Specifically looked at was the connectivity between stream catchments and the marine environment. This aspect is important for the migration of native fish to complete their life cycles and has a direct impact on the species that are likely to inhabit waterways on Tiritiri Matangi.

No macroinvertebrate samples were taken during the survey. This was because there were no sufficiently large areas of permanent stream that were suitable for sampling and also because metrics of stream health based on macroinvertebrate communities are not designed for the dam habitats that were present on the island. The value of any data gained was likely to be minimal when compared to the additional cost of having samples analysed and the inapplicability of results to the dam habitat sampled.

Figure 1: Fyke net

Figure 2: Gee minnow trap

Information on the history and use of the freshwater catchments on the island was gained from speaking with Ray Walter. As the former project manager for Tiritiri Matangi he was able to provide a large amount of useful detail regarding the dates of construction and any current or historical issues with the various dams.

Weather conditions were overcast and rainy for the majority of the survey, with passing heavy showers and hail occurring on 13 November. There was rain in the days preceding the survey as well, so weather conditions were generally typical of spring.

3. Dam Sites

3.1 Bunkhouse Dam – Little Wattle Valley

Description

Originally constructed in 1984, the Bunkhouse Dam holds water year-round and is thought to be 3-4m deep (Ray Walter, pers.comm.).

The water is a dark brown colour and the dam is surrounded by regenerating bush, comprised mainly of cabbage trees, manuka, mahoe, karo and coprosmas. Riparian vegetation consists of reeds and sedges surrounding the margins of the dam and there are two shadecloth shelters provided for the protection of pateke (brown teal) from aerial predators.

At the time of the survey there was no stream flow either coming into or out of the dam. The downstream channel was completely dry and the upstream extent of the dam consisted of an area of damp mud.

Size of dam: 130 m²

Coordinates (NZTM): 1769652 5946974

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 13:00	19.5	7.23	93.4	8.58	432.8

Fish survey results

A total of three fyke nets and five Gee minnow traps were set within Bunkhouse Dam. No fish were captured but a number of diving water beetles and a damselfly (*Xanthocnemis*) larva were found in the Gee minnow traps.

Aquatic flora

No submerged aquatic plants were recorded within the dam. Emergent species around the margins of the dam included wiwi (*Juncus edgariae*), raupo (*Typha orientalis*) and *Carex* sedges (either *Carex lessoniana* or *Carex geminata*).

Figure 3: Location of Bunkhouse Dam

Figure 4: Aerial view of Bunkhouse Dam

Figure 5: Panoramic view of Bunkhouse Dam

3.2 Upper Emergency Landing Dam – Lighthouse Valley

Description

The Upper Emergency Landing Dam is the larger of the two dams in the Lighthouse Valley catchment and was constructed around 1991-1992 (Ray Walter, pers.comm.).

A single stream flows into the south-western end of the dam where the water is relatively shallow, although it shelves steeply and becomes rapidly deeper towards the dam face.

The concrete dam face is 3 metres in height and has a spillway structure of around a metre in width that has a steel plate forming the base (Figure 9). Mosses and bryophytes were growing on damp areas of the dam face in the splash zone surrounding the spillway, although flow at the time of the survey was minimal.

The spillway structure overhangs the dam wall by approximately 0.75m, with water discharging from the dam falling vertically to a small pool at the base of the wall. A small pipe with a valve, presumably for draining the dam, is located near the bottom of the dam wall (Figure 10).

The design of the spillway structure means that fish passage into the dam is likely to be significantly compromised, as migrating fish are unable to climb features that are overhanging or 'perched'.

From the small pool at the base of the upper dam wall the flow disappeared through an area of leaf litter for approximately 10 metres before entering another pool, which is at the top of a 7 metre long rocky cascade that leads into the Lower Emergency Landing Dam.

Size: 324 m²

Coordinates (NZTM): 1769605 5947588

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 15:10	19.5	3.70	109.4	9.96	648

Fish survey results

Three fyke nets and five Gee minnow traps were set overnight in the dam. A shortfin eel (*Anguilla australis*) measuring 720mm in length was captured in one of the fyke nets (Figure 11). In addition, stick caddis larvae from the genus *Triplectides* were found inside a number of the Gee minnow traps.

Aquatic flora

A bed of native aquatic charophytes of the genus *Nitella* or *Chara*, measuring approximately 30m by 5m in size, was present in the north-west corner of the dam where the water is shallowest. This was the only submerged vegetation recorded within the dam and there were no emergent species recorded.

Figure 6: Location of Upper Emergency Landing Dam

Figure 7: Aerial view of Upper Emergency Landing Dam

Figure 8: Panoramic view of Upper Emergency Landing Dam

Figure 9: Spillway structure on Upper Emergency Landing Dam, showing 'perched' overhang

Figure 10: Base of spillway structure, showing drainage valve (circled)

Figure 11: Shortfin eel captured in Upper Emergency Landing Dam

3.3 Lower Emergency Landing Dam – Lighthouse Valley

Description

This dam is the older, and smaller, of the two Emergency Landing dams, having been constructed at some point during the 1960s or earlier (Ray Walter, pers.comm.).

The dam is deep, with the sides shelving steeply. No emergent vegetation was present but riparian vegetation consisted mainly of flax, with two large pohutukawa trees providing shade on the water's surface.

A water take is present within this dam, with a buoy suspending the intake pipe near the water surface close to the dam wall.

