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# AHURIRI REGIONAL PARK JOINT COMMITTEE

# Open **Minutes Attachments**

| | |
|---|---|
| Meeting Date: | Monday 15 June 2026 |
| Time: | 9.30am – 10.55am |
| Venue: | Large Exhibition Hall<br>War Memorial Centre<br>Marine Parade<br>Napier |

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# Bird Strike Risk Assessment – Ahuriri Regional Park

Prepared for

Napier City Council

May 2026

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# Quality Control Sheet

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| 1 | 1/10/2025 | Draft | Lachie Davidge | Lizzie Civil | Jarred Arthur |
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Anna Madarasz-Smith

**Limitations:**

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Napier City Council and Hawke's Bay Airport (not directly contracted by PDP for the work). PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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## 1.0 Introduction

Napier City Council (NCC) is working in partnership with Mana Ahuriri Trust (MAT) and Hawke's Bay Regional Council (HBRC) to design the Ahuriri Regional Park Masterplan (ARPM). The ARPM focuses on restoring the whenua to support stormwater management, enhance mauri and create a space that contributes to the overall health and well-being of people, place and environment.

NCC have engaged Pattle Delamore Partners (PDP) to undertake an assessment of bird strike risk, to evaluate and compare the current bird strike risk levels with those associated with the proposed ARPM design. This assessment is designed to assist both NCC and Hawke's Bay Airport in understanding both the current and potential future bird strike risk profiles, helping to inform the project's design-related decisions and next steps.

This technical report has been prepared to assess Hawke's Bay Airport current bird strike risk, and the risks associated with the proposed ARPM design. It also provides recommended management strategies to inform design modifications aimed at informing bird strike risk management for Hawke's Bay Airport.

### 1.1 Project Background

Ahuriri Regional Park (herein referred to as 'the site') sits adjacent to Te Whanganui-ā-Orotū/Ahuriri Estuary, a unique wetland area that requires restoration due to input from surrounding land uses (including stormwater discharge and sediment runoff). The site is approximately 0.8 km from the Hawke's Bay Airport Runway Threshold 34 and within its landing and approach corridor. The area is currently maintained for livestock grazing (e.g., sheep) and is bordered by mudflats and several wetlands (see Appendix A).

PDP have previously assisted NCC in the planning and design phase of the ARPM, highlighting design aspects within the ARPM that could increase avifauna attractancy and lead to a potential increase in bird strike risk. Design modifications were suggested to inform of the potential increase in bird strike risks and inform management options. The design of wetlands, buildings, flora species, planting, habitat creation, infrastructure, and public areas was discussed. Some alterations were made within the ARPM based on avifauna behavioural ecology and bird strike risk predictions, followed by NCCs request to undertake this formal bird strike risk assessment of the wider area to ground truth bird strike risks.

## 1.2 Bird Hazard Management

Bird hazard management is a crucial component of both airport safety and the protection of local avifauna. It plays an essential role in safeguarding passengers, staff and other stakeholders, while also minimising bird populations in the surrounding area. The ARPM intends to create a new, diverse range of bird habitat 0.8 km south of the main runway (16/34) at Hawke’s Bay Airport. The site sits along the critical landing and approach corridor for aircraft and is within the 3km buffer zone of the airport. This is particularly relevant given that approximately 80% of bird strike incidents occur within 500 ft (152 m) of the ground, primarily during take-off and landing phases (FAA, 2007; ICAO, 2024). As such, the proposed site lies directly within the zone of highest strike risk. The proposed ARPM designs will cause increased habitat attractants for avifauna, which has the potential to increase bird strike risk affecting operations and general safety. See Section 2 for additional information relating to the risk associated with the proposed ARPM designs. To manage and/or reduce the risk of bird strike at an airport, buffer zones are typically established around its vicinity. These are typically set at 3 km, 8 km and 13 km from the circumference of the airport and are used to determine what bird management activities are to be performed. These distances are recommended by several key aviation authorities, including the Federal Aviation Authority (FAA) and International Civil Aviation Organisation (ICAO). Specifically, the FAA recommends areas of habitat for bird species be kept at a minimum separation distance of 3 km for turbine-powered operations, and 8 km if highly hazardous bird species are present (e.g., Canada geese and black swan) (FAA, 2007). ICAO recommends up to 13 km be maintained between bird habitat and airport operational activities (IBSC, 2006; ICAO, 2024).

Other airports in New Zealand, including Christchurch International Airport and Wellington International Airport are protected by wildlife management safeguarding frameworks within their council district plans. These frameworks include 3, 8 and 13 km wildlife management buffer zones following the guidelines established by the FAA and ICAO. These councils typically implement the high-level framework identified in Table 1 below.

**Table 1: Typical wildlife management safeguarding framework requirements per 3 km, 8 km and 13 km buffer zone**

| Habitats Attracting Wildlife | 3 km (high risk) | 8 km (medium risk) | 13 km (low risk) |
|---|---|---|---|
| Landfills<br>Wetlands<br>Water Bodies (storm water, natural, WWTPs)<br>Farms (pasture, agriculture, offal, horticulture)<br>Factories (meat works, fish processing)<br>Building (design)<br>Landscape (design)<br>Recreational parks, sports fields, golf courses | Monitoring of existing sites by aerodrome<br>Council consent sign-off in respect to Aerodrome Safeguarding Framework<br>New areas require conditions including WHMP<br>Specialist ecological risk assessment<br>Council communication and progress follow up | Monitoring of existing sites by aerodrome<br>Council consent sign-off in respect to Aerodrome Safeguarding Framework<br>New areas require conditions that may include WHMP<br>Specialist ecological risk assessment | Monitoring of existing site by aerodrome<br>Council consent sign-off in respect to Aerodrome Safeguarding Framework |

An important aspect of bird hazard management is identifying habitats and features that attract avifauna, posing a high strike risk within each of the three airport buffer zones (e.g., 3 km, 8 km, and 13 km). Best practice suggests an assessment of each zone, identifying habitats that provide foraging, roosting, flocking and nesting birds. Bird counts should be conducted to determine species composition and abundance, with hazardous habitats identified. Habitats and species assessed as high risk to airport activities should be actively managed to reduce strike risk.

There is extensive evidence that wetlands provide habitats for a diverse range of bird species (FAA, 2007; Huang et al., 2022; McKinney et al., 2011), particularly waterfowl, waders, and marine birds (e.g., shags and herons). Additionally, bird abundance and composition are higher in wetland habitats compared to upland areas (Huang et al., 2022; McKinney et al., 2011). A study at Ordos Airport, China, identified several wetlands in its vicinity that provided habitat for high strike risk bird species (including swan, goose and common teal). Wildlife management at the airport, therefore, involved managing these wetland habitats and their attractants to reduce the likelihood of bird strikes associated with each area (Hu et al., 2020). Increases in bird density and abundance have been directly correlated with increased bird strikes at airports (van Tets, 1969).

### 1.3 Project Scope and Objectives

The purpose of this report is to assess the strike risk associated with the proposed site development that will be located 0.8 km south of Hawke’s Bay Airport.

Specifically, the objectives of this report are to:

- Identify and assess the current risk posed by wildlife to aircraft operations.
- Determine what habitats are available in the area and what bird species are using them.
- Assess how the proposed ARPM design will affect the composition of birds found in the area.
- Determine what bird species and habitats are of high-risk and provide appropriate recommendations and potential mitigation options.
- Provide design recommendations and management tool options to help mitigate potential increased bird strike risk to airport operations. Specifically, management tools are provided by the Australian Aviation Wildlife Hazard Group (AAWHG) and New Zealand Aviation Wildlife Hazard Group (NZAWHG).

## 2.0 Site Description

### 2.1 Airport Location and Operation

Hawke’s Bay Airport is located north of Napier City and occupies approximately 204 ha of land that was uplifted during the 1931 earthquake. Previously, the area of the airport and proposed ARPM was part of the extensive Ahuriri Lagoon. The current land use surrounding the airport is primarily pasture grassland, with several high-value wetland conservation areas found north, west and east of the site (see Figure 3). Additionally, Te Whanganui-ā-Orutū/Ahuriri Estuary is located along the south and west boundary of the airport, providing significant wetland and mudflat habitats for native and migratory birds.

Hawke’s Bay Airport has three runways, including Runway (RWY) 16/34 (1,750 m, asphalt), Runway 07/25 (1,199 m, asphalt and grass) and Runway 16/34 (766 m, grass). The main runway is the larger asphalt Runway 16/34 and receives most of the airport's traffic. The main Runway 16/34 is built in a north-south layout, with the smaller, grassed Runway 16/34 along the eastern side. Runway 07/25 is built in a west-east layout across the northern tip of main Runway 16/34 (see Figure 3). The airport primarily supports light aircraft and turboprop-powered aircraft, with limited use by jet-powered aircraft. As of 2024, the airport has 12,135 annual aircraft movements for regular passengers and 9,974 annual movements for general aviation.

## 2.2 Existing Land Use and Habitat Types

The current land use surrounding the airport and the site consists primarily of high-producing exotic grassland, urban areas and short-rotation cropland. Other habitats include herbaceous saline vegetation, orchard, vineyard or other perennial crops, exotic forest blocks, gorse and/or broom, indigenous forest and river (Landcare Research, 2019a; Norris, 2017).

In a 3 km radius of Runway 34 threshold, habitat types present include pasture grassland, wetlands, intermittent, small forest blocks, scrub, estuarine mudflats and open water (estuary, drainage channels and streams) (Pers. obs. Lachie Davidge & Teo Eugenio; see Figure 3).

## 2.3 Proposed Wetland Location and Design

The primary design focus of the ARPM is the construction of the Lagoon Farm Treatment Wetland. The wetland aims to provide an end-of-catchment system for treating the stormwater discharge before it enters the Te Whanganui-ā-Orotū / Ahuriri Estuary north of the site. The proposed treatment wetland is located directly south of Hawke's Bay Airport's 16/34 runway.

The treatment wetland has previously been redesigned due to earlier consultation recommendations (Boffa Miskell, 2025). To manage attracting avifauna fly overs, the treatment wetland has been designed to be densely planted in the first stage of construction to limit areas of open water throughout the site, with water input reduced until vegetation cover is fully established. At full depth, water levels throughout the treatment wetland will be approximately 500 mm.

Ongoing monitoring of the planting has been planned to occur into perpetuity to ensure that any location of open substrate that may provide habitat for birds to roost is replanted. The outer margins and several mounded 'islands' within the wetland will be planted with shrubs and small trees that are maintained to low heights to further restrict roosting potential for birds. Figure 1 provides an overview of how the wetland and mounded 'islands' may look post-completion.

**Figure 1: Overview of the proposed Lagoon Farm Treatment Wetland and mounded 'islands'**

Along the western boundary of the site, existing pasture grassland will be replaced with native forests, shrubs, grasses and reedlands. Taller canopied forest trees will be planted along the western boundary, with smaller trees and shrubs being planted further east before reaching the treatment wetland. Harakeke/flax (*Phormium tenax*) will be concentrated along the western side of the site to form a harvesting location for traditional māori weaving. This plant is a known attractant for species such as the common starling (*Sturnus vulgaris*) that roost in large flocks at the site. This is especially true when harakeke/flax is flowering, as birds feed on its nectar. A predator-proof fence is proposed for construction around the boundary of the forest, natural wetland and salt marshes (see Figure 2).

The Prebenson Reserve Channel, situated along the southern boundary of the site, will also undergo enhancement. Additional riparian tree and shrub species will be planted alongside sedges and rushes where necessary to limit open substrate for bird roosting. Several areas of pasture grass will remain around the site for public use. These areas will be managed using Avanex endophyte grasses to reduce use by black swans (*Cygnus atratus*) and Canada geese (*Branta canadensis*) that currently use these areas of habitat to roost, forage and preen. This includes grassland situated within the proposed ARPM Visitor Hub, situated directly below the landing and approach corridor of Hawke's Bay Airport. Avanex grasses have negative effects on birds and insects that ingest them, making the grasses less palatable to these species.

A native plant nursery is planned in the first stage of development and to supply the greater site with the plants required for future development. This area will be managed by nursery staff, with limited habitat for birds due to deterrent measures being implemented to reduce bird-related damage to growing seedlings.

An amphitheatre area is also planned along the south-eastern boundary of the site, adjacent to the visitors' hub. This area will retain existing tree species, with additional shrubs planted to provide screening and shelter. Avanex, endophyte grasses have been proposed for planting within the amphitheatre grounds to limit bird grazing in the area.

Other habitats proposed in the ARPM include a Pa Harakeke/flax collection area where the plant can be collected and used for traditional weaving. This site will primarily consist of harakeke/flax and will be intermixed with shrubs to create a diverse, natural habitat. A community foraging zone and trails have also been proposed along the eastern boundary of the site. This area would contain fruit, nut, and other food-producing plants, replacing existing pasture grassland.

Two separate research and demonstration ponds (freshwater and saltwater) have been proposed for construction. The freshwater pond will be located along the south-western corner of the site, and the saltwater pond will be constructed along the northern boundary in the centre. Both ponds will have open water and will be bordered by forest and wetland plants. Suspended netting has been suggested for installation over the saltwater research pond to reduce bird attractants.

Once the core park programmes are completed, secondary site initiatives can be developed as funding becomes available.

A key component of this next stage is the expansion of the welcome area to include a visitor centre that enhances the overall visitor experience. The scale and form of this facility will be determined through a detailed business case, ranging from a simple shelter with interpretive information to a fully staffed centre with a café and multi-use community spaces.

Revegetation across the wider site will continue in stages. The existing farming operation will be phased out once remaining pasture is no longer viable. The existing woolshed complex is identified for redevelopment into a bookable community facility, with an open amphitheatre space to the north offering scenic views over the wetlands.

A site-wide trail network is also planned, along with an eco-camping facility on the western side of the site. This area is intended for organised groups such as schools, scouts, and other community organisations, and would likely be managed by a private operator.

Supplementary furniture, play and learning nodes sculpture and art would be progressively installed over time, as funding allows.

**Figure 2: Conceptual landscape designs for Ahuriri Regional Park. Designs sourced from the Ahuriri Regional Park Masterplan (Boffa Miskell, 2025)**

# 3.0 Methodology

## 3.1 Desktop Review

PDP carried out an initial desktop review of available information relating to terrestrial habitats at the site, including current and historical aerial imagery (via Google Earth Pro) and Landcare Research's landcover database and fauna databases (Landcare Research, 2019b). These resources were assessed to identify significant terrestrial ecological features and potential habitats for indigenous avifauna surrounding the airport and the site.

Additionally, an assessment of available bird observation data was conducted using research-grade iNaturalist observations and eBird hotspot data that includes some of the New Zealand Bird Wader Study Data. This was done within a 3 km boundary of Hawke's Bay Airport's 16/34 runway threshold, to determine the species composition of the area and inform site selection for bird counts.

The Hawke's Bay Airport Wildlife Hazard Management Plan (WHMP) and Department of Conservation (DOC) Wildlife Management Plan were reviewed. This was to assess how the proposed ARPM might affect existing avifauna, specifically changes in their composition, distribution and interaction with the airport and its stakeholders.

## 3.2 Field Investigations

### 3.2.1 Bird Counts

Field investigations were conducted on the 26th and 27th of August 2025 by PDP ecologists to collect additional bird observation data and ground-truth data obtained through the desktop assessment. This involved conducting 5-minute bird counts, high-level habitat assessments and recording notes on general bird behaviour and movements at 36 sites pre-selected during the desktop assessment (see Figure 4). Additional data was recorded on date, time of day and general weather conditions at each count location. 5-minute bird counts included birds seen and heard during the assessment.

### 3.2.2 Terrestrial Habitat Assessment

High-level terrestrial habitat assessments were conducted at each of the 36 sites surrounding the airport. This involved categorising the general habitat types present at each site, and photographs of each area were taken to provide additional context. Habitat types used during the assessments included forest, scrub, grassland, wetland, shore, mudflat, urban, open substrate, open water and sedgeland. Explanations of what each habitat type is provided in Table 2.

**Table 2: Summary of definitions for each habitat type**

| Habitat Type | Definition |
|---|---|
| Forest | A large area covered with trees and undergrowth |
| Scrub vegetation | A plant community primarily composed of scrubs, bushes and low-growing trees and grasses |
| Grassland | A large open area covered with grass, often used for grazing |
| Wetland | A semi-aquatic ecosystem with saturated water and ground covers |
| Shoreline | Where a large body of water meets the land |
| Mudflat | A stretch of land left uncovered at low tide |
| Urban | Developed areas consisting of buildings, infrastructure and parks |
| Open substrate | An open surface area usually composed of earth, gravel or shell |
| Open water | Areas of open water with no vegetation and/or open substrate. |
| Sedgeland | A type of wetland ecosystem characterised by the abundance of sedge plants (grass-like, non-woody) |

*Note: Sourced from,* Allaby, M. 2010. *A Dictionary of Ecology* (4th ed.). Oxford University Press.

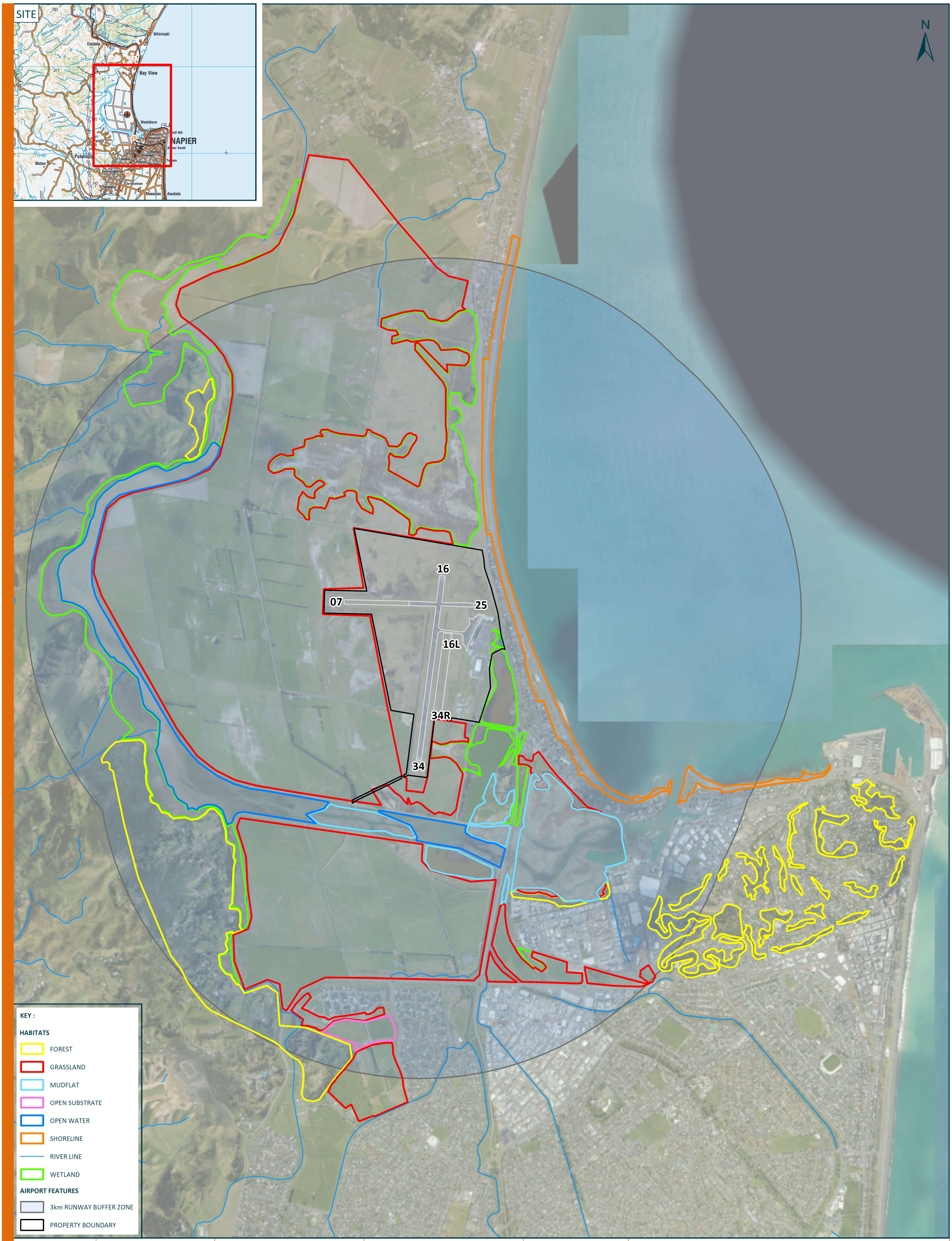

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FIGURE
FIGURE 3: MAP OF HIGH-VALUE AVIAN HABITAT WITHIN A 3km BUFFER ZONE OF HAWKE'S BAY AIRPORT

PROJECT
AHURIRI REGIONAL PARK MASTERPLAN BIRD STRIKE RISK ASSESSMENTS

### 3.3 Risk Assessment Tools

PDP assessed the site and area within a 3 km radius of Hawke's Bay Airport Runway 34 thresholds, to determine the current wildlife strike risk associated with each avian species observed during field investigations. This included the consideration of:

- The current operations of the site and understanding of the current bird strike risk posed.
- Historic bird incident data compiled from the CAA website.
- Current and historic bird count data provided by Hawke's Bay Airport and NCC, as well as a series of PDP ecological habitat assessments and bird counts.
- The sites 'proposed' wildlife strike risk based on current design plans.

The risk assessment is based on the New Zealand Risk Assessment Model (developed by the AAWHG and the NZAWHG). The model is applied to each bird species, using the likelihood of a strike occurring and the consequence associated with a strike (e.g., a large bird that is common in an area (high strike likelihood) will have a high strike risk). More specifically:

- Likelihood - the likelihood of the species being in the area (abundance), which is determined using bird counts in differing habitats as well as bird strike statistics; and,
- Consequence - the consequent damage of each species (low to extreme), this is based on bird species weights, behaviour and flocking characteristics.

Each risk assessment identifies the risk profile for each avian species in the area. Habitats preferred by high-risk species are, therefore, identified as high-risk habitats where bird hazard management should be a priority.

For this project, high-risk habitats were determined to identify whether habitats proposed in the ARPM are associated with high-risk avian species and have been used to inform design and mitigation recommendations for the future of the project.

# 4.0 Results

## 4.1 Summary of Observed Bird Species

The total number of observations per bird species was calculated for all 36 sites assessed during the field investigations. Overall, the most commonly observed species included:

- Black swan (total observations = 1104).
- Canada goose (total observations = 817).
- Southern black-backed gull (*Larus dominicanus;* total observations = 464)
- Pied stilt (*Himantopus Himantopus*; total observations = 360).
- Mallard (*Anas platyrhynchos*; total observations = 237).
- Red-billed gull (*Chroicocephalus novaehollandiae;* total observations = 129).

Each of these species had over 100 observations across all bird count locations. See Appendix B for a summary table of all avian species observed during field investigations.

### 4.1.1 Black Swan

Black swans are a large waterbird found throughout New Zealand. They have black-purple plumage, a red beak and have pure white feathers visible on the undersides of the wings when in flight. Black swans feed on aquatic vegetation in and near freshwater lakes and streams and are often seen in flocks numbering from several nesting pairs to hundreds of individuals.

These birds lay between 5 and 6 eggs around the edges of lakes or large water bodies. Incubation takes 36 days, and eggs are primarily cared for by the female. Breeding occurs once a year between July and March inclusive; however, under appropriate conditions, a second brood may be laid in late summer. Nests are made near waterbodies with vegetation piled together to create a raised platform on which the adult will sit.

Males typically weigh between 5 and 7 kg, and females are between 4 and 6 kg. Once black swans are established in an area, their population size can grow rapidly each year. This is due to their large size, efficient breeding characteristics and aggressive nature.

The aviation risk associated with black swans relates to their size, large flying flocks, active movement and high potential damage upon impact with an aircraft due to their weight.

*Note, several active black swan nests were observed during the field investigation (see Appendix A), within the wetlands north of the airport (between sites 27 and 29; see Figure 4).*

### 4.1.2 Canada goose

Canada geese are a large, light-brown bird with a black neck and head, and a white chinstrap. The breast and abdomen are white and light brown, and the abdomen and undertail are white, with a darker brown back and upper wing. These birds eat sugar-laden grasses, clovers, and other legumes typically associated with pastural farmland, and when on water are known to feed on submerged macrophytes and riparian sedges.

Canada geese form large flocks, ranging from several breeding pairs to several hundred birds. During breeding season, Canada geese create a depression nest in the ground, often hidden by long grasses or rushes. The female will lay between 2 and 10 eggs from September to January inclusive. Nests are often made within pastoral land near lakes, ponds, wetlands and other large waterbodies.

Individuals typically weigh between 4.5 and 5.5 kg. Like black swans, once Canada geese are established in an area, their population size can grow rapidly each year. This is due to their large size, efficient breeding characteristics and aggressive nature.

The aviation risk associated with black swans relates to their size, flocking behaviour, and potential damage upon impact with an aircraft.

### 4.1.3 Southern black-backed gull

Adult southern black-backed gulls have a white head and neck with a black back and upper wings. Birds will have a yellow bill with a red spot near the tip of the lower beak, and pale green legs. These birds are predators, feeding on various prey, including invertebrates, fish, small mammals, birds and their eggs and chicks. Additionally, southern black-backed gulls are commonly seen scavenging on organic landfill waste and offal from processing factories and waste from fishing boats.

These birds can be seen alone or in flocks ranging from 10 to several hundred individuals. Nests are bulky and made from grass, sticks, seaweed or a simple scrape in sand along coastlines. The female lays between 2 and 3 eggs in the nest between October and January inclusive. Nests are made on offshore islands, along estuaries, harbours, shorelines, riverbeds and sometimes in farmland. Southern black-backed gulls typically weigh around 1 kg.

The aviation risk associated with southern black-backed gulls is associated with their size and flocking behaviour.

### 4.1.4 Pied stilt

Pied stilt is a medium-large wader with long, pink legs and a long, black bill. The body is mainly white, with black back and wings, and black on the back of the head and neck. Pied stilts typically forage for terrestrial and aquatic invertebrates, typically near waterbodies and are often seen feeding in the intertidal zone during low tide.

They form flocks ranging from several breeding pairs to several hundred birds. During breeding season, mating pairs form large colonies from June to February inclusive. Nests are built on the ground near water using mud, vegetation and other debris. Females typically lay between 3 and 6 eggs up to twice a year if conditions are adequate. Individuals typically weigh around 190 g, with limited differences between males and females.

The aviation risk associated with pied stilts relates to their flocking behaviour and abundance around many New Zealand airports.

### 4.1.5 Mallard

Male mallards have glossy, dark green plumage on the head separated from the maroon breast by a thin white collar, with the back and sides being pale grey. Females are dull brown and have an indistinct dark eyestripe on the face. Mallards typically feed on plant material, including seeds, grains, grasses, clovers, aquatic plant tips and human food scraps (e.g., bread).

They form flocks of between 2 and 1,000 birds, often seen roosting on open water or along the banks of rivers, streams or other large waterbodies. Breeding occurs from July to December inclusive, and females typically lay between 10 and 13 eggs. In urban areas, two broods can be produced per year due to the abundance of food. Nests are a simple ‘bowl’ in the ground, made near water using vegetation, debris and plucked feathers and down. Individuals typically weigh between 1,050 and 1,300 g.

The aviation risk associated with mallards relate to their size, abundance and flocking behaviour.

### 4.1.6 Red-billed gull

Red-billed gulls are a medium-sized bird with a pale grey back and wings, black main flight feathers with white tips, white eyes and bright red bill and legs. They typically forage for krill, however, they also commonly feed on terrestrial and aquatic invertebrates, small fish, and organic waste.

Red-billed gulls form flocks ranging in size from several individuals to thousands of birds. Breeding occurs from September to January inclusive, with the female laying between 1 and 3 eggs. Nests are usually built in large colonies along coastlines, inland lakes and offshore islands, and nests are made from grasses, seaweed or twigs. Individuals typically weigh between 240 and 320 g.

The aviation risk associated with red-billed gulls is related to their flocking behaviours and abundance.

## 4.2 Risk Assessment

Three species of birds found in the area were categorised as ‘extreme’ strike risk (black swan, Canada goose and mallard) as per the NZAWHG risk matrix (see Appendix C). Additionally, one species was categorised as having a ‘high’ strike risk (southern black-backed gull; see Appendix C).

Table 3 below provides a summary of the bird species observed within a 3 km buffer zone of Hawke’s Bay Airport, and categorised with an extreme, high and medium bird strike risk for Hawke’s Bay Airport. Overall, there are 21 birds with a bird strike risk score of medium or higher.

**Table 3: Summary of extreme to medium bird strike risk species and their general habitat preferences**

| Risk | Common Name | Species | Habitat Type Preference |
|---|---|---|---|
| **Extreme** | Black swan | *Cygnus atratus* | Grassland, wetland, waterbody, sedgeland, shoreline, mudflats |
| **Extreme** | Canada goose | *Branta canadensis* | Grassland, wetland, waterbody, sedgeland, shoreline |
| **Extreme** | Mallard | *Anas platyrhynchos* | Wetland, waterbody, sedgeland, urban, grassland, mudflats |
| **High** | Southern black-backed gull | *Larus dominicanus* | Grassland, wetland, shoreline, urban, open substrate, waterbody, mudflats |
| Medium | Pied stilt | *Himantopus himantopus* | Grassland, wetland, waterbody, sedgeland, shoreline, mudflats |
| Medium | Red-billed gull | *Chroicocephalus novaehollandiae* | Grassland, wetland, shoreline, urban, open substrate, waterbody, mudflats |
| Medium | Greylag goose | *Anser anser* | Grassland, wetland, waterbody, sedgeland |
| Medium | Grey teal | *Anas gracilis* | Wetland, waterbody, sedgeland |
| Medium | Common starling | *Sturnus vulgaris* | Scrub, grassland, urban, open substrate |
| Medium | Australasian shoveler | *Spatula rhynchotis* | Wetland, waterbody, sedgeland |
| Medium | Pūkeko | *Porphyrio melanotus* | Grassland, wetland, urban, open substrate, waterbody, sedgeland |
| Medium | Royal spoonbill | *Platalea regia* | Wetland, waterbody, sedgeland, shoreline, mudflats |
| Medium | Rock pigeon | *Columba livia* | Forest, scrub, grassland, shore, urban, open substrate |
| Medium | Paradise shelduck | *Tadorna variegata* | Grassland, wetland, urban, open substrate, waterbody, sedgeland, mudflats |
| Medium | Variable oystercatcher | *Haematopus unicolor* | Grassland, open substrate, waterbody, shoreline, mudflats |
| Medium | White-faced heron | *Egretta novaehollandiae* | Forest, grassland, wetland, shore, waterbody, sedgeland, shoreline, mudflats |
| Medium | Bar-tailed godwit | *Limosa lapponica* | Grassland, wetland, shoreline, waterbody, mudflats |
| Medium | Black shag | *Phalacrocorax carbo* | Forest, wetland, shoreline, waterbody |
| Medium | Little shag | *Microcarbo melanoleucos* | Forest, wetland, shoreline, waterbody |
| Medium | South Island pied oystercatcher | *Haematopus finschi* | Grassland, shoreline, open substrate, waterbody, mudflats |
| Medium | Kererū | *Hemiphaga novaeseelandiae* | Forest, scrub, urban |

*Note: only species that had a risk score of medium or higher were included in Table 3 above. Appendix B provides a summary of all birds observed during field investigations and their associated risk scoring.*

### 4.2.1 Hawke's Bay Airport Bird Incident Statistics

Each airport in New Zealand is assigned a risk category based on a 12-month average bird strike rate per 10,000 aircraft movements. Categories are broken down into **low, medium** and **high**. **Low-risk** airports have an average strike rate of below 5 strikes per 10,000 movements. **Medium-risk** airports have an average strike rate of between 5 and 9.9 strikes per 10,000 movements. Finally, **high-risk** airports have an average strike rate of 10 or more per 10,000 movements.

Hawke's Bay Airport has the highest strike rate in New Zealand as of 2025. Its highest strike rate was 32.7 strikes per 10,000 movements (first quarter of 2024), and the lowest strike rate of 5.3 strikes per 10,000 movements (third quarter of 2024). The airport has been categorised in the **high-risk** category for the last 9 years, with an average strike rate of over 10 strikes per 10,000 movements (see Table 4). The current average strike rate per 10,000 movements is 18.6 (as of the third quarter of 2025)[1].

**Table 4: CAA Average Quarterly Strike Rate and Risk/Trend Categories for Hawke's Bay Airport**

| Year[1] | 2020 | 2021 | 2022 | 2023 | 2024[2] | 2025[2] |
|---|---|---|---|---|---|---|
| Q1 | 15.9 | 11.9 | 18.1 | 24.1 | 32.7 | 27.1 |
| Q2 | 14.5 | 12.0 | 22.4 | 21.1 | 23.9 | 16.3 |
| Q3 | 14.3 | 13.6 | 25.1 | 18.5 | 5.3 | 18.6 |
| Q4 | 14.4 | 14.2 | 24.6 | 16.9 | 15 | ND[5] |
| **Average Strike Rate[3]** | **14.8** | **12.9** | **22.6** | **20.2** | **19.2** | **20.7[6]** |
| **Average 5-yearly Strike Rate[4]** | **17.5** | | | | | |
| **Overall Strike Risk/Trend Category** | **High - Upward** | | | | | |

*Notes:*

1. *Quarterly strike data was acquired from the CAA bird incident dashboard from the CAA website in April 2026.*
2. *Quarterly strike data was taken from the new CAA bird incident dashboard.*
3. *Annual average strike rate per 10,000 aircraft movements.*
4. *Yearly average strike rate per 10,000 aircraft movements.*
5. *No data (ND)*
6. *Average strike rate calculation for 2025 does not include Q4 s it is not available on the CAA bird incident dashboard.*

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# 5.0 Discussion

## 5.1 Risk Associated with Habitat Creation

The proposed landscape designs for ARPM include the creation of several indigenous forest blocks, wetlands, two ponds (freshwater and saltwater), grassed public areas, and several streams that will flow into Te Whanganui-ā-Orutū / Ahuriri Estuary, as detailed in the (Boffa Miskell, 2025) Ahuriri Regional Park Masterplan ARPM These combined areas will provide optimal habitats for all of the species listed in Table 3, but of highest concern are the species assessed as ‘extreme’ or ‘high’ risk for aircraft bird strike.