The outflow for the dam consists of a horizontal metal pipe set in the dam wall and connected via a 90° join to a vertical pipe on the downstream side of the wall (Figure 15Figure 16). At the time of the survey the water level of the dam was at the level of the outflow pipe, but very little discharge was observed.

Connectivity with the stream below was compromised by the vertical discharge pipe ending halfway down the dam wall, making it unlikely that fish would be able to migrate into the dam via this route.

Size: 64 m²

Coordinates (NZTM): 1769640 5947593

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 14:00	18.3	4.19	80.9	7.59	590

Fish survey results

Three fyke nets and five Gee minnow traps were set within the dam, with one shortfin eel measuring 1050 mm in length being captured in a fyke net (
Figure 17). No other fish were caught, although *Xanthocnemis* damselfly larvae and *Triplectides* caddis larvae were found in the Gee minnow traps.

Spotlighting was carried out on the evening of 13 November, during which a large eel was seen sitting vertically in the water column at the upstream end of the dam below a rocky cascade (Figure 18). It is possible that this may have been the same individual captured and released from the fyke net earlier that day.

Aquatic flora

No submerged or emergent flora was present in the Lower Emergency Dam.

Figure 12: Location of Lower Emergency Landing Dam

Figure 13: Aerial view of Lower Emergency Landing Dam

Figure 14: Panoramic view of Lower Emergency Landing Dam

Figure 15: Outlet pipe from Lower Emergency Dam

Figure 16: Vertical section of outlet pipe on dam wall

Figure 17: Shortfin eel captured in Lower Emergency Landing Dam

Figure 18: Large eel seen while spotlighting

3.4 'Stagnant Pond' – East Coast Track

Description

The 'Stagnant Pond' is a small 'offline' dam (i.e. not constructed in an active stream channel) built in the mid '90s (Ray Walter, pers.comm.).

Water depth was very shallow (<1 m deep) and there was no flow into or out of the pond observed. As implied by the name of the pond, the lack of water movement, small size and shallow depth resulted in low levels of dissolved oxygen within the water column.

Riparian vegetation was present around the entire perimeter of the pond, giving a high degree of shading to the water's surface. This was mainly made up of flax (*Phormium tenax*) and manuka (*Leptospermum scoparium*).

Size: 22 m²

Coordinates (NZTM): 1769318 5948013

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 15:30	18.1	6.37	52.9	4.95	359.9

Fish survey results

Two fyke nets and four Gee minnow traps were set overnight in the pond. No fish were captured, although numerous Dytiscidae diving beetles were found in the minnow traps the next day.

Aquatic flora

Emergent vegetation present included willow weed (*Persicaria* sp.), while a large sedge (*Carex secta*) was present in the mid-section of the pond. No submerged macrophytes were present.

Figure 19: Location of Stagnant Pond

Figure 20: Aerial view of Stagnant Pond

Figure 21: Stagnant Pond and surrounding vegetation

3.5 Upper Dam – Silvester Wetlands

Description

The Upper Dam in the Silvester Wetlands is the smaller of two dams in the area that were constructed approximately 15 years ago. The Upper Dam was rebuilt around 2 years ago following a high rainfall event where the dam overflowed and which resulted in the dam wall losing 600mm in height due to erosion (Ray Walter, pers.comm.).

The outflow from the dam is via a 300mm PVC pipe, which is embedded in rip-rap (Figure 25). At the time of the survey there was no flow occurring out of the dam.

The riparian vegetation surrounding the dam consisted of regenerating manuka, flax and exotic grasses.

Size: 164 m²

Coordinates (NZTM): 1768471 5948507

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 17:15	19.1	6.69	101.2	9.35	365.5

Fish survey results

Four fyke nets and five Gee minnow traps were set within the Upper Silvester Dam overnight. No fish were captured, although diving beetles were found inside a number of the Gee minnow traps.

Aquatic flora

While no submerged macrophytes were recorded, there was some emergent vegetation in the form of willow weed (*Persicaria* sp.) and *Juncus* rushes present around the shallow marginal areas of the dam.

Figure 22: Location of Upper Silvester Dam

Figure 23: Aerial view of Upper Silvester Dam

Figure 24: Panoramic view of Upper Silvester Dam

Figure 25: Outflow pipe for Upper Silvester Dam

3.6 Lower Dam – Silvester Wetlands

Description

The Lower Dam is the larger of the two dams within the Silvester Wetlands and was constructed at the same time as the Upper Dam (around 15 years ago). The dam face currently has a crack running through it and it is due to be repaired (Ray Walter, pers.comm.).

Like the Upper Silvester Dam, the water in the Lower Dam is a dark brown colour, which is likely due to the soil chemistry in the wetland catchment.

The surface of the dam is largely unshaded, with riparian vegetation consisting of largely of flax and cabbage trees (*Cordyline australis*).

The outflow from the dam is via a shallow channel reinforced with small rocks (Figure 29). At the time of the survey the water level of the dam was level with the outflow, which was damp but barely flowing.

Size: 412 m²

Coordinates (NZTM): 1768391 5948557

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 16:35	19.5	6.44	79.1	7.24	505.5

Figure 26: Location of Lower Silvester Dam

Figure 27: Aerial view of Lower Silvester Dam

Figure 28: Panoramic view of Lower Silvester Dam

Figure 29: Outflow from Lower Silvester Dam

Fish survey results

A total of four fyke nets and five Gee minnow traps were set overnight in the Lower Silvester Dam.