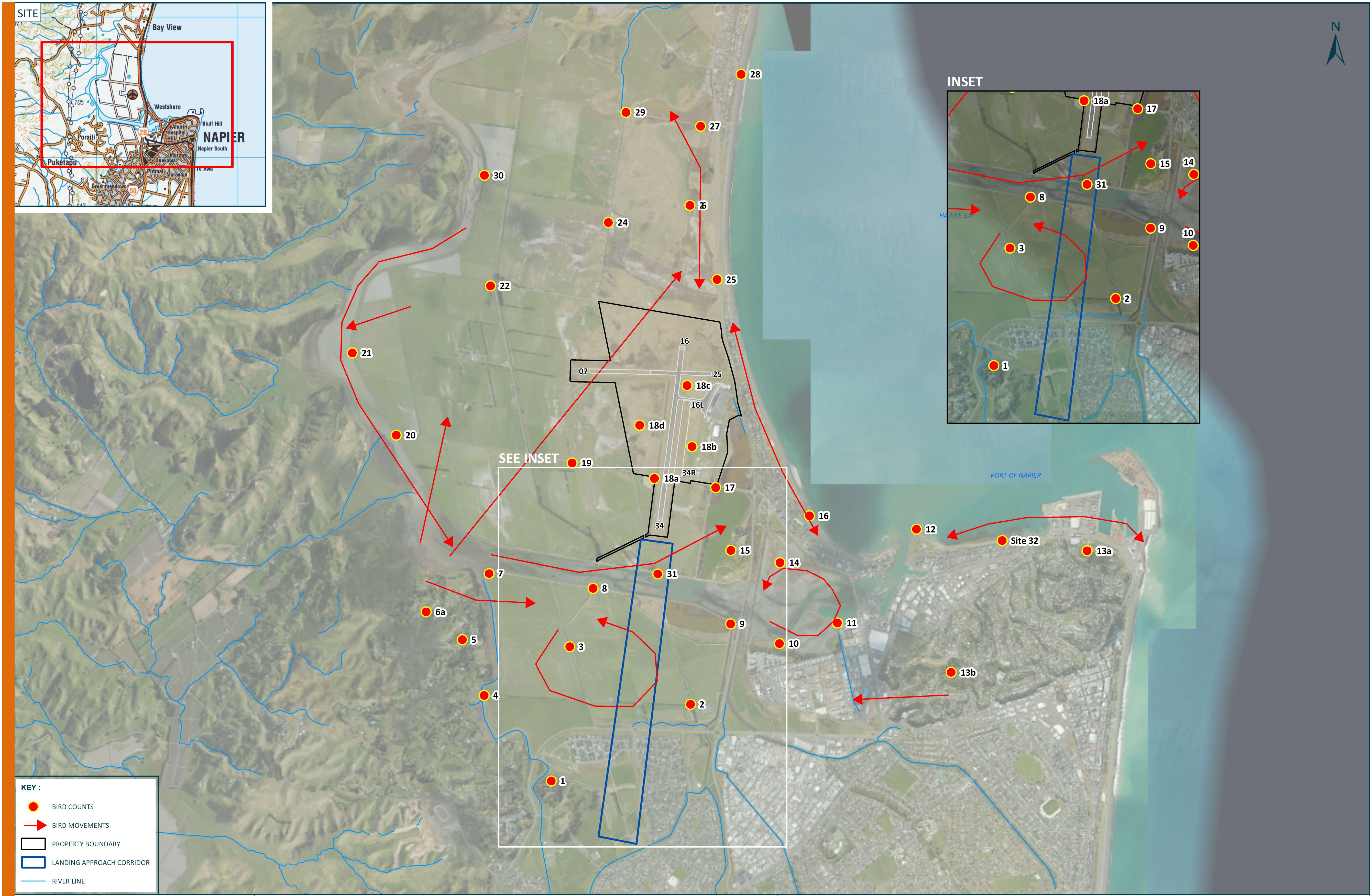
Black swan, Canada goose and mallard are categorised as ‘extreme’ risk and prefer habitats such as grassland, wetland, open water and sedgeland. Mallards are also occasionally observed within urban areas if enough food is present and a waterbody is nearby. Southern black-backed gulls are more general in their habitat preferences, being found in grasslands, wetlands, shorelines and beaches, mudflats, urban areas, open substrate and along or in open water. This species is categorised as ‘high’ risk to aircraft operations.

In addition to wetlands and open water, forest, scrub and harakeke/flax habitats are proposed within the site. These areas will likely provide habitat for other species found in Table 3, specifically those that prefer forested or scrub habitats that are less common around the airport (e.g., common starling, tūī, kererū and various other small forest birds). Increasing habitat and food availability for these species will likely result in a subsequent increase in bird density, abundance and movement in the area. The habitat complexity proposed in the ARPM designs will offer roosting, breeding and foraging sites (e.g., trees, shrubs, grassland and open water) throughout the regional park. This is likely to increase bird movements between existing and future proposed habitats (see Figure 4 for current observed bird movements).

Increases in bird density, abundance and activity will be further enhanced by the inclusion of a predator-proof sanctuary proposed for construction along the western boundary of the site. This will result from the removal of mammalian predators, which can cause bird populations to ‘spill over’ from these habitats into the surrounding area as a result of increased breeding success (Tanentzap & Lloyd, 2017). This is especially true for waterfowl and forest birds, which will likely increase breeding and introduce new breeding species in the area due to the lack of predators.

The proposed regional park will be located within the 3 km buffer zone surrounding the airport. As per FAA and ICAO guidelines, habitats within a 3 km buffer zone of an airport should be managed or removed to reduce bird strike risk. Wetland habitats provide habitat for a variety of avifauna, and are associated with higher population densities and abundances (McKinney et al., 2011; van Tets, 1969). Hawke's Bay Airport has the highest average annual strike rate in New Zealand (see Table 4). Increases in bird abundance and density within the 3 km buffer zone of the airport have the potential to cause further increases in strike occurrence. Compounding this, at approximately 300 m from the ground, planes reach a critical height at which they are unable to alter course (e.g., increase or decrease height during landing and/or take-off).

The CAA Good Aviation Practice report on bird hazards recommends that pilots should, in the first instance, avoid flying directly over wetlands and/or known nesting areas (CAA, 2020). If this is not possible, pilots are advised to remain above 1000 ft from these areas, as most bird incidents occur below 500 feet during take-off and landing (CAA, 2020). If the habitats proposed in the ARPM are created, the increased abundance and density of various avian species has the potential to cause heightened strike risk immediately within the critical landing and approach corridor of Hawke's Bay Airport's main runway (RWY 16/34) (see Figure 4). Additionally, the strike risk of other species currently categorised as 'medium' or 'low' risk may increase, leading to additional species of concern for Hawke's Bay Airport operations.



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SOURCE:
1. AERIAL IMAGERY (FLOWN 2024-2025) SOURCED FROM THE LINZ DATA SERVICE https://data.linz.govt.nz/ AND LICENCED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.

CLIENT
NAPIER CITY COUNCIL
Te Kaunihera o Ahuriri

FIGURE
FIGURE 4: BIRD COUNT LOCATIONS AND OBSERVED BIRD MOVEMENTS AROUND HAWKE'S BAY AIRPORT.

PROJECT
AHURIRI REGIONAL PARK MASTERPLAN BIRD STRIKE RISK ASSESSMENTS

## 6.0 Recommendations

### 6.1 Wetland Design and or Location Modifications

Design modifications to the current wetland and landscape plans outlined in Section 6.3 of the ARPM may help reduce bird strike risk. While these changes and associated management measures may offer some benefit, they will be unlikely to fully mitigate the increase in risk posed by habitat creation in this location.

Investigations are understood to be underway to determine whether design modifications could both improve Hawke's Bay water quality outcomes and enable the wetland design and/or location to be reconsidered. Any proposed changes will require further assessment by PDP to evaluate their effectiveness in managing bird strike risk.

From a risk management perspective, relocating the wetland away from Hawke's Bay Airport's primary landing/approach corridor would be the most effective means of avoiding an increase in bird strike risk. This approach aligns with international best practice, including guidance from FAA and ICAO on managing wildlife attractants in proximity to airports.

While PDP are aware that the overall wetlands have been designed to facilitate the treatment of stormwater prior to discharge to the estuary, it is recommended that the proposed wetland extents are re-evaluated. Specifically, to reduce their overall coverage to limit the availability of habitat for bird species and increasing separation distance to the HBA approach/landing corridor.

Areas of open water should be minimised, as they provide roosting opportunities for high-risk species such as black swans, Canada geese, and mallard species known to inhabit similar wetland and open water environments in the region. Where open water cannot be avoided, deterrent measures such as installing tight netting over freshwater and saline ponds should be considered to discourage flocking. Properly installed netting reduces the attractiveness of open water to waterfowl, thereby minimizing flocking activity and decreasing the area's suitability as flocking habitat.

### 6.2 Vegetation and Landscape Management

Ongoing vegetation management will also be essential to limit the attractiveness of the site to birds and to support broader bird strike risk mitigation objectives.

Vegetation design should prioritise species and structural characteristics that reduce habitat suitability for birds, particularly those species that pose a risk to aircraft. This includes avoiding large trees and dense shrub layers that provide shelter, roosting and nesting opportunities.

Instead, planting should favour low stature species, such as sedges and rushes, established at higher densities to limit open ground and reduce foraging opportunities.

Regular maintenance will be required to ensure vegetation does not mature into higher-risk structures over time. This includes ongoing control of plant height, density, and species composition to ensure alignment with the intended low-attractiveness design outcomes.

## 6.3 Wildlife Management Techniques

Active and passive bird deterrents are useful tools for managing bird hazards on and around airports. Active management involves directly removing or reducing the number of birds or animals in areas associated with high strike risk. Passive management involves modifying habitats or other aspects of the environment to indirectly remove or reduce the number of birds in high-risk areas.

Should the decision be made to continue with the park development, we recommend that active and passive wildlife management procedures be provided as described in Sections 6.3.1 and 6.3.2 below.

### 6.3.1 Active Management

Actively scaring birds from the high-risk areas along the runway should be undertaken before the arrival of inbound flights. Noise and visual disturbances, such as gas cannons, should be installed at points within the park and set off before the arrival of a flight. The northern area of the site, which is directly under the flightpath and closest to the Runway 34 threshold, should be a prioritised management zone. Active management techniques should be deployed before aircraft land or take-off at low altitudes over areas of avifauna habitat.

Active wildlife surveillance and reporting to relevant airport staff, including Air Traffic Control (ATC) and airport fire rescue staff, should also be implemented. This would involve conducting daily wildlife management patrols to count the number of birds around the site. This information should be provided to Hawke’s Bay Airport to inform their internal bird hazard management practices. Wildlife surveillance is a crucial component of wildlife management, as it reveals shifts in species composition and abundance, which are essential for determining whether current management practices are effective and if there are any emerging threats.

Based on Hawke’s Bay Airport’s (HBA’s) current bird strike risk assessment (see Section 4.2), some species have been categorised as posing an ‘extreme’ or ‘high’ risk. If the populations of these species such as black swans, Canada geese, mallards, and southern black-backed gulls continue to increase, and current wildlife management practices prove ineffective at reducing strike risk, then more intensive measures may be required.

In such cases, regional wildlife hazard management plans that include culling may be necessary to control the risk.

Culling involves removing a select number of individuals from a population to reduce the impact the species is having on its surrounding environment. At airports such as Auckland International, culling is annually used to control large or high-risk bird populations, such as the black swan, that are causing increased risk and/or bird strike damage to airport operations.

### 6.3.2 Passive Management

#### 6.3.2.1 Grassland and Vegetation

Areas of grassland should be maintained at a height of between 200 and 270 mm to remove flowers and seed heads that birds feed on. Recreational areas of groomed grass will attract roosting species such as southern black-backed gull, black swan and Canada geese. Large trees can hide birds and create roosting habitats for bird species such as common starling, rock pigeon, kererū, white-faced heron, black shag and little shag (all rated as medium strike risk). To mitigate these risks, small tree species should be planted (particularly within the landing and approach corridor) or maintained to a low height (e.g., cut low). Common bird species' food sources should be removed, such as flax heads.

Avanex grasses are used to deter grazing by bird species and are used by several airports around New Zealand. Avanex contains an endophyte that decreases insect abundance and causes stomach discomfort when digested by birds (PGG Wrightson Turf, 2025). Thus, it is intended to discourage bird foraging and grazing in areas where it is planted. This method may discourage species such as Canada geese, black swan and greylag geese from using grassed areas as foraging habitat. However, it must be fertilised regularly and kept healthy to maintain endophyte health and be fit for purpose.

#### 6.3.2.2 Treatment Wetlands and other bodies of water

Areas of open water should be planted with raupō, or a large net should be constructed over the surface to discourage large waterfowl, such as Canada geese and black swans, from roosting. This method mitigates the likelihood of birds seeing open water and landing when flying overhead. However, it does create shelter, offering a safe area where species such as black swans and mallards may breed.

If birds do nest in these areas, it is hard to determine numbers and species presence. Waterbody netting has been used by Auckland Airport, which recently finished construction of an artificial wetland near the airport. The netting is designed to restrict birds from landing on the water's surface, eliminating the area as additional habitat for birds, its successfulness is yet to be determined.

A similar design could be implemented at Hawke’s Bay Airport, in which the netting is built over the two proposed freshwater and saline ponds.

#### 6.3.2.3 Buildings and Infrastructure

Any buildings constructed at the site should have pitched roofs to discourage roosting. There are no recommended guidelines on best pitch angles for roofing to deter bird roosting, however, it is documented in the literature that flat or low-pitched roofs are often used as roosting habitat by birds (UK CAA, 2017).

Additionally, artificial lighting such as streetlights can often indirectly attract birds or cause disorientation in individuals at night (especially migratory species) (Rebke et al., 2019). Street light colours are known to cause differing levels of bird attractance into an area, with blue, white and green lights the most attractive to birds. To mitigate this, red lights should be used at night, as this colour attracts significantly fewer birds (Rebke et al., 2019; Zhao et al., 2020). Furthermore, blinking street lights were less attractive to birds than continuous lights (Rebke et al., 2019), and thus should be installed throughout the site or at a minimum within the landing and approach corridor south of Hawke’s Bay Airport’s main runway.

## 6.4 Wildlife Hazard Management Plan

Should the decision be made to continue with the Ahuriri Regional Park development, a Wildlife Hazard Management Plan (WHMP) should be prepared to help manage bird strike risk (active and passive management) associated with pre and post development. It is important to note that there is a high degree of uncertainty that an active WHMP will reduce the increased risk from the creation of the park area, rather reduce the level of the increased risk.

The WHMP should be prepared in consideration of the existing Hawke’s Bay Airport WHMP and should detail management methods, including:

- Pre-development mitigations, e.g., mowing site grass to disperse birds in a southward direction away from the Hawke’s Bay Airport approach/landing corridor.
- Communication plan of development timelines with Hawke’s Bay Airport before development works take place to mitigate potential avifauna issues and offer support if any issues arise.
- Roles and responsibilities - includes liaising with external stakeholders (e.g., Hawke’s Bay Airport) to determine the obligations of respective organisations and their personnel.
- Passive and active management methods (as described in Section 6.3) – surveillance and monitoring, grounds management specifications (i.e., recommended grass heights to deter high-risk species), and

seasonal bird counts (this could be completed by Hawke’s Bay Airport and/or site surveillance personnel).

- Landscape and waterbody design standards and mitigations.
- Monitoring and review procedures of WHMP – this should include liaison with Hawke’s Bay Airport, with increases in bird numbers onsite being communicated so appropriate countermeasures can be implemented.

Post-development of the Ahuriri Regional Park, the WHMP should continue to be followed to ensure bird hazards at the site are managed on an ongoing basis. A site representative should be assigned to conduct monitoring of the area, noting bird numbers, changes in abundance and the presence of high-risk species. This person should also be responsible for communicating relevant information to Hawke’s Bay Airport, especially if there is an increase in high-risk bird species activity.

### 6.5 Monitoring Plan

Should the project go forward, and post-project completion, ongoing bird monitoring should be conducted on the site. Bird counts should focus on areas of critical habitat, particularly in the wetlands below the landing and approach corridor (see Figure 4).

Bird counts should occur daily, and the information should be provided to Hawke’s Bay Airport to inform their bird management practices. Adaptive management triggers should be established to ensure that increases in bird abundance and species density in the area are met with changes in bird hazard procedures to better manage strike risk associated with the site. For example, changes in species-specific abundance with season or weather conditions may require a shift in focus by airport staff, targeting new, high-risk species proactively, and removing available habitat (if possible).

## 7.0 Summary and Conclusions

The current landscape design and proposed location of the ARPM place it directly beneath the critical landing and approach corridor of Hawke’s Bay Airport’s main runway (16/34), and just 0.8 km south of the airport, well within the 3 km bird hazard management buffer zone.

Hawke’s Bay Airport has the highest bird strike rate of any airport in New Zealand, averaging 17.5 strikes per 10,000 aircraft movements annually. This consistently places the airport within the CAA five-year bird strike risk classification of High-Upward to High-Downward. The elevated strike risk is primarily due to the region's high bird densities, which are supported by extensive nearby wetlands, mudflats, and open water bodies.

The ARPM's proposed habitat creation, including a large wetland, ponds, indigenous forest, streams, grasslands, and built structures, will likely attract and support many of these high-risk bird species. It will, therefore, **increase the overall bird strike risk to aircraft operating at Hawke's Bay Airport**. While a combination of design interventions, active deterrence, and reactive management measures could reduce some risks, the scale, habitat diversity, and location of the proposed park, particularly the treatment wetland, make it unlikely that such measures would sufficiently mitigate the risk.

The addition of high-value wetland and open water habitats directly under the approach path poses a significant hazard. Aircraft approaching Hawke's Bay Airport over the site descend below 500 metres of ground level, substantially increasing the probability of strikes involving birds moving between the site and the surrounding habitats.

Given these findings, we strongly recommend reconsidering the location of the proposed ARPM site. Specifically, the site should be relocated outside the airport's critical approach path, at a minimum, beyond the 3 km bird strike buffer zone. Alternatively, if NCC do wish to proceed with the ARPM in its current location, the landscape design should be revised to limit the attractiveness of the site to high-risk bird species. This should include reduction in wetland size and (if possible) increased vegetation density in wetlands to deter large waterfowl, restrictions on tall tree species, implementation of both passive and active bird deterrents, development of a comprehensive Wildlife Hazard Management Plan (WHMP), and ongoing avifaunal monitoring throughout the site's lifecycle.

Given the current design and locality of ARPM, PDP has assessed the risk of bird strike for Hawke's Bay Airport from its current status of **high risk**, to an **increased high risk** given the development of habitat conducive to high and extreme risk bird species.

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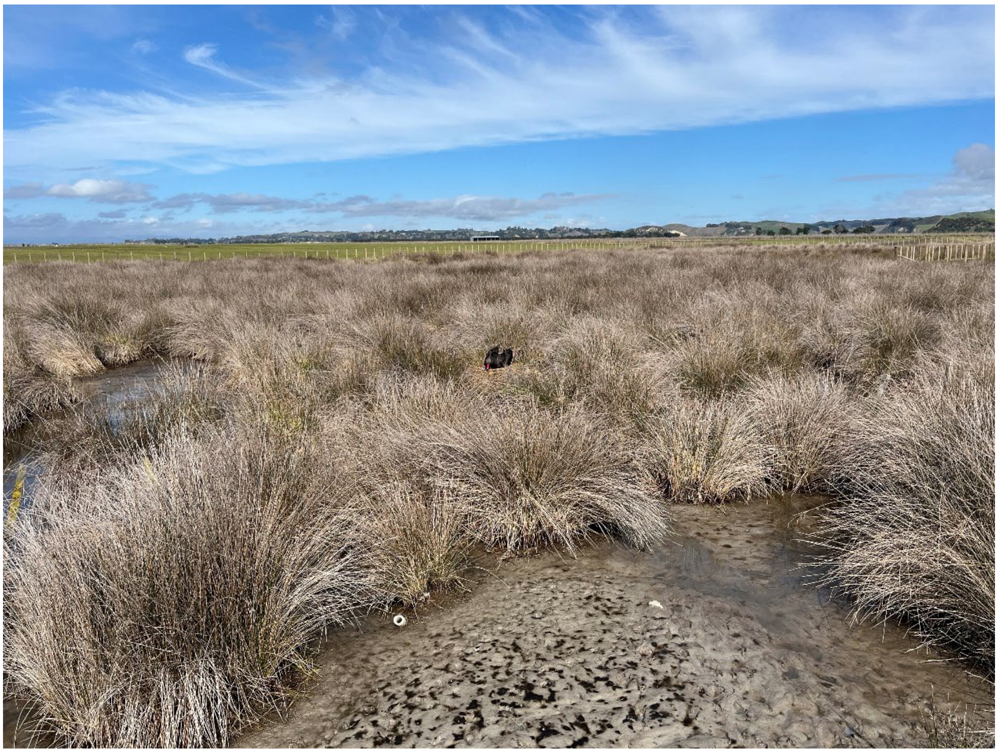
# Appendix A: Photographs

**Photograph 1: The proposed Ahuriri Regional Park site is currently used for livestock grazing.**

**Photograph 2: A wetland and saltmarsh are located along the western border of the proposed site.**

**Photograph 3: Te Whanganui-ā-Orotū/Ahuriri Estuary is located along the site's northern border.**



**Photograph 4: Several black swan nests were found during field investigations. This particular nest was found between bird count sites 27 and 29.**

# Appendix B: Summary of Bird Species observed during Field Investigations

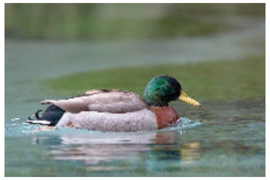
## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Extreme | Black swan<br> | *Cygnus atratus*<br>*No: 1099* | Prefer open water bodies such as lakes, ponds and rivers and are often seen foraging in grassland, wetlands or along lakesides margins.<br>Grassland, wetland and open water | Black swans feed on aquatic vegetation in and near freshwater lakes and streams.<br>They are often seen in flocks numbering from several nesting pairs to hundreds of individuals.<br>Breeding occurs once a year between July to March inclusive; however, under appropriate conditions, a second brood may be laid in late summer. Females lay between 5 to 6 eggs around the edges of lakes or large water bodies. Incubation takes 36 days, and eggs are primarily cared for by the female. Nests are made from lakeside vegetation piled together to create a raised platform on which the adult will sit.<br>Males typically weigh between 5 to 7 kgs, and females are between 4 to 6 kgs.<br>The aviation risk associated with black swans relates to their size, flocking behaviour and potential damage upon impact with an aircraft. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Extreme | Canada goose<br> | *Branta canadensis*<br>*No: 798* | Prefer pastural land near open water bodies such as lakes, lagoons, ponds and rivers.<br>Grassland, wetland and open water | These birds eat sugar-laden grasses, clovers, and other legumes typically associated with pastural farmland, and when on water are known to feed on submerged macrophytes and riparian sedges.<br>Canada geese form large flocks, ranging from several breeding pairs to several hundred birds.<br>During breeding season, Canada geese create a depression nest in the ground, often hidden by long grasses or rushes. The female will lay between 2 to 10 eggs from September to January inclusive. Nests are often made within pastoral land near lakes, ponds, wetlands and other large waterbodies.<br>Individuals typically weigh between 4.5 to 5.5 kgs.<br>The aviation risk associated with black swans relates to their weight, flocking behaviour and potential damage upon impact with an aircraft. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Extreme | Mallard<br> | *Anas platyrhynchos*<br>*No: 234* | Prefer open water bodies such as lakes, lagoons, ponds and rivers, and are commonly seen in urban areas and in pastural grassland.<br>Wetland, open water, grassland and urban areas | Mallards typically feed on plant material, including seeds, grains, grasses, clovers, aquatic plant tips and human food scraps (e.g., bread).<br>They form flocks of between 2 to 1,000 birds, often seen roosting on open water or along the banks of rivers, streams or other large waterbodies.<br>Breeding occurs from July to December inclusive, and females typically lay between 10 to 13 eggs. In urban areas, two broods can be produced per year due to the abundance of food. Nests are a simple ‘bowl’ in the ground, made near water using vegetation, debris and plucked feathers and down.<br>Individuals typically weigh between 1,050 to 1,300 g.<br>The aviation risk associated with mallards relates to their weight, abundance and flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| High | Southern black-backed gull<br> | *Larus dominicanus*<br>*No: 439* | Southern black-backed gulls are habitat generalists and are commonly found in most areas other than forest and scrubland.<br>Grassland, wetland, coastlines, urban and open water | Southern black-backed gulls are predators, feeding on various prey, including invertebrates, fish, small mammals, birds and their eggs and chicks. Additionally, they are commonly seen scavenging on organic landfill waste and offal from fishing boats and processing factories.<br>These birds can be seen alone or in flocks ranging from 10 to several hundred individuals.<br>Nests are bulky and made from grass, sticks or seaweed or a simple scrape in sand along coastlines. The female lays between 2 to 3 eggs in the nest between October to January inclusive. Nests are made on offshore islands, along estuaries, harbours, shorelines, riverbeds and sometimes in farmland.<br>Southern black-backed gulls typically weigh around 1 kg.<br>The aviation risk associated with southern black-backed gulls is associated with their weight and flocking behaviour. |

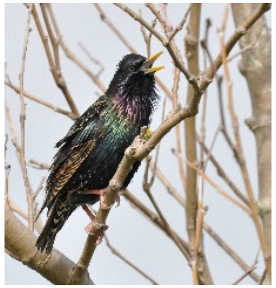
## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Australasian shoveler<br> | *Spatula rhynchotis*<br>*No: 37* | Prefer open water bodies and are commonly found in freshwater wetlands, lakes and lagoons.<br>Wetlands, open water | Australasian shovelers are specialist filter feeders, occasionally feeding on benthic invertebrates. Their diet primarily consists of small freshwater molluscs, crustaceans and small seeds.<br>They form large flocks numbering up to 1,000 birds, especially during the breeding season, which occurs from October to February. Females lay between 5 and 14 eggs in a shallow bowl nest, typically made using fine vegetation. Nests are usually made in long grass near open water bodies where they feed.<br>Male shovelers weigh between 570 and 850 g, and females are between 545 and 745 g.<br>The aviation risk associated with Australasian shovelers is related to their flocking behaviour and weight. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | Bar-tailed godwit  | *Limosa lapponica*<br>*No: 12* | Prefer soft intertidal mudflats and are occasionally observed foraging in wet pasture.<br>Grassland, wetland, shore, open water, mudflats | Bar-tailed godwits primarily feed on polychaetes but also eat small bivalves and crustaceans.<br>They typically form large flocks and undergo mass migrations between seasons, flying from Alaska, where they breed.<br>Males typically weigh between 275 and 400 g, whereas females can weigh between 325 and 600 g.<br>The aviation risk associated with bar-tailed godwits is related to their flocking behaviour. |
| Medium | Black shag  | *Phalacrocorax carbo*<br>*No: 7* | Prefer habitats near open water such as wetlands, lakes, ponds, lagoons, rivers and coastlines.<br>Wetland, open water, shore | Black shags feed on small to medium-sized pelagic and benthic fish, as well as invertebrates, molluscs, kōura and have been known to prey on ducklings.<br>They are typically solitary birds, however, are occasionally seen in pairs, especially during breeding season or if food is abundant.<br>Breeding occurs year-round, with females laying between 3 and 6 eggs. Nests are typically built along cliff ledges, in swamps or tree canopies, using sticks, twigs and other vegetation. |

**Appendix B: Summary of bird species observed during field investigations**

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| | | | | Individuals tend to weigh between 2,000 and 2,400 g.<br>The aviation risk associated with black shag is related to their weight. |
| Medium | Common starling<br> | *Sturnus vulgaris*<br>*No: 49* | Prefer open habitats commonly associated with human settlement or activities. They are not typically found in alpine zones and in forested regions, although they are known to nest along forest edges if available.<br>Forest, scrub, grassland, urban | Common starlings feed on a variety of invertebrates, including earthworms, caterpillars, spiders, beetles and their larvae. Additionally, they forage for food scraps in urban areas, and nectar from flowers and other plants such as harakeke/flax.<br>Common starlings form flocks numbering between several individuals to thousands of birds.<br>Breeding occurs from September to December, with females laying between 1 and 9 eggs. Nests are made in cavities (e.g., tree hollows and cliff banks) and are lined with grass and feathers.<br>Individuals typically weigh around 85 g.<br>The aviation risk associated with the common starling is related to their flocking behaviour and high abundance if populations are left uncontrolled. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name[1]** | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | Grey teal<br> | *Anas gracilis*<br>*No: 64* | Prefer open water habitats, including shallow freshwater lakes, lagoons and wetlands, and occasionally seen on salt and brackish water.<br>Open water, wetland | Grey teal are typically nocturnal feeders, foraging at dawn and dusk in areas of open water or wetlands. They eat a range of aquatic invertebrates such as insects, molluscs and seeds.<br>Grey teal form flocks ranging in size from several individuals to several hundred birds and often fly long distances between feeding grounds.<br>Breeding occurs from June to January inclusive, and females lay between 5 and 9 eggs. Nests are found within tree hollows or in rank grass and are lined with feathers.<br>On average, males typically weigh around 505 g, whereas females are around 470 g.<br>The aviation risk associated with grey teal relates to their flocking behaviour and weight. |

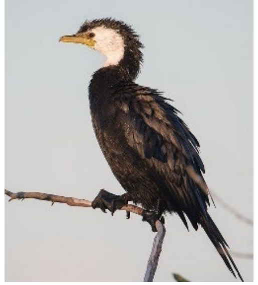
## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Greylag goose<br> | *Anser answer*<br>*No: 81* | Prefer urban areas near water bodies, such as urban parks and pasture grassland near ponds.<br>Open water, grassland, wetland | Greylag geese are herbivores, grazing on grasses, seeds, and other foliage, and are sometimes observed feeding on invertebrates.<br>Birds usually form small flocks ranging from several individuals to 50 or more if adequate habitat is present.<br>Breeding occurs from August to December inclusive, with females laying around 4 to 6 eggs. Nests are large and bowl-shaped, made from twigs, grasses and other vegetation, and lined with feathers.<br>On average, individuals weigh around 3 kg.<br>The aviation risk associated with the greylag goose is related to their weight, flocking behaviour and often their proximity to urban areas. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Kererū<br> | *Hemiphaga novaeseelandiae*<br>*No: 2* | Prefer forested habitats of either native or exotic plants. Birds have also been observed in farmland shelterbelts, urban parks and semi-urban gardens.<br>Forest, scrub, urban | Kererū are herbivorous birds, feeding on buds, leaves, flowers and fruit of both native and exotic plants. Important food plants include broom, elm, kōwhai, poplar, tree lucerne and willow.<br>Although typically seen alone or in small flocks of several birds, large flocks of up to 100 individuals have been observed at seasonal feeding locations.<br>Breeding occurs year-round, and pairs can have up to 3 successful broods. Females lay 1 egg in a roughly made platform nest of twigs.<br>On average, an individual weighs around 630 g.<br>The aviation risk associated with kererū relates to its weight. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | Little shag<br> | *Microcarbo melanoleucos*<br>*No: 5* | Prefer open water habitats from which they can roost and forage. Habitats include coastal and freshwater lakes, rivers, ponds and streams.<br>Open water, wetlands, shore | Little shags primarily feed on small fish, eels and crustaceans, however, they are also known to feed on frogs and invertebrates.<br>These birds are typically solitary but form small flocks if enough food is present.<br>Breeding occurs from August to March inclusive, and the species forms breeding colonies ranging from 5 to 200 pairs. The female lays between 2 and 5 eggs once per year. Nests are built from twigs and other foliage and form a bowl shape.<br>On average, little shags weigh between 400 and 880 g.<br>The aviation risk associated with little shags relates to their weight. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Paradise shelduck<br> | *Tadorna variegata*<br>*No: 22* | Prefer pasture grassland from lowland to highland zones, along river margins, shorelines, urban parks and waterbodies such as lakes and ponds.<br>Grassland, open water, urban | Paradise shelducks are typically herbivorous, feeding on pasture grasses and clover, seeds, aquatic plants and terrestrial and aquatic invertebrates.<br>Paradise shelducks are monogamous and are commonly seen in single breeding pairs. Flocks are sometimes observed and are typically formed of pre-breeding individuals.<br>Breeding occurs from August to February, and females lay between 5 and 15 eggs. Nests are a depression in the ground, lined with feathers and other vegetation.<br>On average, male birds weigh around 1,700 g, whereas females typically weigh around 1,400 g.<br>The aviation risk associated with paradise shelducks is related to their weight. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Pied stilt<br> | *Himantopus Himantopus*<br>*No: 341* | Prefer habitats such as wetlands, mudflats, intertidal zones, braided rivers, and are occasionally found in wet grassland.<br>Wetlands, open water, shore, mudflats, grassland | Pied stilts typically forage for terrestrial and aquatic invertebrates, typically near waterbodies and are often seen feeding in the intertidal zone during low tide.<br>They form flocks ranging from several breeding pairs to several hundred birds.<br>During breeding season, mating pairs form large colonies from June to February inclusive. Nests are built on the ground near water using mud, vegetation and other debris. Females typically lay between 3 to 6 eggs up to twice a year if conditions are adequate.<br>Individuals typically weigh around 190 g, with limited differences between males and females.<br>The aviation risk associated with pied stilts relates to their flocking behaviour and abundance around many New Zealand airports. |