Two banded kokopu of 160mm and 130mm in length were caught, as well as three shortfin eels, measuring 400, 509 and 808 mm in length respectively. All of these fish were captured in the fyke nets, although numerous *Triplectides* caddisfly larvae and water boatman (*Sigara*) insects were found in the Gee minnow traps.

Aquatic flora

The margins of the Lower Silvester Dam were fringed by *Juncus* rushes. No submerged macrophytes were present.

Figure 30: Banded kokopu captured in Lower Silvester Dam

3.7 Excavated Pond – Bush 22

Description

The 'Excavated Pond' is a shallow, muddy man-made pond in Bush 22. With no inflow or outflow it is fed solely from rainfall within its catchment. While full of water at the time of the survey, it has reportedly dried up over the previous two summers (K.Milton, pers. comm.)

The pond is located in the midst of a large, monospecific stand of kanuka (*Kunzea robusta*) with a number of large flax plants present around the margins of the pond.

Size: 55 m²

Coordinates (NZTM): 1768449 5948075

Date/Time	Water temp. °C	pH	Dissolved O_2 %	Dissolved O_2 mg/L	Conductivity µS/cm
12/11/14 17:50	17.9	6.52	93.2	8.83	177.0

Fish survey results

Only two fyke nets were set overnight, as there were no Gee minnow traps remaining and the lack of connectivity to any streams meant that it was unlikely that any fish were living in the pond.

As expected, no fish were captured when the nets were checked the following day.

Aquatic flora

No submerged flora was present, with emergent vegetation being limited to small bunches of *Juncus* rushes around the margins.

Figure 31: Location of Excavated Pond

Figure 32: Aerial view of Excavated Pond

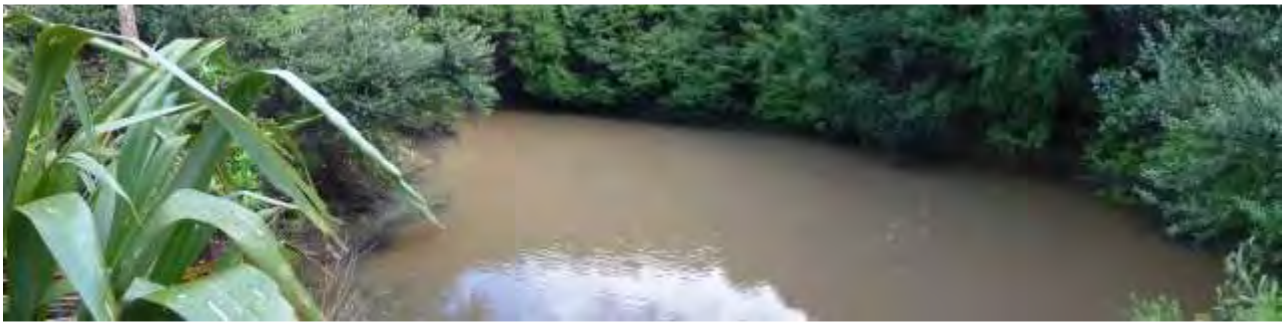

Figure 33: Panoramic view of Excavated Pond

3.8 Wharf Pond – Bush 6

Description

The Wharf Pond is a small pond that was created where rock was excavated to provide roading material for the island. It has had ongoing issues with water leakage and is due to be re-lined and sealed with bentonite and cloth in March 2015 (Ray Walter, pers.comm.).

At the time of the survey the water level was very low, around 0.5m at its deepest. The source of water in the pond is from rainfall only, as there was no defined inlet or outlet.

Size: 18 m²

Coordinates (NZTM): 1769020 5947208

Fish survey results

Two fyke nets and two Gee minnow traps were set overnight. No fish were captured.

Aquatic flora

The pond is fringed with *Juncus* rushes and emergent vegetation consists of the exotic water purslane (*Ludwigia palustris*).

Figure 34: Location of Wharf Pond

Figure 35: Aerial view of Wharf Pond

Figure 36: Fyke nets and Gee minnow traps set in Wharf Pond

4. Stream sites

In addition to the dams surveyed, all streams on Tiritiri Matangi were also assessed. This consisted of walking along the stream and taking notes and photos of the condition of the watercourse, including measuring in-stream features such as pools.

4.1 Kawerau Stream – Bush 1

The Kawerau Stream in Bush 1 is one of the largest streams on Tiritiri Matangi and has previously been noted as providing habitat for banded kokopu and eels. The Kokopu Pool, which is below a footbridge in the upper part of the catchment, is so named because of the resident population of banded kokopu that were found there. A large interpretative sign is still present at the bridge, proving information about native fish, and banded kokopu in particular.

Anecdotal reports suggest that following a large flood in 1986/87 the habitat within the stream was significantly altered and the fish population was badly affected, with banded kokopu no longer being commonly seen (Ray Walter, pers.comm.).

Figure 37: Location of Kawerau Stream

The length of the Kawerau Stream catchment was surveyed from the bridge above the Kokopu Pool to the point where the stream meets the beach. The majority of the stream was composed of a series of small pools with undercut banks, separated by stretches of stream channel that were completely dry (see Figure 38). It appears that the stream is intermittent in nature, only flowing fully when a large amount of rainfall has occurred within the catchment.

Spotlighting was carried out on a number of small pools located in the vicinity of the Kokopu Bridge at the upper end of the catchment. A small eel of approximately 400 mm in length was spotted in a shallow pool approximately 40m downstream of the bridge and at least two other smaller eels were also seen in separate pools.

The small size of the pools and intermittent flow of the stream in this area of the catchment means that there is inadequate habitat for larger eels and other species of native fish to establish stable populations.

At the lower end of the catchment, approximately 100m from the beach, there were a series of three big pools located under sizeable pohutukawa trees, the largest of which measured 6m long by 2.5m wide and 0.3m deep (Figure 39). All pools featured undercut banks and a high degree of shade from riparian vegetation, making them some of the best stream habitat available for fish on the island.

Sightings of fish within these pools, which were almost certainly banded kokopu, have been recorded recently (Hester Cooper, pers. comm.), so the pools appear to support at least a modest population of this species.

Further downstream, a build-up of leaf litter and debris at the base of flax bushes bordering the beach prevented the stream from reaching the sea. There was virtually no flow in the stream at the time of the survey.

Figure 38: Typical small pool in mid-catchment area of Kawerau Stream

Figure 39: Large pool at downstream extent of Kawerau Stream

4.2 Bush 2 Stream

The Bush 2 stream is located just to the north of the toilet block at Hobbs Beach. The upper areas of the catchment are on steep terrain and were dry at the time of the survey, while further down the catchment the stream channel was progressively damper.

At the bottom end of the catchment near the beach there were a series of shallow, muddy pools that were isolated from each other by stretches of dry channel (see Figure 41). Habitat within these pools was minimal due to a lack of water, although a shortfin eel of around 500mm in length was found foraging in a muddy pool while spotlighting (Figure 42).

Figure 40: Location of Bush 2 Stream

Figure 41: Example of a small pool in Bush 2 Stream

Figure 42: Small eel foraging in thick mud in Bush 2 Stream

4.3 Bush 3 Stream

The Bush 3 Stream is located to the north of where Hobbs Track meets Hobbs Beach. The lower reaches of this stream contained a number of stagnant pools with heavy bacterial growth, indicating a lack of flow and warm water temperatures (Figure 44).

Further upstream there were a number of larger pools that did not feature the same level of bacterial growth, although there was still a lack of stream flow and the pools were isolated from one another by dry areas (Figure 45). The upper extent of water within the catchment was a shallow, muddy pool located in an area with a number of nesting boxes fixed to trees beside the stream. Upstream of this area the channel was dry, with no pools present.

Figure 43: Location of Bush 3 Stream

No spotlighting or trapping was carried out in this stream due to logistical constraints, but the relatively small amount of habitat available suggests that fish numbers would be minimal.

Figure 44: Stagnant pool with bacterial growth at the bottom of the Bush 3 Stream

Figure 45: Shallow pools in the upper part of the Bush 3 catchment

4.4 Silvester Wetland Stream

The Silvester Wetland Stream originates at the outflow of the Lower Silvester Dam (see Section 3.6 & Figure 29) and flows down a small valley towards Northeast Bay.

Figure 46: Location of Silvester Wetland Stream

Immediately after exiting the Lower Silvester Dam the stream disappears into thick flax, which covers the valley below. Halfway down the valley there was no defined stream channel, with only a damp flow path present (Figure 47).

Figure 47: Damp flow path through flax

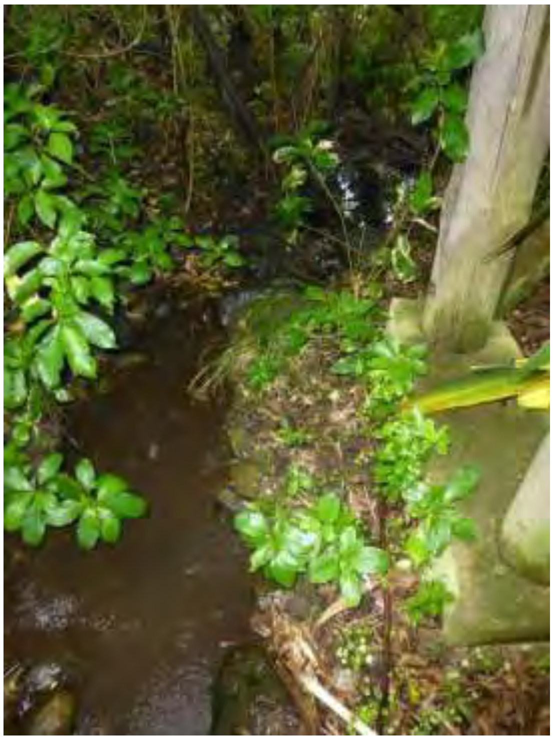

Figure 48: Small pool beneath bridge

Towards the bottom of the catchment there is a bridge where the North East Bay Track crosses the stream. At this point there was a small pool measuring 2.2m long by 0.7 m wide and 9 cm deep (Figure 48). The habitat within the pool appeared suitable for fish and it had good riparian cover, with shading of around 80%. There was a small amount of flow at the time of the survey as it was raining lightly.

At the very bottom of the catchment there was a shallow, muddy pool above a series of small rock steps, over which there was a small flow of water (Figure 49). Immediately below this the stream terminated on the beach, where the flow disappeared beneath the shingle before reaching the sea (Figure 50). Connectivity between the sea and upper areas of the catchment would only be likely during periods of heavy, sustained rainfall where a continuous flow was maintained.

There were no locations within this stream that were suitable for setting Gee minnow traps, as the water depth was too shallow. Given the very limited habitat available the likelihood of a permanent fish population within the stream was low.

Figure 49: Small rock cascade at bottom of Silvester Wetland Stream

Figure 50: View of the stream disappearing into the shingle beach at Northeast Bay

4.5 Emergency Landing Stream – Lighthouse Valley

The Emergency Landing Stream originates below the Lower Emergency Dam and flows a distance of around 60m to the bay below (Figure 51).