**Appendix B: Summary of bird species observed during field investigations**

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | Pūkeko  | *Poryphyrio melanotus*<br>*No: 29* | Prefer to be near areas of water such as wetlands, lakes, rivers, streams, lagoons, as well as wet grassland and farm drainage channels. Birds are also seen in urban parks and forest margins.<br>Open water, wetlands, grassland, urban | Pūkeko are herbivorous, although they are known to feed on small animals and eggs. Their diet is comprised of stems, shoots, roots and seeds of various plants, terrestrial and aquatic invertebrates, and they are occasionally known to eat frogs, lizards, fish and nesting birds.<br>Pūkeko are often seen in small flocks of 2 to 6 individuals. Larger flocks can occur if conditions are right and food is abundant.<br>Breeding occurs year-round, and females typically lay between 4 and 6 eggs. These birds have a unique mating system in which multiple females will lay in the same nest. In these cases, up to 18 eggs can be laid in a single nest. Nests are typically made from grasses and other vegetation to form a raised platform and are usually concealed near water or wetland habitats.<br>On average, males typically weigh 1,090 g, and females weigh around 880 g.<br>The aviation risk associated with pūkeko is related to their weight. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Red-billed gull<br> | *Chroicocephalus novaehollandiae*<br>*No: 102* | Prefer coastal habitats and are commonly seen in urban areas near coastlines.<br>Shore, open water, urban, grassland | Red-billed gulls typically forage for krill, however, they also commonly feed on terrestrial and aquatic invertebrates, small fish, and organic waste.<br>They form flocks ranging in size from several individuals to thousands of birds.<br>Breeding occurs from September to January inclusive, with the female laying between 1 and 3 eggs. Nests are usually built in large colonies along coastlines, inland lakes and offshore islands, and nests are made from grasses, seaweed or twigs.<br>Individuals typically weigh between 240 and 320 g.<br>The aviation risk associated with red-billed gulls is related to their flocking behaviours and abundance. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Rock pigeon<br> | *Columba livia*<br>*No: 25* | Prefers urban and rural environments associated with human activity, as well as cliff ledges and caves.<br>Urban, grassland, forest, scrub | Rock pigeons have a broad diet, including food waste, seeds and terrestrial invertebrates.<br>Individuals commonly forage in pairs or loose flocks, however, they will aggregate into large flocks of up to 400 birds.<br>Breeding happens year-round, with females laying between 1 and 4 eggs in a platform nest made of twigs, grasses and other objects such as plastics. Pairs can have up to 7 successful broods a year.<br>On average, individuals weigh between 265 and 432 g.<br>The aviation risk associated with rock pigeons relates to their flocking behaviour and preference for urban habitats. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | Rook<br> | *Corvus frugilegus*<br>*No: 7* | Prefer open grassland and farmland where they breed in large rookeries.<br>Grassland, scrub | Rooks primarily feed on invertebrates, nuts, carrion, grasses and clover.<br>They tend to form roosting colonies, splitting off into smaller groups to forage during the day.<br>Breeding occurs from August to November, and females lay between 1 and 7 eggs on a raised platform nest made of twigs and sticks. Nests tend to be constructed in the upper canopy of trees, away from predators.<br>Males typically weigh between 425 and 500 g, and females weigh from 350 to 400 g.<br>The aviation risk associated with rooks is related to their weight. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Royal spoonbill  | *Platalea regia*<br>*No: 29* | Prefers habitat near water where it can forage. Habitats include coastline, wetlands, mudflats, intertidal mudflats, estuaries, rivers, lakes and ponds.<br>Open water, wetland, shores, mudflats | Royal spoonbills typically feed on fish, crustaceans, aquatic invertebrates and frogs.<br>They form flocks ranging from several individuals to large flocks of up to 150 birds.<br>Breeding occurs from October to March, and females lay between 2 and 4 eggs. Nests are bowl-shaped and are made from sticks, twigs and leaves.<br>On average, individuals weigh between 1,400 and 2,000 g.<br>The aviation risk associated with the royal spoonbill is related to its weight. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | South Island pied oystercatcher<br> | *Haematopus finschi*<br>*No: 4* | Prefer coastal habitats such as estuaries and harbours, but are also seen along riverbeds, grassland, wetlands, mudflats and lagoons.<br>Open water, mudflats, grassland | South Island pied oystercatchers typically feed on molluscs, worms, bivalves, crustaceans, cnidarians, fish and aquatic and terrestrial invertebrates.<br>Flocks of up to several thousand birds have been observed, however, during the breeding season, birds often form pairs or smaller flocks.<br>Breeding occurs from August to January, and females lay between 1 and 3 eggs. Nests are a scrape in the ground, usually in sand, gravel or soil with clear visibility of the surrounding area.<br>On average, individuals weigh around 550 g.<br>The aviation risk associated with the South Island pied oystercatcher relates to its weight and flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | Variable oystercatcher<br> | *Haematopus unicolor*<br>*No: 21* | Prefer coastal areas, including shorelines, mudflats, dunes, intertidal mudflats, and occasionally in grassland.<br>Open water, mudflats, grassland | Variable oystercatchers have a broad diet, including terrestrial and aquatic invertebrates, molluscs, crustaceans, annelids and sometimes fish.<br>Birds are usually seen in breeding pairs, however, they do form flocks of up to 50 individuals.<br>Breeding occurs from September to March inclusive, and females typically lay between 1 and 3 eggs. Nests are a scrape in the ground, usually in sand, shell beaches and soil.<br>On average, individuals weigh around 720 g.<br>The aviation risk associated with the variable oystercatcher relates to their weight and flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Medium | White-faced heron  | *Egretta novaehollandiae*<br>*No: 18* | They are found near areas of water where they can forage such as wetlands, mudflats, lakes, rivers, streams, and lagoons.<br>Open water, wetlands, mudflats, shore, grassland | White-faced herons are carnivorous, feeding on small fish, crustaceans, aquatic and terrestrial invertebrates, small mammals, reptiles and amphibians.<br>They tend to be solitary, however, they do form loose roosting and breeding flocks.<br>Breeding occurs from June to April inclusive, with females laying between 3 and 5 eggs. Nests are made of twigs and sticks and form a raised platform, usually in the canopy of mature trees near open water.<br>On average, individuals weigh around 550 g.<br>The aviation risk associated with the white-faced heron relates to its weight. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name[1]** | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Medium | Yellowhammer<br> | *Emberiza citronella*<br>No: 13 | Prefer open habitats such as farmlands, tussockland, cropland, and loose scrub and forest.<br>Grassland, scrub | Yellowhammers primarily feed on seeds from a variety of grasses, as well as terrestrial invertebrates.<br>These birds form small flocks, often joining with other species such as greenfinch, chaffinch and house sparrows.<br>Breeding occurs from October to March, and females lay between 3 and 5 eggs. Nests resemble a woven cup, loosely constructed with grass, moss, and other fine fibres.<br>On average, individuals weigh between 18 and 30 g.<br>The aviation risk associated with the yellowhammer is related to its flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | Australian magpie<br> | *Gymnorhina tibicen*<br>*No: 14* | Prefer open habitats such as farmland, urban parks, forest shelterbelts, and are found from lowlands to the hill country.<br>Grassland, urban, scrub | Australian magpies primarily feed on terrestrial invertebrates, however, they are known to opportunistically consume lizards, small mammals and birds.<br>These birds typically form small flocks between 2 and 10 individuals, however, in certain instances, flocks can range up to 80 birds.<br>Breeding occurs from July to January, and females typically lay between 2 and 5 eggs. Nests resemble a woven cup, and are made of twigs, sticks, roots and other materials, and are lined with wool, hair and feathers.<br>On average, individuals weigh around 350 g.<br>The aviation risk associated with Australian magpies is associated with their weight and flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Caspian tern<br> | *Hydroprogne caspia*<br>*No: 1* | Prefer coastal habitats such as shell roosts, sandspits, braided rivers, and mudflats, and are occasionally seen on braided rivers and inland lakes.<br>Open water, shore, mudflat | Caspian terns primarily feed on small fish and will occasionally eat invertebrates and marine worms found in grassland and intertidal mudflats.<br>These birds are typically solitary, however, during breeding season, they form large colonies along coastlines.<br>Breeding occurs from September to January, with females typically laying between 1 and 3 eggs. Nests are formed from a scrape in sand or shingle along a coastline.<br>On average, individuals weigh around 700 g.<br>The aviation risk associated with Caspian terns is related to their weight. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | Chaffinch<br> | *Fringilla coelebs*<br>*No: 3* | Chaffinches are habitat generalists and can be found in a wide range of habitats, from forests, scrub and grassland to urban areas.<br>Forest, scrub, grassland, urban | Chaffinches feed on a variety of seeds from a range of plants, including harakeke/flax, beech trees, rimu and various grasses.<br>These birds form flocks of varying sizes, typically comprised of several different species. During breeding season, chaffinches disperse into mating pairs and defend a patch of territory.<br>Breeding occurs from September to February, and females lay between 3 and 6 eggs. Nests resemble a woven cup made of fine grasses, wool and moss, camouflaged by moss around the outside, and lined with feathers.<br>On average, birds weigh between 17.5 and 24.5 g.<br>The aviation risk associated with chaffinches is related to their flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Common myna<br> | *Acridotheres tristis*<br>*No: 1* | Common mynas are habitat generalists, found in most habitats except for interior forest remnants.<br>Grassland, urban, forest, scrub | Common mynas are omnivorous, with a broad diet, including terrestrial invertebrates, fruit, seeds and organic food waste.<br>These birds form roosting flocks at dusk, however, they forage in pairs over the day. During breeding season, pairs vigorously defend a nesting territory, destroying the eggs of others if found.<br>Breeding season occurs from October to March inclusive, and females lay between 1 and 6 eggs. Nests are either in a hole or cavity and are often lined with leaves or other materials.<br>On average, individuals weigh around 125 g.<br>The aviation risk associated with common mynas relates to their habitat preferences. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Eurasian blackbird<br> | *Turdus merula*<br>*No: 31* | These birds inhabit a range of habitats, including urban areas (e.g., parks and gardens), pasture grassland, orchards and cropland, and lowland forest blocks.<br>Urban, grassland, forest, scrub | Eurasian blackbirds primarily eat terrestrial invertebrates such as snails, slugs, earthworms, insects and spiders, found whilst foraging through grassland, leaf-litter and forested areas.<br>These birds do not form unified flocks, typically preferring to forage alone or in pairs. However, if food is abundant, juveniles will occasionally form foraging 'groups' of up to 20 individuals.<br>Breeding occurs from August to February, with male–female pairs avidly defending a territory in which they build their nest. Females typically lay between 3 and 4 eggs in a woven-cup-shaped nest made of grass, twigs, and other materials found locally.<br>On average, individuals weigh around 90 g.<br>The aviation risk associated with this bird is related to its abundance. |

**Appendix B: Summary of bird species observed during field investigations**

| **Risk** | **Common Name[1]** | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | Eurasian skylark<br> | *Alauda arvensis*<br>*No: 59* | Prefer open grassland habitats such as pasture grassland, tussock and dunes.<br>Grassland, shore | Eurasian skylark feeds on a variety of seeds such as cereals, clover and weeds, and terrestrial invertebrates, including snails, slugs, insects and spiders.<br>These birds form loose flocks, especially if seeds are abundant. During breeding season, they form monogamous pairs that defend a small territory on which they build their nest.<br>Breeding season occurs from August to January inclusive, and females typically lay between 2 and 5 eggs. Nests are a woven cup-shaped ground-level hollow made of grasses. Nests are made beneath long grasses or rushes and are formed from grasses.<br>On average, individuals weigh around 38 g.<br>The aviation risk associated with the Eurasian skylark is related to its habitat preferences and abundance. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name[1]** | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | European goldfinch<br> | *Carduelis carduelis*<br>*No: 5* | Prefer open habitats such as farmland, urban areas, cropland and orchards, riverbeds and loosely vegetated exotic and native forest blocks.<br>Grassland, urban, shore, forest, scrub | European goldfinch feed on seeds and terrestrial invertebrates. Important food sources include thistles, pasture grasses, insects and spiders.<br>These birds commonly form flocks of between several individuals and hundreds of birds if food is abundant.<br>Breeding occurs from October to March inclusive, and females lay between 2 and 6 eggs, and build a woven cup-shaped nest made from grasses and roots, lined with thistle down, feathers and wool.<br>On average, individuals weigh around 15 g.<br>The aviation risk associated with the European goldfinch relates to its flocking behaviour. |

**Appendix B: Summary of bird species observed during field investigations**

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | European greenfinch<br> | *Chloris chloris*<br>*No: 2* | Are found country-wide, except for alpine regions, in habitats such as farmland, scrub, exotic and native forest blocks, urban parks and gardens.<br>Grassland, urban, forest, scrub | European greenfinch feeds on a variety of seeds from grasses to trees and shrubs. In particular, they are commonly seen foraging on wild turnip and radish, pine tree seeds and thistles. To a lesser extent, individuals will also feed on terrestrial invertebrates.<br>These birds form flocks ranging from 10 birds up to thousands. During breeding season, birds form monogamous pairs.<br>Breeding season occurs from October to March inclusive, and females lay between 3 and 6 eggs. Nests are made of twigs, grass and moss, lined with feathers or wool and formed into a woven-cup shape.<br>On average, individuals weigh around 28 g.<br>The aviation risk associated with the European greenfinch relates to its flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Grey warbler<br> | *Gerygone igata*<br>*No: 3* | This species is a habitat generalist, found everywhere except alpine tussockland. They are commonly seen in forested areas, scrub and shrubland, but are also present in urban areas and grassland near farm shelterbelts.<br>Forest, scrub, urban, grassland | Grey warblers primarily feed on terrestrial invertebrates, and are often seen foraging along tree bark, tree branches, and forest canopy.<br>These birds form pairs and will defend an area of territory from others.<br>Breeding occurs from August to February inclusive, and females typically lay between 2 and 5 eggs. Nests are made from grasses, twigs and other vegetation, lined with feathers and other soft materials. The nest forms an enclosed dome within which the eggs are incubated.<br>On average, individuals weigh between 5.5 and 6.5 g.<br>The aviation risk associated with these birds is related to their abundance. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | House sparrow<br> | *Passer domesticus*<br>*No: 59* | These birds are habitat generalists and are found everywhere except alpine regions and dense forests. They are most commonly seen in grassland, urban areas, farmland, cropland and forest peripheries.<br>Grassland, urban, forest, scrub | House sparrows primarily feed on seeds from a variety of plants, however, they also eat terrestrial invertebrates and human food waste when available.<br>These birds form large flocks ranging from several birds to hundreds and are seldom seen alone.<br>Breeding occurs from September to March inclusive, and females typically lay between 2 and 5 eggs. Nests are made of grasses and twigs, lined with feathers and other soft materials and form an enclosed dome.<br>On average, individuals weigh around 28 g.<br>The aviation risk associated with the house sparrow is related to its flocking behaviour, habitat preferences and abundance. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | New Zealand falcon<br> | *Falco novaeseelandiae*<br>*No: 1* | Prefer forested and alpine habitats, however, are occasionally found in farmland and urban areas near forest blocks.<br>Forest, scrub | The New Zealand falcon feeds on small to medium-sized birds, lizards and mammals, and juveniles will occasionally feed on terrestrial invertebrates.<br>They are most often solitary, however, form monogamous pairs during the breeding season.<br>Breeding season occurs from August to May inclusive, and females typically lay between 1 and 4 eggs.  Nests are a scrape on the ground under a log, vegetation, rock stack, along a cliff or in tree epiphytes.<br>On average, males weigh between 205 and 340 g, whereas females typically weigh between 420 and 740 g.<br>The aviation risk associated with the New Zealand falcon is related to its weight. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | New Zealand pipit<br> | *Anthus novaeseelandiae*<br>*No: 1* | Prefer open habitats from coastal regions to alpine zones. Habitats such as riverbeds, coastlines, felled forest blocks, grassland, wetlands, tussock and shrubland.<br>Grassland, shore, wetland, shrubland | The New Zealand pipit feeds primarily on terrestrial invertebrates and plant seeds.<br>These birds form flocks ranging from several birds to hundreds of individuals.<br>Breeding occurs from August to February inclusive, and females typically lay between 2 and 4 eggs. Nests are shaped like a woven cup, made from grasses and hidden under an object.<br>On average, individuals typically weigh around 35 g.<br>The aviation risk associated with these birds is related to their habitat preferences. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Reef heron<br> | *Egretta sacra*<br>*No: 1* | Prefers habitats near the coast or adjacent to water bodies such as rivers, lakes, lagoons, coastlines, mudflats, wetlands and estuaries.<br>Open water, wetlands, shore, mudflats | Reef herons prey on small fish, crustaceans and worms in freshwater and saline waterbodies.<br>These birds are typically seen as solitary individuals, although they will occasionally be seen in small groups when roosting at high tide.<br>Breeding occurs from September to December, with females typically laying between 2 and 5 eggs. Nests are made of a pile of sticks and are often found in rock crevices, under bridges, in caves or among tree roots.<br>On average, individuals weigh around 400 g.<br>The aviation risk associated with reef herons is related to their weight. |

**Appendix B: Summary of bird species observed during field investigations**

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Sacred kingfisher<br> | *Todiramphus regia*<br>*No: 16* | These birds are found in all habitats adjacent to waterbodies, including rivers, streams, lakes, wetlands, lagoons, coastlines, ponds and drainage channels.<br>Open water, wetlands, grassland, urban | Sacred kingfisher typically feeds on small fish, terrestrial and aquatic invertebrates in freshwater and saline habitats.<br>These birds are primarily solitary animals, however, they are seen in pairs, especially during breeding season.<br>Breeding season occurs from October to January inclusive, and females typically lay between 3 and 7 eggs. Nests are usually tree burrows or existing hollows.<br>On average, individuals weigh around 55 g.<br>The aviation risk associated with the sacred kingfisher is low due to their solitary nature, small size and habitat preferences. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Shining cuckoo  | *Chrysococcyx lucidus*<br>*No: 1* | Prefer habitats associated with grey warblers and thus found in a variety of habitats countrywide.<br>Forest, scrub, urban, grassland | Shining cuckoos predominantly feed on terrestrial invertebrates, including some toxic species.<br>They are solitary birds, occasionally seen in pairs during the breeding season.<br>Breeding occurs from October to March inclusive. They are a brood parasite, in which females typically lay 1 egg in a grey warbler nest whilst the parents are away.<br>On average, individuals weigh around 23 g.<br>The aviation risk associated with the shining cuckoo is low due to its timid nature, habitat preferences and small size. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Silvereye (Waxeye)<br> | *Zosterops lateralis*<br>*No: 5* | These birds are habitat generalists and are seen in a variety of habitats, from native and exotic forest blocks, urban areas, wetlands and grassland.<br>Forest, scrub, sedgeland, wetland, grassland, urban | Silvereyes are omnivorous and feed on terrestrial invertebrates, seeds, fruits, nectar and occasionally human food waste. Additionally, during winter, birds will often supplement their diet with fat and lard from bird feeders.<br>These birds are commonly seen in flocks ranging from 3 to 30 birds. During breeding season, these flocks disperse into pairs and defend a small territory for nesting and foraging.<br>Breeding occurs from August to February inclusive, and females lay between 2 and 4 eggs. Nests are made from moss, lichen, twigs and other materials, and are formed into a woven cup shape.<br>On average, individuals weigh around 13 g.<br>The aviation risk associated with the silvereye is related to their flocking behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name[1]** | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | Song thrush<br> | *Turdus philomelos*<br>*No: 2* | Prefer habitats such as urban areas, farmland, and lowland native and exotic forests.<br>Urban, forest, scrub, grassland | Song thrushes predominantly feed on terrestrial invertebrates, berries and other fruits.<br>Individuals are usually seen alone or in pairs, with pairs defending a territory during the breeding season.<br>Breeding occurs from August to February inclusive, and females typically lay between 2 and 3 eggs. Nests are made of grass, twigs, lichen wool and other soft materials and are formed into a woven cup shape.<br>On average, individuals weigh around 70 g.<br>The aviation risk associated with the song thrush low due to its habitat preference and solitary nature. This species is often confused by pilots for Eurasian skylarks. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Spur-winged plover<br> | *Vanellus miles*<br>*No: 26* | Prefer open habitats typically associated with human activities, such as farmland, urban areas, wetlands, riverbeds, lakesides, estuaries and beaches.<br>Grassland, urban, wetland, shore, mudflats | Spur-winged plovers typically feed on marine and terrestrial invertebrates, including molluscs, crustaceans, insects and worms.<br>These birds are typically seen in pairs, however, they do form into larger flocks on occasion.<br>Breeding occurs from April to November inclusive, and females typically lay between 3 and 4 eggs. Nests are a scrape in the ground, lined with whatever materials are found in the surrounding area.<br>On average, individuals weigh between 350 and 370 g.<br>The aviation risk associated with the spur-winged plover is related to their weight, abundance, aggressive nature and habitat preferences. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Swamp harrier<br> | *Circus approximans*<br>*No: 13* | These birds are commonly seen over farmland, wetlands, estuaries, pine forests and coastal margins. They are less common in urban areas and dense native forests.<br>Grassland, wetland, forest, shore, urban | Swamp harriers prey on small to medium-sized birds, lizards and mammals, and are often seen scavenging carrion along roadways.<br>These birds are usually solitary, however, they can be seen in pairs during the breeding season.<br>Breeding occurs from September to April inclusive, and females typically lay between 2 and 7 eggs. Nests are made from sticks, twigs, grasses and other vegetation, and are usually found on the ground within dense grass, wetlands, sedges and shrubs.<br>On average, males weigh approximately 650 g, whereas females typically weigh around 850 g.<br>The aviation risk associated with swamp harriers is associated with their weight, habitat preferences and soaring/ hunting behaviour. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | Tūī  | *Prosthemadera novaeseelandiae*<br>*No: 26* | These birds prefer forested areas and are also often seen in urban areas if native, nectar-producing plants are present.<br>Forest, scrub, wetlands, urban | Tūī have a varied diet primarily consisting of nectar from plants such as harakeke/flax, kōwhai, rata, kahikatea and fuchsia. Additionally, these birds feed on fruits and terrestrial invertebrates.<br>These birds are often seen in small flocks of 2 to 3 birds, however, larger flocks of over 60 have been observed on occasion.<br>Breeding occurs from September to February inclusive, and females typically lay between 2 and 4 eggs. Nests are a bulky cup shape made of sticks and twigs and lined with grasses.<br>On average, males weigh around 125 g, whereas females weigh approximately 90 g.<br>The aviation risk associated with the tūī is low due to their habitat preference for forested areas and small size. |