Figure 51: Location of Emergency Landing Stream

Immediately below the face of the Lower Emergency Dam were two pools separated by a 3 metre-long section of dry channel. A shortfin eel of approximately 600mm in length was seen in the second pool while spotlighting on 13 November.

Below the second pool the stream channel was again dry for a distance of 30 metres before continuing as a series of small interconnected pools (Figure 52). The dry sections showed a distinct channel, indicating that there is a high volume of flow when a large amount of rainfall occurs within the catchment.

The largest pool within this stream measured 4m long by 2m wide and 0.3m deep.

At the bottom of the catchment a small amount of flow was trickling down a near-vertical 5 metre-high rock face to form a stagnant pool at the top of the beach (Figure 53). At the time of the survey the stream flow disappeared into the rocks on the beach approximately 50 metres from the sea.

While the rock face would be scalable by climbing fish species, such as eels and banded kokopu, the amount of habitat within the stream above was very restricted.

Figure 52: A series of interconnected pools in the Emergency Landing Stream

Figure 53: Damp flow down the rock face at the bottom of the catchment

4.6 Lighthouse Valley Stream

The Lighthouse Valley Stream is located upstream of the Upper Emergency Dam, and during the survey had a wetted length of around 40 metres (Figure 54). Good quality stream habitat was present, with a high level of riparian shading and a good degree of instream cover suitable for fish.

The largest pool measured 2.5m in length by 1.2m wide and 0.7m deep and contained a thin layer of naturally-occurring red-orange iron bacteria. A number of smaller pools were also present, although they were separated by sections of dry channel.

At the time of the survey connectivity with the Upper Emergency Dam was reduced, but this should increase in heavy rain.

Figure 54: Location of Lighthouse Valley Stream

Figure 55: Large pool in Lighthouse Valley Stream

5. Other sites

A number of stream and dam sites were surveyed that did not hold any water at the time of the survey. These are briefly described below.

5.1 Bush 21 Stream & Dam – Pohutukawa Cove

The stream and associated offline dam were completely dry at the time of the survey, offering no value as freshwater habitat. In addition there is a 20 metre-high waterfall/cliff downstream of the East Coast Track (Ray Walter, pers.comm.) making it unlikely that the stream and dam would hold resident fish populations even if adequate water was present.

Figure 56: Location of Bush 21 stream and dam

5.2 Fisherman's Bay Pond – Fisherman's Bay

The Fisherman's Bay Pond was constructed in the mid-90s but was prone to leaking due to root intrusion. It was rebuilt in 2013 but continues to leak and is due to be repaired in March 2015 by lining it with bentonite (Ray Walter, pers.comm.).

At the time of the survey the pond was completely dry and overgrown with plants (Figure 58).

Figure 57: Location of Fisherman's Bay Pond

Figure 58: View of the dry and overgrown Fisherman's Bay Pond

5.3 Bush 22 stream – Pohutukawa Cove

The Bush 22 stream is located in a steep catchment that is also one of the largest on the island. The stream channel is heavily incised and at the time of the survey was completely dry. The large amount of leaf litter in the stream bed indicated that there had not been any recent flow and it is likely that this only occurs in the event of heavy rainfall within the catchment.

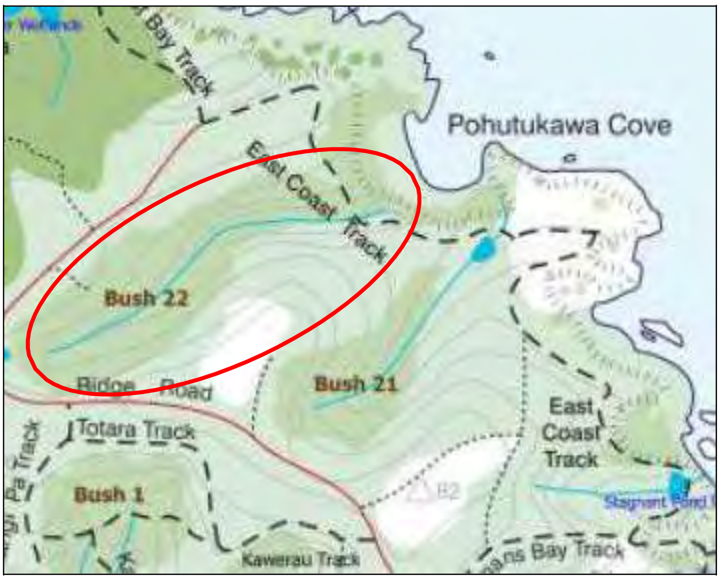

Figure 59: Location of Bush 22 stream

6. Results

The surveys revealed that there is very little permanent freshwater habitat on Tiritiri Matangi, apart from the network of artificial dams around the island. The small, steep nature of the island's catchments mean that streams are only likely to flow during periods of heavy rainfall, with only isolated pools remaining when conditions are drier. This was evident in most of the streams surveyed, where a defined channel was present but a lack of water meant that there was very little flow, with streams being largely reduced to isolated pools or areas of damp ground.

The survey was undertaken in late spring during weather conditions that were unsettled and rainy. The minimal in-stream habitat observed is likely to be even further reduced during the height of summer, when a lack of rain and high temperatures will result in existing pools shrinking in size and dissolved oxygen levels dropping further.

While some species of native fish, especially eels, are able to tolerate sub-optimal conditions, the lack of permanent stream habitat in all catchments was reflected in the very low numbers of fish captured and observed during the survey.

The other likely reason for the lack of fish found during the survey are the low levels of connectivity between the sea and the high-quality habitats found within the various dams. With the lack of permanent water in the stream sections between the dams and the coast, new recruits will only be able to migrate upstream during periods when sufficient rainfall to allow stream flow coincides with the migration period (usually around October – January). Depending on how frequently this occurs there may be years when no recruits are able to migrate into permanent habitat within the dams.

It is also for this reason that the only dams that were found to contain fish were those that had active outflows (Upper & Lower Emergency Dams, Lower Silvester Dam). Predictably, dams that lack connection to a stream appear unlikely to be colonised by fish.

The short, steep nature of the catchments on Tiritiri Matangi makes it unsurprising that the only two species of fish found during the survey were banded kokopu and shortfin eels. These are two of the most common freshwater fish species in the Auckland region and they both possess superior climbing abilities when migrating upstream from the sea.

Aside from the general lack of flow in the streams there are also significant obstacles, both natural (such as the rock face at the base of the Emergency Landing Stream, shown in Figure 53) and man-made (e.g. the spillway structure on the Upper Emergency Landing Dam in Figure 9) that fish are required to negotiate in order to access permanent habitat. Improvement of fish passage over the man-made structures may assist in increasing fish populations in certain dams. This will be addressed in greater detail in Section 7.

Submerged macrophytes within the permanent habitat contained behind the dams were generally lacking, with the exception of an area of native charophytes present in the Upper Emergency Dam. This is likely to be due to a lack of a substantial source population from which seeds can be spread around the island, although the lack of suitable shallow margins in many of the dams that could be colonised by macrophytes may also be a factor.

Emergent vegetation was present around the margins of all dams, with *Carex* sedges, *Juncus* rushes, flax and willow weed being among the common species found.

Measurements of pH, conductivity, water temperature and dissolved oxygen that were taken at all of the dams indicate good water quality in the majority of these sites. As expected, the 'Stagnant

Pond' had the lowest dissolved oxygen readings of all the sites (52.9%), due mainly to its very shallow nature and lack of flow.

Dissolved oxygen readings the other sites ranged between 109.4% in the Upper Emergency Dam and 79.1% in the Lower Silvester Dam, which indicated good conditions for maintaining aquatic life.

pH was circum-neutral in all sites except for the Upper and Lower Emergency Dams, where readings of 3.7 and 4.19 respectively were recorded. The notably acidic nature of the water within these dams will be due to the soil chemistry within the catchment should not pose any concerns regarding the quality of the freshwater habitats.

Likewise, any variations in conductivity will be attributable to differences in catchment chemistry, as there are no sources of organic pollution on the island which conductivity would normally be used as an indication of.

Overall, the areas that hold permanent water on the island provide an array of high-quality freshwater habitats that are suitable for colonisation by freshwater flora and fauna. Limitations on this are mainly due to the lack of source populations on the island or issues with connectivity for fish, as outlined above.

7. Opportunities for improving freshwater habitats

As mentioned in Section 6 there is a general lack of permanent freshwater habitat on Tiritiri Matangi. Coupled with poor connectivity between the dams and the sea, this limits the options available for improving the freshwater ecology of the island, although there are a number of possibilities for consideration outlined below.

7.1 Fish passage improvements

Improving fish passage into permanent habitat within many of the dams is difficult, since the ability of fish to migrate upstream is largely dependent on sufficient flow being present in the stream sections between the dam and the sea during the migration period.

While there is no easy way to improve the situation in the streams themselves, as this is largely governed by the size and topography of the catchments and the amount of rainfall, there are steps that can be taken in order to make it easier for fish that reach the base of the dams to gain access to the habitat behind them.

The only dams where improvements to fish passage are likely to be practical are the Upper and Lower Emergency Dams. This is because both of these dams have outflow structures that are less than ideal for allowing fish access, and also because the Emergency Landing Stream is relatively short and is able to provide a suitable route for fish to enter the dams, as evidenced by the eels captured in each of them.

The Lower Emergency Dam has an outflow consisting of a metal pipe with a 90° angle in it, as previously described in Section 3.3 and illustrated in Figure 15 & Figure 16. This pipe is currently impossible for fish to use for climbing upstream into the dam and has reportedly been previously blocked by a dead eel that was trapped while trying to exit the dam downstream, so it is recommended that it be permanently blocked off at the upstream end where it exits the dam wall.

As well as blocking the outlet pipe, a two-metre wide section of the dam wall in the middle of the span next to the pipe should be lowered by approximately 10 cm to provide a preferential spillway for flow from the dam to trickle down the dam face. Allowing the flow to exit vertically down an area of the dam face will make it possible for climbing fish species to easily scale the concrete surface and enter the dam. As long as the area remains damp then mosses will thrive on the dam face (see Figure 60), providing moisture retention and extra purchase for eels and banded kokopu to climb their way upwards into the dam.

Access for fish into the Upper Emergency Dam is currently hampered by the presence of the overhanging or ‘perched’ spillway structure (see Section 3.2 and Figure 9 & Figure 10). The design of the structure makes it impossible for fish to climb the dam face when the flow is confined to the spillway (i.e. in low flow conditions), so it is recommended that modifications are made to improve fish passage over the dam. The steel plate forming the base of the spillway should be removed and the spillway entrance blocked off so that it is the same height as the rest of the dam wall.