## Appendix B: Summary of bird species observed during field investigations

| **Risk** | **Common Name**[1] | **Species/ number observed within 3 km buffer zone of HBA** | **Habitat** | **Behaviour and Characteristics** |
|---|---|---|---|---|
| Low | Welcome Swallow<br> | *Hirundo neoxena*<br>*No: 88* | Prefer habitats near water bodies and are often seen in wetlands or along the coast.<br>Open water, wetlands, grassland, urban, shore | Welcome swallows feed on small invertebrates caught whilst in flight.<br>They form flocks ranging in size from several individuals to hundreds of birds, and roost in large flocks along cliffs facing or on man-made structures such as buildings or bridges.<br>Breeding occurs from August to March inclusive, and females typically lay between 2 and 7 eggs. Pairs can have up to 3 successful broods in a season. Nests are cup-shaped, made from mud, lined with grasses and feathers, and are typically built along cliff faces or other vertical surfaces such as buildings.<br>On average, individuals typically weigh around 9 to 20 g.<br>The aviation risk associated with welcome swallows relates to their abundance, flocking behaviour and habitat preferences. |

## Appendix B: Summary of bird species observed during field investigations

| Risk | Common Name[1] | Species/ number observed within 3 km buffer zone of HBA | Habitat | Behaviour and Characteristics |
|---|---|---|---|---|
| Low | Whitehead<br> | *Mohoua albicilla*<br>*No: 1* | Prefer native forest blocks, dense scrub and shrubland, but are also seen in mature pine plantations.<br>Forest, scrub | Whiteheads are insectivorous, primarily feeding on insects and spiders and are occasionally seen feeding on fruits.<br>These birds often form mixed species flocks during the non-breeding season, ranging from several individuals to 30 birds.<br>Breeding occurs from September to January inclusive, and females lay between 2 and 4 eggs. Nests are tightly woven and cup-shaped, made from vegetation and lined with soft materials such as grasses, feathers and moss.<br>On average, individuals weigh between 15 and 18 g.<br>The aviation risk associated with the whitehead is low due to its preference for forested habitats and small size. |

*Notes:*

1. *All images used in this table are credited to their respective owners via New Zealand Birds Online*

# Appendix C: Summary of the Bird Risk Matrix associated with Hawke's Bay Airport

## Appendix C: Summary of the bird risk matrix associated with Hawke's Bay Airport

| | | Consequence | | | | |
|---|---|---|---|---|---|---|
| Likelihood | | Negligible (0-4) | Minor (8-20) | Moderate (21-33) | Significant (34-46) | Severe (47+) |
| | Very Likely (5) | 🟨 | 🟧 | 🟧 | 🟥 | 🟥 Black swan |
| | Likely (4) | 🟨 | 🟨 Pied stilt, Red-billed gull | 🟧 Southern black-backed gull | 🟧 | 🟥 Canada goose, Mallard |
| | Possible (3) | 🟩 Australian magpie, Eurasian blackbird, Swamp harrier, House sparrow, Sacred kingfisher, Eurasian skylark, Spur-winged plover, Welcome swallow, Yellowhammer | 🟨 Australasian shoveler, Black shag, Grey teal, Little shag, Paradise shelduck, Pūkeko, Common starling, Variable oystercatcher, White-faced heron | 🟨 Bar-tailed godwit, Greylag goose, Rock pigeon, Royal spoonbill | 🟧 | 🟥 |
| | Unlikely (2) | 🟩 Chaffinch, New Zealand fantail, European goldfinch, Grey warbler, Silvereye, Song thrush, Tūi | 🟨 Kererū, Rook, South Island pied oystercatcher, Chicken | 🟨 | 🟨 | 🟧 |
| | Very Unlikely (1) | 🟩 European greenfinch, Common myna, New Zealand falcon, New Zealand pipit, Shining cuckoo | 🟩 Caspian tern, Reef heron, Whitehead | 🟨 | 🟨 | 🟧 |

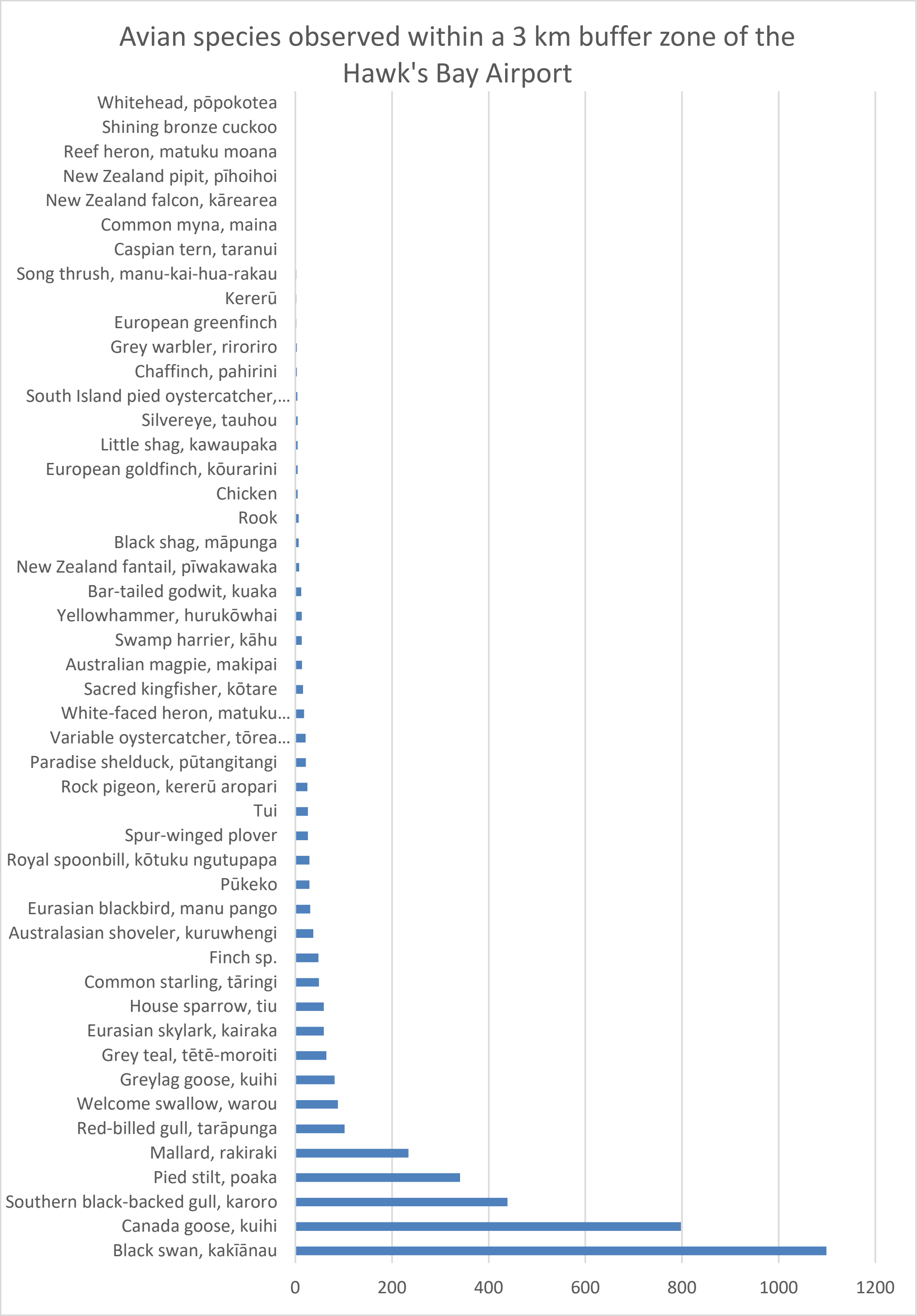
🟩 *Low Risk: no further action beyond current management is required*

🟨 *Medium Risk: review current management options for any additional actions*

🟧 *High Risk: take action to reduce risk*

🟥 *Extreme Risk: take immediate action to reduce risk*

# Appendix D: Avian Species observed within a 3 km Buffer Zone of Hawke's Bay Airport


Avian species observed within a 3 km buffer zone of the Hawk's Bay Airport
Whitehead, pōpokotea
Shining bronze cuckoo
Reef heron, matuku moana
New Zealand pipit, pīhoihoi
New Zealand falcon, kārearea
Common myna, maina
Caspian tern, taranui
Song thrush, manu-kai-hua-rakau
Kererū
European greenfinch
Grey warbler, riroriro
Chaffinch, pahirini
South Island pied oystercatcher,…
Silvereye, tauhou
Little shag, kawaupaka
European goldfinch, kōurarini
Chicken
Rook
Black shag, māpunga
New Zealand fantail, pīwakawaka
Bar-tailed godwit, kuaka
Yellowhammer, hurukōwhai
Swamp harrier, kāhu
Australian magpie, makipai
Sacred kingfisher, kōtare
White-faced heron, matuku…
Variable oystercatcher, tōrea…
Paradise shelduck, pūtangitangi
Rock pigeon, kererū aropari
Tui
Spur-winged plover
Royal spoonbill, kōtuku ngutupapa
Pūkeko
Eurasian blackbird, manu pango
Australasian shoveler, kuruwhengi
Finch sp.
Common starling, tāringi
House sparrow, tiu
Eurasian skylark, kairaka
Grey teal, tētē-moroiti
Greylag goose, kuihi
Welcome swallow, warou
Red-billed gull, tarāpunga
Mallard, rakiraki
Pied stilt, poaka
Southern black-backed gull, karoro
Canada goose, kuihi
Black swan, kakīānau
0
200
400
600
800
1000
1200

Tonkin+Taylor

23 April 2026
Job No: 1018914.6001

Napier City Council
215 Hastings St
Napier South
Napier 4110

Attention: Antony Rewcastle

Dear Antony

## Lagoon Farm Stormwater Diversion and Treatment
## PCN02 - Interim Site Investigation

## 1 Introduction

This interim site investigation report has been prepared by Tonkin & Taylor Ltd (T+T) to support the refinement of the Lagoon Farm Stormwater Diversion and Treatment concept design as part of the larger Ahuriri Regional Park project for Napier City Council (NCC).

The purpose of this interim site investigation is to address the key uncertainties around the wetland lining requirements, specifically the availability of site-won low permeability fill availability and existing infiltration characteristics, to inform NCC's decision around progressing to preliminary design.

This report has been prepared in accordance with the terms of the offer of service (PCN 02 (November 2025)) which is a variation of the original 2024_07_04 - C2695 - OOS - Lagoon Farm Stormwater Diversion Project - T+T agreement, signed on 4 July 2024).

### 1.1 Background

The Lagoon Farm area, as shown in red in Figure 1.1, is currently a working Farm owned by NCC and operated by the City Services Directorate. The Lagoon Farm area is proposed to be developed into a regional park, as part of the larger Ahuriri Regional Park (ARP) project for Hawkes Bay Regional Council (HBRC) and Napier City Council (NCC).

The ARP project is proposed to include a large-scale stormwater treatment system targeting 'end-of-line' treatment before stormwater is discharged to the Ahuriri Estuary to satisfy the requirements of the joint NCC/HBRC comprehensive stormwater discharge consent (AUTH-123310-01).

*Figure 1.1: Site boundary.*

## 1.2 Previous design stages

This report is to be read in conjunction with the following reports (summarised below) from the previous design stages:

- Lagoon Farm Stormwater Diversion Project – Concept Design Report v1.1 prepared by T+T, issued August 2025.
- Lagoon Farm Stormwater Diversion Project – Optioneering Report v1.1 prepared by T+T, issued April 2025.
- Lagoon Farm Stormwater Diversion Project Basis of Design and Constraints Report v0.1 prepared by T+T, issued September 2024.

## 1.3 Concept design

A concept design report (Lagoon Farm Stormwater Diversion – Concept Design Report, issued April 2025) was prepared by T+T to develop the NCC preferred option (maximum water quality treatment footprint) to concept design stage.

The concept design, shown in Figure 1.2, proposes a large-scale surface flow wetland system that will treat runoff from up to 2,905 hectares of contributing catchment from urban Napier. The proposed wetland system is designed as a surface flow wetland, operating offline from the main drainage network. The wetland layout is proposed to include three large parallel wetland bays spanning 106 ha and sized to retain and treat 220,000 cubic metres of stormwater runoff at any one time.

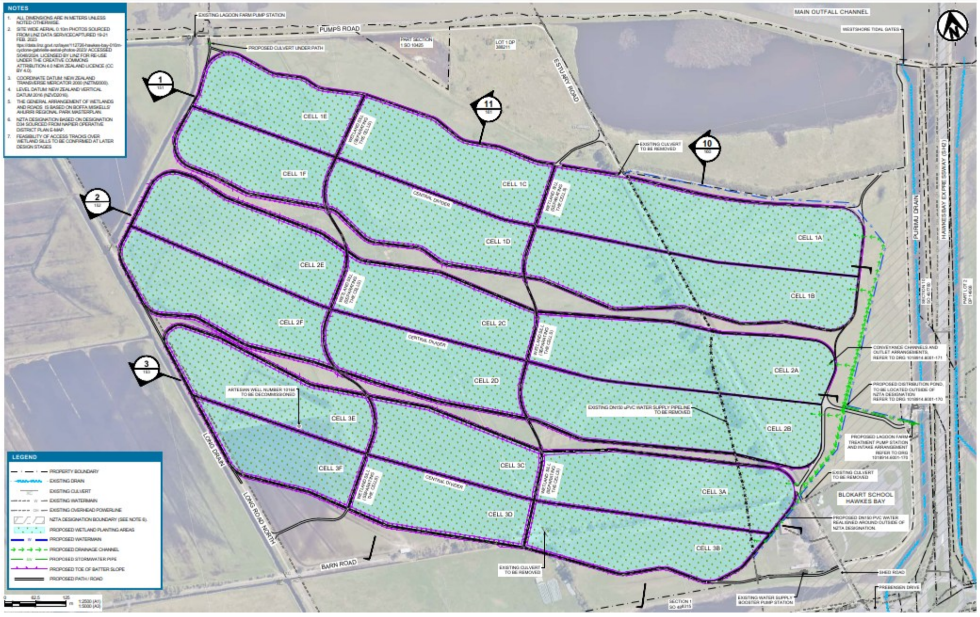


*Figure 1.2: Concept Design wetland footprint (sourced from Lagoon Farm Stormwater Diversion Project – Concept Design Report v1.1 prepared by T+T, issued August 2025).*

The concept design report discusses a potential staged approach, where the full wetland footprint is earmarked but construction and catchment integration occur progressively over time, as outlined below:

- Phase 1 involves the initial construction of the northern wetland (36 ha) to treat runoff from the Pūrimu Drain and the connected Waverley Catchment.
- Phase 2 expands treatment by adding the central wetland (38 ha), enabling runoff from the adjacent Pūrimu, County, and Waverley Catchments.
- Phase 3 completes the full 106 ha wetland footprint with the southern wetland (30 ha), allowing treatment of all major catchments discharging to the Ahuriri Estuary.

This approach supports flexibility in funding (especially in terms of offsite conveyance infrastructure) and implementation while enabling progressively increased treatment coverage over time.

The concept design phase of the Lagoon Farm wetland system revealed several key technical challenges that require further investigation in subsequent design stages. One of the most significant challenges is the permeability of the soil at Lagoon Farm being  such that there is a risk of the wetland drying out for extended periods and the potential cost implication of installing a low permeability liner to mitigate this risk.

### 1.3.1 Key risk – lining requirement

According to initial hydraulic conductivity results of the soils beneath the proposed wetland footprint (which were tested in the installed site piezometers), the wetland would frequently dry out between rainfall events for extended periods due to infiltration losses, which would ultimately lead to plant mortality and treatment failure.

While plant species more tolerant of dry conditions could be selected to partially mitigate this risk, the anticipated seasonal fluctuations between full submersion and complete dryness would likely exceed the tolerance range of these species.

Installing a low-permeability liner was recommended to maintain water suitable levels. Synthetic liners (e.g., geosynthetic clay liner (GCL) or similar) and importing a clay liner from offsite were discussed as options with an imported clay liner likely being the most cost-effective. However, importing clay to form a liner this is still expected to represent an increase in overall project cost by 35-40 % (an additional $23 million).

This cost was identified as a key project risk in the concept design report, as importing a liner may be cost prohibitive. Therefore, several actions were recommended in the concept design report to better quantify and, where possible, reduce this risk prior to progressing to preliminary design:

1 Carry out additional site infiltration testing including:
   - a Conduct additional infiltration testing of the near-surface soils to confirm the infiltration rate that should be used in the water balance model to quantify the risk of the wetland drying out (eliminate the risk of inferring infiltration rates from hydraulic conductivity) and whether a liner is needed.
   - b Investigate the western extent of the site to determine if there is a site-won low permeability material (clay) available.

2 Further refine the water balance model based on the refined infiltration rates.

3 Consider developing a hybrid partially lined wetland to minimise cost implications of installing site-won low permeability material (clay).

This report addresses the actions outlined in Point 1(a) & (b). Point 2 and 3 will be considered further in Preliminary Design if NCC progress the project.

# 2 Interim site investigations

The purpose of this interim site investigation is to address the key uncertainties and cost implications associated with the wetland lining requirements, specifically the following:

- Infiltration testing of the near-surface soils underneath the proposed wetland footprint.
- Test pits on the western portion of the site to determine if there is a site-won low permeability material (clay) available.

## 2.1 In-situ infiltration testing

Eighteen double ring infiltrometer tests were undertaken at representative locations across the proposed wetland footprint (approximately one week of fieldwork), as shown in Figure 2.1. The tests were used to assess near-surface infiltration rates of the in-situ soils, to support an understanding of the proposed wetland's hydraulic performance and to inform liner requirements. The laboratory site report is attached in Appendix A.