The section of the dam wall between the current spillway and the concrete pillar should also be lowered by 10 cm to create a new spillway that would allow water to flow directly down the dam face, as for the Lower Emergency Dam outlined above (Figure 61).

Below the face of the Upper Emergency Dam the flow goes through an area of leaf litter around 10 metres in length before it enters the top pool of the Lower Emergency Dam. Manually clearing a channel through this leaf litter may help to encourage fish to enter the Upper Emergency Dam as well.

In conjunction with any improvements to fish passage it is recommended that a basic monitoring programme also be undertaken to determine whether fish are recruiting into these dams. This would easily be accomplished by setting a number of Gee minnow traps in each dam for a few nights on an annual basis and seeing if any juvenile galaxiids or eels are detected. The presence of small fish would indicate that fish passage has been established to an adequate level.

Figure 60: Mosses growing on the face of the Lower Emergency Dam

Figure 61: Area of spillway to be blocked off (red bar) and section of dam wall to be lowered (yellow highlight)

7.2 Potential for black mudfish translocation

One of the opportunities identified during the survey was the potential for the Bunkhouse Dam to be used as a translocation site for black mudfish (*Neochanna diversus*), a native species with a conservation status of “At Risk – Declining” (Goodman, et al., 2014).

Black mudfish are usually found in acidic peat wetland habitats, which are increasingly rare, both nationally and within the Auckland region. Eels are known to predate upon mudfish, so habitats that are free of eels are thought to provide the best chance of a flourishing population.

Mudfish are able to aestivate in dry conditions, which involves the fish burrowing into damp mud under logs or other debris, creating a mucus covering around itself to conserve moisture, and lowering its metabolic rate. This adaptation allows fish to survive in intermittent water bodies that may dry up over summer, although this behaviour is facultative and mudfish will survive perfectly well in areas that contain permanent water.

Black mudfish are only known from a very small number of sites within the Auckland region, with the largest known breeding population being in the wetlands bordering Lake Tomarata. Although this species is unlikely to have ever naturally existed on Tiritiri Matangi, creating a new population on the island would serve as a valuable addition to the mainland sites, some of which remain under threat from disturbances such as livestock grazing.

The qualities of the Bunkhouse Dam that lend itself to being suitable habitat for black mudfish include the large amount of riparian cover around the margins of the dam, the good level of shading from surrounding trees, and the apparent lack of eels within the dam, which will reduce the predation risk considerably.

Although the pH of the Bunkhouse Dam is higher than the acidic conditions that black mudfish are typically found in (pH in the dam was 6.81 - 7.23), this is less of a factor than other variables, such as the presence of ephemeral water and low turbidity (Dr Nick Ling, University of Waikato, pers.comm.).

Improvements to the Bunkhouse Dam to improve the habitat available for black mudfish could include the addition of large woody debris around the margins of the dam, re-contouring some areas of bank to create additional shallow zones around the edges of the dam, and planting of *Eleocharis* sedges to provide extra cover from avian predators such as kingfishers.

There is currently a programme underway involving Auckland Zoo, Auckland Council, Mahurangi Technical Institute (MTI) and DOC, to look at whether captive bred black mudfish can be used to establish new populations of this species. Given the proximity of Tiritiri Matangi to where the captive breeding is being undertaken at MTI, it appears that there would be a strong case for the Bunkhouse Dam to be included as one of the experimental release sites.

As well as potentially adding another threatened native species to the array already present on Tiritiri Matangi, a translocation such as this would also help to satisfy Objective 4 *“maintain and increase populations of all mudfish species”* in DOC’s Mudfish Recovery Plan (Department of Conservation, 2003).

If the potential for a translocation of black mudfish was to be explored further then it is recommended that approaches be made to the leader of DOC’s Mudfish Recovery Group, and David Cooper, the Special Projects Manager at MTI, to establish support for setting up a project. If DOC and MTI are supportive then it would be worth investigating whether Auckland Zoo’s Conservation Fund could assist the project with staff time and/or funding support.

7.3 Improvements to aquatic flora

The majority of aquatic flora on Tiritiri Matangi, both emergent and submerged, consists of native species. Exotics, such as the water purslane present in the Wharf Pond, would be relatively easy to manually control if this was desired, but the impacts of this on the current state of the habitat in these areas is minimal.

Janeen Collings, a senior botanist in Auckland Council's Biodiversity team, has expressed interest in working with the Supporters of Tiritiri Matangi to provide advice on any future plantings that may be planned to maximise the aquatic values and biodiversity on the island.

8. Recommendations

Below is a list of recommended actions arising from the results of the survey carried out on Tiritiri Matangi. As previously discussed, there is a limited amount that can be done to improve the freshwater ecology of the island due to the limitations imposed by the nature of the catchments themselves.

- Permanently block the existing outflow pipe on the Lower Emergency Dam and create a preferential spillway down the dam face by lowering a portion of the dam wall in order to improve fish passage into the dam.

- Block off the overhanging spillway on the Upper Emergency Dam and create a new spillway down the dam face by lowering a section of the dam wall near the middle of the span.

- Manually clear a small channel through the leaf litter immediately below the face of the Upper Emergency Dam to improve connectivity to the upper reaches of the Lower Emergency Dam.

- Investigate the possibility of having the Bunkhouse Dam used a site for the experimental translocation of captive-bred black mudfish, in collaboration with DOC, Mahurangi Technical Institute, and potentially Auckland Zoo.

- Contact Janeen Collings (Janeen.Collings@aucklandcouncil.govt.nz) in Auckland Council's Biodiversity team for any specific advice on improvements to marginal and emergent vegetation on the island.

9. Bibliography

Department of Conservation. (2003). *New Zealand mudfish (Neochanna spp.) recovery plan 2003-13. Threatened Species Recovery Plan 51.* Wellington.

Goodman, J., Dunn, N., Ravenscroft, P., Allibone, R. M., Boubee, J., David, B., et al. (2014). *Conservation status of New Zealand freshwater fish, 2013.* Wellington: Department of Conservation.

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- Matt Bloxham and Janeen Collings from Auckland Council for botany advice.

Appendices

Appendix A – Species list

A list of all freshwater species recorded during the survey is provided in Table 1.

Table 1: Species list

	Common name	**Scientific name**	**Native or exotic?**	**Locations found**
	Banded kokopu	*Galaxias fasciatus*	Native	Lower Silvester Dam Kawerau Stream[1]
	Shortfin eel	*Anguilla australis*	Native	Emergency Landing Stream Lower Emergency Dam Upper Emergency Dam Bush 1 Stream Bush 2 Stream Lower Silvester Dam
	Diving beetle	Family: Dytiscidae	Native	Bunkhouse Dam Stagnant Pond Upper Silvester Dam
	Stick caddis	*Triplectides* sp.	Native	Upper Emergency Dam Lower Emergency Dam Lower Silvester Dam
	Water boatman	*Sigara* sp.	Native	Lower Silvester Dam
	Damselfly larvae	*Xanthocnemis zealandica*	Native	Bunkhouse Dam Lower Emergency Dam
	Charophytes	Family: Characeae	Native	Upper Emergency Dam
	Water purslane	*Ludwigia palustris*	Exotic	Wharf Pond
	Wiwi	*Juncus edgariae*	Native	Bunkhouse Dam
	Carex sedge	*Carex lessoniana* or *geminata*	Native	Bunkhouse Dam
	Carex sedge	*Carex secta*	Native	Stagnant Pond

[1] Unconfirmed but credible report prior to the survey being undertaken

	Common name	Scientific name	Native or exotic?	Locations found
	Raupo	*Typha orientalis*	Native	Bunkhouse Dam
	Flax	*Phormium tenax*	Native	Upper Emergency Dam
	Willow weed	*Persicaria* sp. (*hydropiper* or *decipiens)*	Exotic (*hydropiper*)/ Native (*decipiens*)	Stagnant Pond Upper Silvester Dam
	Juncus rushes	*Juncus* sp.		Upper Silvester Dam Lower Silvester Dam Excavated Pond Wharf Pond

Appendix B – GPS waypoints

A map of the GPS waypoints that were recorded during the survey was created with Google Maps, and is accessible via the link below:

https://www.google.com/maps/d/edit?mid=zA2snPvQwMZ4.k2a2HhBSt7C0

A list of all waypoints and their descriptions is provided in Table 2.

Table 2: List of GPS waypoints and descriptions

Label	Description
TTF01 – 03	Fyke net locations in Bunkhouse Dam
TTG01 – 05	Gee minnow trap locations in Bunkhouse Dam
TTF04 – 06	Fyke net locations in Lower Emergency Dam
TTG06 – 10	Gee minnow trap locations in Lower Emergency Dam
TTF07 – 09	Fyke net locations in Upper Emergency Dam
TTG11 – 15	Gee minnow trap locations in Upper Emergency Dam
TTF10 – 11	Fyke net locations in 'Stagnant Pond'
TTG16 – 19	Gee minnow trap locations in 'Stagnant Pond'
TTWP01	Bridge dry channel on Bush 21 Stream
TTWP02	Former offline dam, now completely dry.
TTF12 – 15	Fyke net locations in Lower Silvester Dam
TTG20 – 24	Gee minnow trap locations in Lower Silvester Dam
TTWP03	Location where water parameters were measured in Lower Silvester Dam
TTWP04	Location where water parameters were measured in Upper Silvester Dam

Label	Description
TTF16 – 19	Fyke net locations in Upper Silvester Dam
TTG25 – 29	Gee minnow trap locations in Upper Silvester Dam
TTF20 – 21	Fyke net locations in Excavated Pond
DRY DAM	Location of dry dam at Fisherman's Bay
DRYSTREAM	Location of dry channel in Bush 22 stream
NOCHANNEL	Location of damp flow path with no defined channel in Silvester Wetland Stream
POOLS	Location of a series of small pools in Silvester Wetland Stream
BRIDGE	Location of bridge over Silvester Wetland Stream
EXIT	Location where Silvester Wetland Stream exits to the beach
POOL2	Location of large pool in Lighthouse Valley Stream
DRY	Start of dry channel in Lighthouse Valley Stream
WATER	Upstream extent of water in Lighthouse Valley Stream
WATERFALL	Location of steep rock face at downstream end of Emergency Landing Stream
STRMEND	Location of Emergency Landing Stream terminus on the beach

Label	Description
EEL1	Location of ~600mm shortfin eel in Emergency Landing Stream
EEL2	Location of ~500mm shortfin eel in Emergency Landing Stream
STRM1	Location of Bush 1 Stream
EEL3	Location of ~500mm shortfin eel in muddy pool in Bush 1 Stream
STAGNANT	Location of stagnant pool in Bush 3 Stream
KAW1 - 3	Location of a series of three large pools at the lower end of the Kawerau Stream. KAW3 was the largest of these.
KAWEND	Location of Kawerau Stream terminus