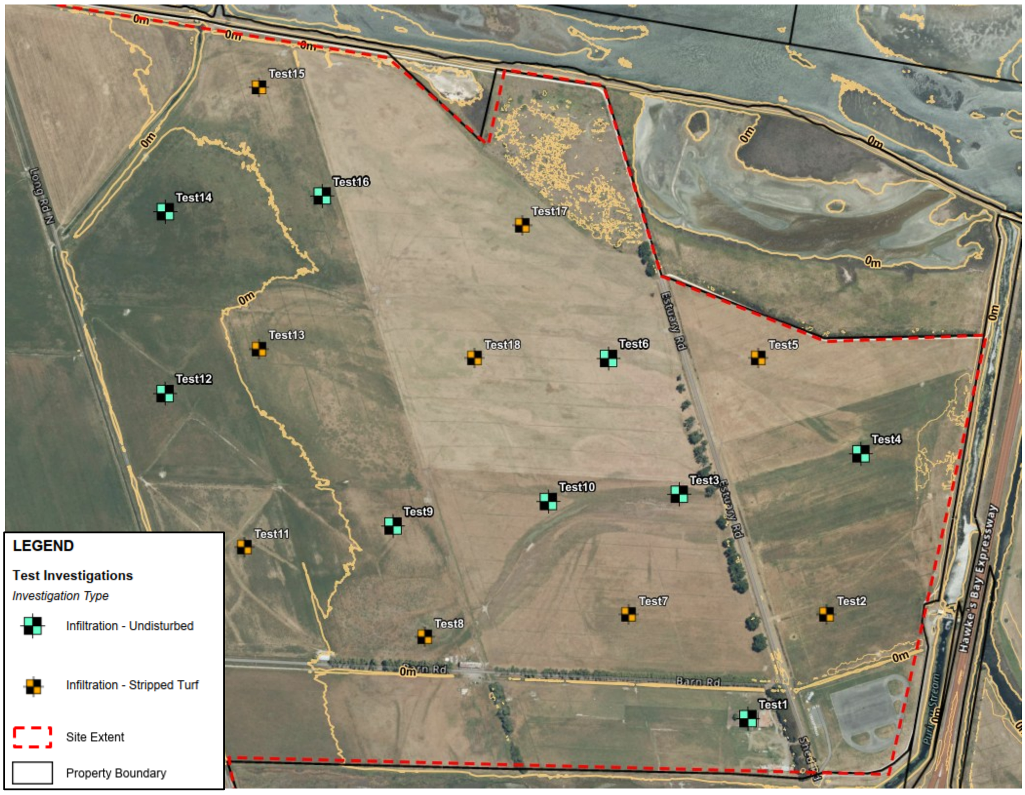


*Figure 2.1: Infiltration test locations (red).*

### 2.1.1 Results and findings

The infiltration test results are summarised in Table 2.1, which includes conversions to soakage rates and hydraulic conductivity. Generally, the target permeability is in the order of 1-5 mm/day or $1.0 \times 10^{-8}$ m/s.

**Table 2.1: Infiltration testing results**

| Test | Site Infiltration Results | | Soakage Rates | | Hydraulic Conductivity |
|---|---|---|---|---|---|
| | Reported Soakage Rate (L/s/m²) | Undisturbed or Stripped | Soakage Rate (mm/hr/m²) | Soakage Rate (mm/day/m²) | m/s |
| 1 | 0.028 | Undisturbed | 101 | 2,419 | $2.80 \times 10^{-5}$ |
| 2 | 0.014 | Stripped | 50 | 1,210 | $1.40 \times 10^{-5}$ |
| 3 | 0.008 | Undisturbed | 29 | 691 | $8.00 \times 10^{-6}$ |
| 4 | 0.047 | Undisturbed | 169 | 4,061 | $4.70 \times 10^{-5}$ |
| 5 | 0.025 | Stripped | 90 | 2,160 | $2.50 \times 10^{-5}$ |
| 6 | 0.061 | Undisturbed | 220 | 5,270 | $6.10 \times 10^{-5}$ |
| 7 | 0.035 | Stripped | 126 | 3,024 | $3.50 \times 10^{-5}$ |
| 8 | 0.009 | Stripped | 32 | 778 | $9.00 \times 10^{-6}$ |
| 9 | 0.059 | Undisturbed | 212 | 5,098 | $5.90 \times 10^{-5}$ |
| 10 | 0.071 | Undisturbed | 256 | 6,134 | $7.10 \times 10^{-5}$ |
| 11 | 0.002 | Stripped | 7 | 173 | $2.00 \times 10^{-5}$ |
| 12 | 0.014 | Undisturbed | 50 | 1,210 | $1.40 \times 10^{-5}$ |
| 13 | 0.071 | Stripped | 256 | 6,134 | $7.10 \times 10^{-5}$ |
| 14 | 0.057 | Undisturbed | 205 | 4,925 | $5.70 \times 10^{-5}$ |
| 15 | 0.066 | Stripped | 238 | 5,702 | $6.60 \times 10^{-5}$ |
| 16 | 0.061 | Undisturbed | 220 | 5,270 | $6.10 \times 10^{-5}$ |
| 17 | 0.066 | Stripped | 238 | 5,702 | $6.60 \times 10^{-5}$ |
| 18 | 0.08 | Stripped | 288 | 6,912 | $8.00 \times 10^{-5}$ |

A summary of the infiltration results is provided as follows:

- Eighteen infiltration tests were completed across the proposed wetland footprint, including nine tests on undisturbed ground (topsoil and vegetation left in place) and nine tests on stripped ground (topsoil removed or disturbed to reflect conditions likely during earthworks).
- Undisturbed areas generally recorded higher infiltration rates than stripped areas, as shown in Figure 2.2. On average, the undisturbed tests recorded infiltration rates around 1.5 times higher than the stripped tests.
- Stripped areas showed the widest range of results, including both the slowest and fastest infiltration rates measured.

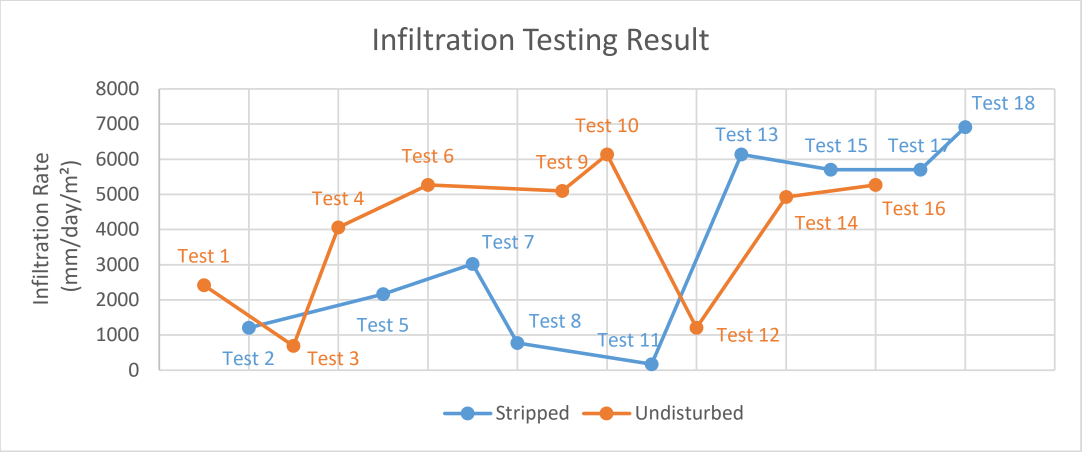


*Figure 2.2: Infiltration testing results.*

- Despite the differences between the two test ground conditions, all recorded infiltration rates are relatively high, meaning the soils allow water to pass through quickly regardless of whether the surface is disturbed or not.
- The lowest recorded infiltration rates were recorded in Tests 2, 3, 8, 11 and 12, these test locations are shown in Figure 2.3. These have typically been recorded on the southern and western end of the site, but do not show a consistent spatial pattern.

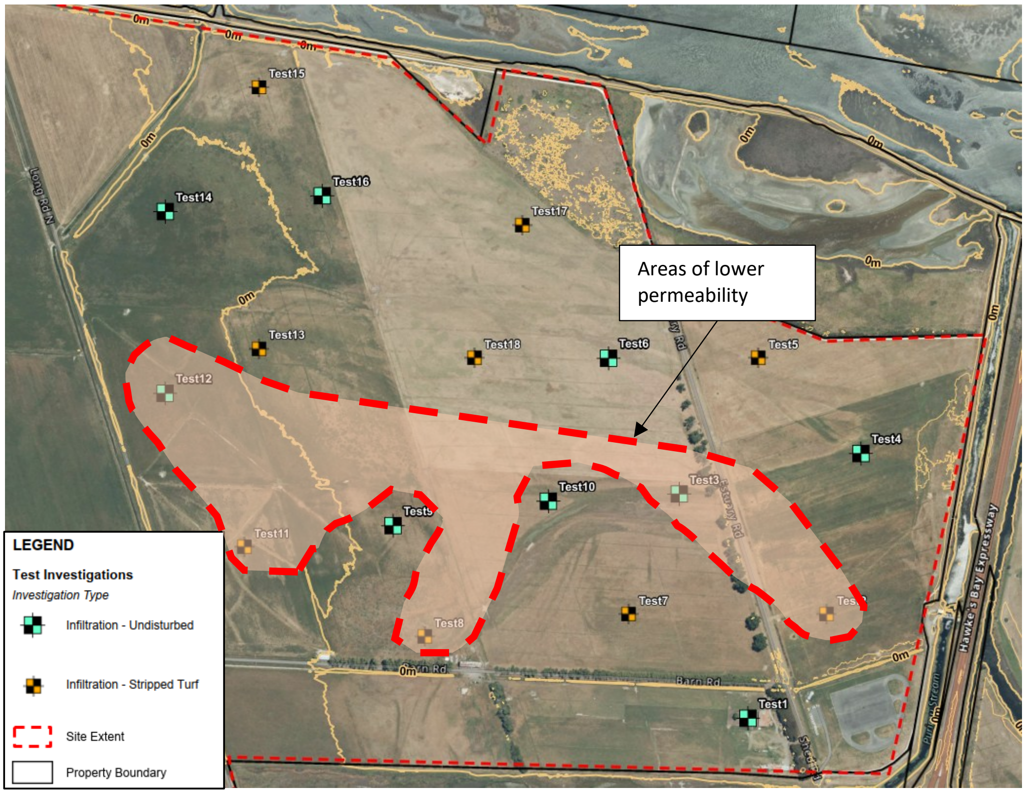


*Figure 2.3: Lower infiltration rates area.*

When the results are converted to hydraulic conductivity, the near-surface soils still show high permeability compared to the target rates, and the values reported in this testing round are generally higher than those previously reported in the earlier T+T Groundwater Assessment Report (28 mm/day). The implications of this on the wetland design are discussed in Section 3.

## 2.2 Test pit investigation

Interim investigations were undertaken by T+T between late January and early April 2026 and comprised:

- 8 No. Test Pits (TP) excavated to depths of approximately 1.5 mbgl (target depth).
- 2 No. Compaction Test – Maximum Dry Density (Standard Compaction; NZS 4402 Test 4.1.1(b)).
- 2 No. Hydrometer Test – Hydrometer Testing (NZS 4402 Test 2.8.4(b)).
- 2 No. Permeability Test – ISO 17892 Part 11(b)-3, Remoulded, adjusted water content.

The test pit investigations were undertaken by Slick Civil Limited and were supervised by a Geotechnics field technician. The encountered ground conditions were logged on 26 January 2026 at the location shown in blue in Figure 2.4. The test pit logs are presented in Appendix B.

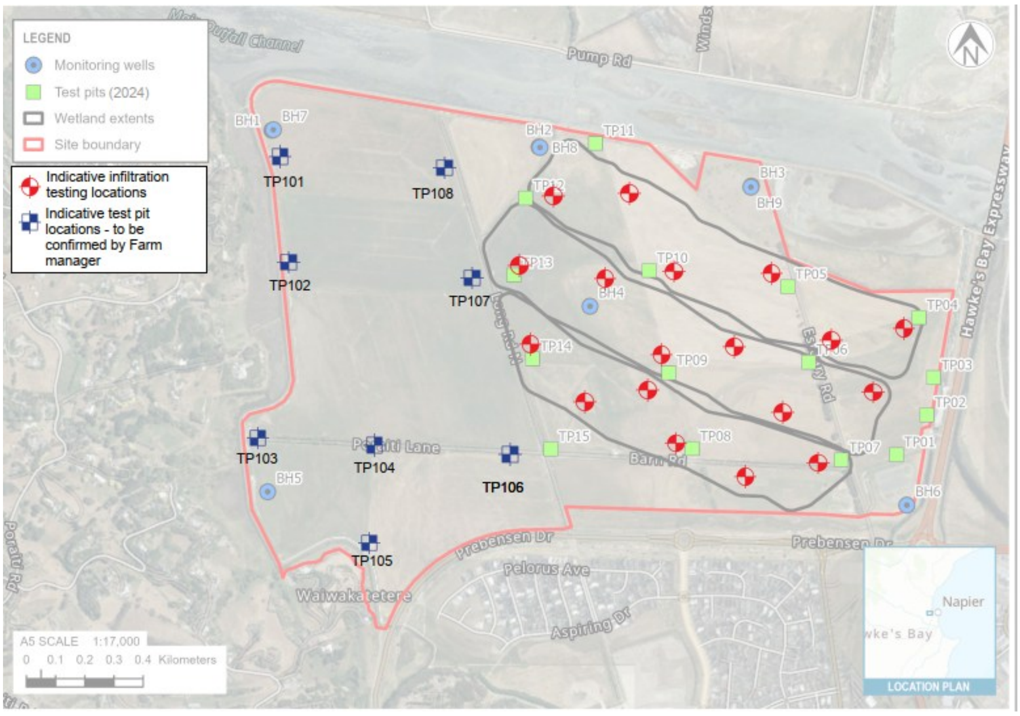


*Figure 2.4: Test Pit locations (blue).*

Laboratory testing was undertaken on soil samples collected during the recent test pit (TP) investigations. The soil samples were sent to Geotechnics' Auckland laboratory for testing with results summarised below in Section 2.2.2 and included as Appendix C.

### 2.2.1 Field investigation findings

A distinct layer of silty clay was encountered at shallow depth in most of the test pits, specifically TP101, TP102, TP106, TP107, and TP108. This material was not identified at a similar depth on the eastern half of the site, where the proposed wetlands are located. It was only identified in BH01 and BH07 (close to TP101) at a similar depth during the first round of investigation in July 2024. This may be explained by the depositional environments of the former Ahuriri Lagoon as was discussed in the earlier Concept Design report. Based on historical maps the western side of the site was formed by deeper estuarine environments, whilst the eastern part of the site comprises sand and shell beds.

The characteristics of this layer silty clay are as follows:

- Depth: This cohesive layer typically begins beneath the near-surface silts at depths ranging from 0.50 m (TP102, TP108) to 0.70 m (TP101, TP107) and 0.80 m (TP106).
- Thickness: The thickness of this cohesive layer is approximately 0.8 m.
- Engineering characteristics: In all locations where the silty clay was found, it is consistently described as stiff, wet, and possessing high plasticity.
- Colour and mottling: The clay is generally described as greyish brown or light greyish brown. It frequently exhibits prominent mottling, usually orange (TP101, TP102, TP107) or a combination of orange and blue (TP106).
- Secondary components: While mostly comprised of silt and clay, the silty clay layer in TP106 notably contains trace amounts of fine-to-coarse gravel and shells.

### 2.2.2 Laboratory testing findings

Subsequently, representative samples were collected from TP107 and TP108 and submitted for laboratory testing. Two samples underwent standard compaction, hydrometer, and permeability testing, with particle size distribution testing undertaken where applicable. Table 2.2 below presents a summary of the geotechnical laboratory testing results, with full results presented in Appendix C.

**Table 2.2: Summary of laboratory test results**

| Material<br>(Site-Won Silty CLAY) | Natural Water Content | Optimum Water Content | Maximum Dry Density (t/m3) | Fines Content | Coefficient of Permeability at 20.5 °C | Infiltration Rate (mm/day) |
|---|---|---|---|---|---|---|
| **TP107**<br>**(sample collected from 1-1.5 m)** | 54.6 % | 30 % | 1.38 t/m$^3$ | 99 % | 1.87 E-09 m/s | 0.2 mm/day |
| **TP108**<br>**(sample collected from 1-1.5 m)** | 56.1 % | 34 % | 1.35 t/m$^3$ | 99 % | 4.46 E-10 m/s | 0.04 mm/day |

Based on the wetland design requirements, the results of the geotechnical laboratory testing, and T+T's local experience with similar soils in comparable areas, it is considered that the site-won silty clay encountered on the western side of the site could be suitable for use as a clay liner for the proposed wetlands, if sufficient conditioning of the fill is undertaken as outlined in Section 3.2.

# 3 Implication on wetland design

A water balance model was developed during the concept design to provide an understanding of how water would move through the proposed wetland system. Understanding of the water balance is crucial for ensuring the wetland can support vegetation, maintain ecological function, and deliver effective water treatment. The average operating depth of the proposed wetland is 250 mm (varying from 0 – 500 mm), so excessive losses through the base have the potential to completely drain the wetland.

The key system inputs for the water balance model are summarised in the flow chart in Figure 3.1.

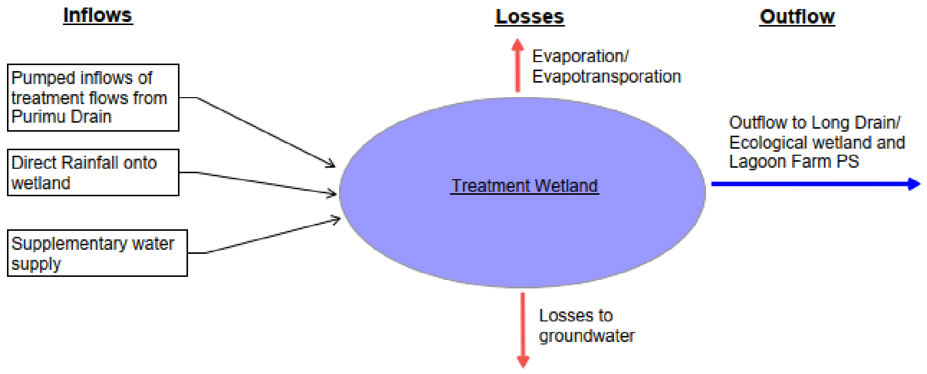


*Figure 3.1: Water balance conceptual model.*

One of the key losses requiring quantification is seepage to groundwater through the wetland base. An infiltration rate of 28 mm/day for the in-situ wetland base (i.e. without a liner) was assumed in the initial water balance model, based on earlier site investigations.

Figure 3.2 presents the results of the water balance modelling for the 2014–2015 period using this assumed infiltration rate (results for other periods are provided in the Concept Design Report). The modelling indicates that an infiltration rate of 28 mm/day would result in frequent and prolonged dry conditions that would compromise treatment performance and wetland vegetation. Excluding losses to evaporation, the assumed soil infiltration rate of 28 mm/day would draw the wetland down from its maximum depth of 500 mm to empty in approximately 18 dry days (i.e. with no additional rainfall/inflow).

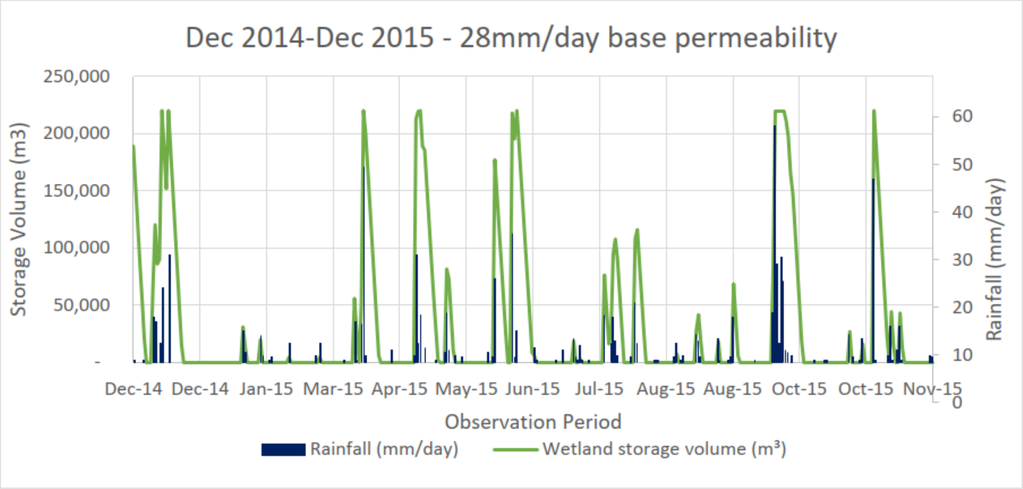


*Figure 3.2: 2014 – 2015 water balance model results – insitu soils (28 mm/day) base.*

For comparison, the water balance model results, assuming a low permeability liner (~1 mm/day) is shown below in Figure 3.3. With losses to groundwater largely minimised, the wetland storage volume remains much more consistent over time, significantly reducing the likelihood of complete drying compared to the unlined scenario. It also shows that even with the low permeability liner, extended dry periods can result in a short-term drying out of the wetland due to evaporation and evapotranspiration losses. Based on the current water balance model, it is expected that losses through the base of less than approximately 5 mm/day would be acceptable, in terms of minimising extended periods leading to the wetland drying out.

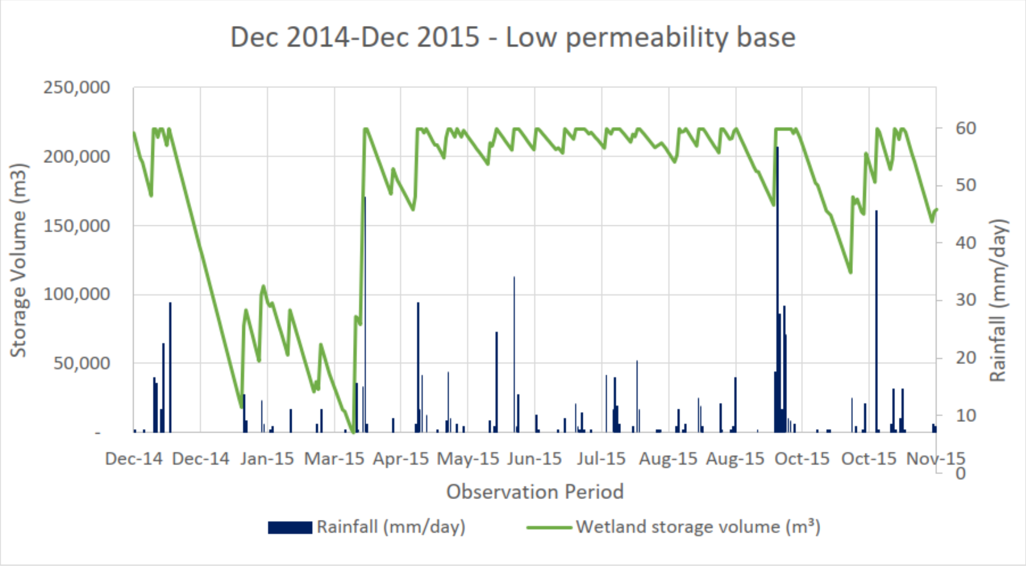


*Figure 3.3: 2014 – 2015 water balance model results – low permeability (<1 mm/day) base.*

## 3.1 Permeability of in-situ soils

The tested infiltration rates from around the footprint of the wetland varied from 173 mm/day to 6.1 m/day, which is significantly more permeable that the acceptable infiltration rates through the wetland base. Excluding losses to evaporation, the best-case tested soil infiltration rate of 173 mm/day would draw the wetland down from its maximum depth of 500 mm to empty in approx. 3 dry days (i.e. no additional rainfall/inflow).

Accordingly, it is recommended that an impermeable liner (clay or engineered) is included as part of the design to achieve acceptable hydraulic performance.

## 3.2 Onsite low permeability material

The lab tested permeability testing results ($\sim 1 \times 10^{-10}$ to $1 \times 10^{-9}$ m/s at optimum moisture content) of the silty clay located on the western portion of the site was approximately one to two orders of magnitude lower than the target permeability adopted for wetland lining purposes (typically taken as $\sim 1 \times 10^{-8}$ m/s). The tested permeability equates to an infiltration rate of 0.04 – 0.2 mm/day. On this basis, the tested silty clay material demonstrates permeability characteristics that are more than adequate to limit seepage losses to acceptable levels (given suitable conditioning/drying).

### 3.2.1 Material properties

Laboratory testing indicates that the natural moisture content of the site-won silty clay is in the order of 54–56 %, which is significantly higher than the measured optimum moisture content (OMC) of approximately 30–34 %. As a result, the material in its natural state is unsuitable for immediate use as a clay liner and would require conditioning/drying (moisture conditioning) prior to placement and compaction, as detailed in Section 3.2.3.

### 3.2.2 Material volumes

The site-won silty clay was encountered on the north-western side of the site, extending over an area of approximately 250 – 400 ha. This material was typically present at shallow depth and exhibited an average thickness of approximately 800 mm, noting that some local variability in thickness is expected.

Based on the estimated areal extent and thickness of the silty clay layer, the volume of potentially suitable site won material was estimated to be in the order of 140,000 - 210,000 m³. This estimate is intended for preliminary earthworks planning and assessment only and is based on an interpreted occurrence area and an indicative thickness of approximately 0.8 m from the test pits and allows for an estimated 30 % reduction of the available volume to account for unsuitable material, wastage, or compaction/bulking effects. Further investigation is recommended to confirm the lateral extent, thickness, and suitability of the silty clay layer and to enable more accurate volume quantification.

The approximate volumes of low permeability material required for the three wetlands, based on 300 mm liner thickness across the full footprint, are outlined in Table 3.1. Although the indicative liner volume required exceeds the estimated available volume of site-won low permeability material, this difference reflects the use of simplified, conservative assumptions applied for concept design. It is expected that liner requirements would be refined and rationalised through further design to reduce construction costs and improve constructability. This will include staged implementation and consideration of partial or hybrid lined and unlined wetland configurations, such that the estimated shortfall is not a fundamental issue with the concept

**Table 3.1: Concept design wetland liner requirements**

| Wetland | Area (ha) | Approx. Liner Volume (m³) |
|---|---|---|
| **Northern Wetland** | 36 | 108,000 |
| **Central Wetland** | 38 | 114,000 |
| **Southern Wetland** | 30 | 90,000 |
| **Total** | **106** | **318,000** |

### 3.2.3 Fill conditioning and placement

To achieve the required compaction and permeability performance for use as a wetland clay liner, the site-won silty clay will require substantial drying prior to placement. Based on T+T's local experience with similar materials in comparable areas (i.e. landfill liner), this drying process takes considerable time period and requires appropriate handling and stockpiling practices. These are summarised in Table 3.2.

**Table 3.2: Low permeability liner drying and construction preliminary requirements**

| Requirement | Description |
|---|---|
| **Drying requirements for clay liner material** | The material will need to be excavated, stockpiled onsite, and sealed or managed to limit further moisture ingress, particularly from rainfall. Even under favourable weather conditions, drying to near-optimum moisture content is expected to be gradual. In some instances, the site-won material may be placed wetter than optimum and allowed to dry back on the wetland base prior to compaction through windrowing. |
| **Stockpiling and moisture management** | In order to control moisture content effectively, stockpiles should be constructed at low heights and, where practicable, reworked periodically to promote moisture loss. Stockpiles should also be protected (e.g. by shaping, sealing, or covering) to avoid re-saturation during wet periods.<br>Based on local experience, the drying and conditioning process may take at least 3–4 months, depending on weather conditions and stockpile management. |
| **Construction timing considerations** | To facilitate effective drying of the clay liner material and minimise construction risk, it is recommended that excavation and stockpiling commence in early spring, with the primary drying period occurring during September and October. This timing allows advantage to be taken of typically drier and warmer conditions, supporting moisture reduction prior to liner placement.<br>Subject to successful drying and moisture conditioning, wetland liner construction could then be undertaken from late spring through to early autumn, when conditions are more favourable for earthworks and compaction quality control. |
| **Clay fill placement and compaction** | As noted above, the site-won silty clay was typically wetter than optimum and therefore required drying back, both in stockpiles and on the liner face, prior to compaction. The material will need to be carted to the fill face using an articulated dump truck (or similar), spread over the prepared |

| Requirement | Description |
|---|---|
| | subgrade, and placed in thin layers using a bulldozer. Once the clay has dried back to a suitable moisture content (potentially with turning and windrowing to dry), it can be compacted using a sheep's-foot roller.<br>Upon completion of the required liner thickness, the clay liner may require overbuilding to provide protection against drying and desiccation. Given the complexity of the proposed earthworks and clay liner construction, the works will need to be carefully planned and undertaken by an experienced subcontractor (with construction support provided by an engineer familiar with liner construction) to achieve a homogeneous clay liner and ensure that losses through the base are suitably reduced. |
| **Placed clay liner protection** | A topsoil layer supporting vegetation will be placed over the clay liner to help reduce moisture loss and protect the liner from drying. Given the high plasticity of the clay, shrink–swell behaviour may occur during prolonged dry periods. If the liner dries out, it may crack; therefore, maintaining cover and vegetative protection is important to minimise desiccation and potential cracking. The final wetland clay liner design will need to consider this. |
| **Burrow pit remediation** | NCC should also consider the implications of the land use for the borrow sites, noting this may not be suitable for grazing land, once excavated and lowered. The borrow area could be backfilled with unsuitable materials and topsoil if volumes allow. |

# 4 Conclusion and recommendations

This interim site investigations have been undertaken to address key uncertainties associated with the wetland lining requirements for the Lagoon Farm Stormwater Diversion and Treatment project, to inform NCC's decision around progressing to preliminary design. Specifically, the investigations focused on:

- Confirming near-surface infiltration characteristics across the proposed wetland footprint to confirm the need for a liner.
- Assessing the availability and suitability of site-won low-permeability material for use as a clay liner.

The results of the infiltration testing demonstrate that the in-situ near-surface soils across the proposed wetland footprint exhibit relatively high permeability. The higher infiltration rates measured during this investigation have confirmed that the underlying soils beneath the wetland footprint are such that there is a risk of extended periods where the wetland would dry out leading to the wetland plant mortality. An impermeable liner (either clay or engineered) is therefore recommended to address this risk.

The test pit investigations on the western portion of the site identified a silty clay layer with favourable permeability characteristics for use as a wetland liner. Laboratory testing indicates that, when appropriately moisture-conditioned and compacted, this material can achieve permeability values one to two orders of magnitude lower than target liner performance. On this basis, the site-won silty clay is considered suitable for use as a wetland liner, subject to appropriate conditioning, placement, and quality control. To inform appropriate moisture conditioning and construction planning, the following factors were identified:

- The lab testing results indicated that the natural moisture contents of the clay are higher than optimum, meaning that substantial drying, stockpiling, and careful construction planning will be required. Based on local experience, moisture conditioning is expected to take several months and will have implications for construction sequencing, programme risk, and cost.
- Further investigation (ideally including trial compaction pads) and assessment are recommended to confirm the maximum allowable field moisture content (and associated conditioning requirements) that will still achieve the required permeability for wetland lining purposes. This may allow less stringent moisture conditioning during construction and therefore potentially reduce construction time and costs.
- NCC should also consider the implications of the land use for the borrow sites, noting this may not be suitable for grazing land, once excavated and lowered.
- In terms of the available volume of material, approximately 140,000–210,000 $m^3$ of suitable clay is estimated to be available onsite (allowing for 30 % contingency), which is approximately 44 – 66 % of the volume required to line the full concept wetland footprint (which will likely be refined and rationalised in future design stages). Further investigation is recommended to confirm the lateral extent, thickness, and suitability of the silty clay layer and to enable more accurate volume quantification. Alternative (imported) sources may be required to provide the balance of the eventual required liner volumes.

Although site-won low-permeability material is available, the effort and cost associated with mining, drying, conditioning, and placing this material is potentially significant and there may also be a shortfall in terms of available volumes. Moving forward, it is expected that the liner extent and requirements will be refined and rationalised through further design to reduce construction costs and improve constructability. This may include staged implementation and consideration of partial or hybrid lined and unlined wetland configurations.

## 4.1 Recommendations

The following items are recommended to be assessed during the next design stage (preliminary design) to further understand the liner cost and constructability considerations, noting that the liner remains a major cost driver for the project and that opportunities to reduce liner extent, thickness, or performance requirements could result in significant cost savings.

Rationalising liner usage:

a Refinement of the water balance model under a range of liner permeability assumptions to assess the minimum liner extent, thickness, and permeability required to maintain acceptable wetland hydraulic performance. This assessment should include evaluation of hybrid lined and unlined wetland configurations, and identification of areas where liner performance requirements may be reduced while maintaining vegetation viability and treatment outcomes, thereby reducing overall liner volumes and cost.

Site-won material:

b Assessment of constructability, programme, and cost implications associated with staged excavation, conditioning, and placement of site-won clay versus an off-site supply (if available) or engineered liners. If the site-won material is the preferred liner option, then it is recommended to progress the following:

  - Further delineation of the lateral extent, thickness, and variability of the site-won silty clay resource to improve confidence in available volumes and recoverability.
  - A full-scale compaction trial to determine the feasibility of extracting, drying, conditioning, and placing this material to achieve the required liner performance. In addition, this may also assist in optimising the required moisture contents for liner placement.

These steps will support an informed decision on liner extent and implementation strategy prior to progressing to detailed design.

# 5 Applicability

This report has been prepared for the exclusive use of our client Napier City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

| | |
|---|---|
| Report prepared by: | Authorised for Tonkin & Taylor Ltd by: |
| ....................................................... | ....................................................... |
| Byron Munro<br>Water Resources Engineer | Josh Hodson<br>Project Director |

Attachments:

- Appendix A: Infiltration testing site report.
- Appendix B: Test pit logs.
- Appendix C: Laboratory testing results.

23-Apr-26
\\ttgroup.local\corporate\nelson\projects\1018914\1018914.6001 - lagoon farm stormwater\issueddocuments\20260305.bymu.lagoonfarmpc02report.fnl.docx

# Appendix A Infiltration testing site report

17 February 2026
Our Ref: 1102259.0000.0.0/Rep1
Customer Reference: 1018914.6001

Tonkin & Taylor Limited
PO BOX 5271
AUCKLAND 1141

Attention: Leon Pemberton

Dear Leon

# Lagoon Farm

# Site Report – Double Ring Infiltration Testing

## Customer's Instructions

We were instructed to complete:

Complete 18 Double Ring Infiltration tests (DRI).

## Specifications

None issued.

## Dates of Procedures

9th-13th February 2026

## Locations

Client identified the locations.

The attached plan provides indicative locations only and is not to scale. All other information we provide regarding location should be referenced to the asset owner.

Coordinates are provided in the Field Sheets.

a Method used to determine locations: Site plan\map
b Expected accuracy for location: +/-10 m
c Expected accuracy for elevation: +/-10 m

## Method

New Zealand Ground Investigation Specification Volume 1 – 12.10 Infiltration Test: Double Ring Infiltrometer test - ISBN: 978-1-98-851731-5 (online).

## Results

The following is attached:

- Double Ring Infiltration test results.
- Site photos can be accessed via hyperlink below. Valid until 6/6/2026.

https://transfer.tonkinandtaylorgroup.com/link/hYpFmLJyth3vCbrPs3zcds

## Test Remarks

Constant head in the inner ring was maintained using a Measuring cylinder.

Half of the DRI tests were conducted on stripped turf. Turf stripping was carried out manually using a shovel, with organic material removed to below the root zone.

## General Remarks

This report has been prepared for the benefit of Tonkin & Taylor Limited, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

The inherent uncertainties of site investigation work, mean the nature and continuity of subsoil away from the test location could vary from the data logged.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of the letterhead page.

GEOTECHNICS LTD

| | |
|---|---|
| Report approved by: | Authorised for Geotechnics by: |
| ...................................................... | ...................................................... |
| Liam Mullen | Alan Benton |
| Hamilton Manager | Project Director |

\\ttgroup.local\corporate\geotechnicsgroup\projects\1102259\workingmaterial\20260217 lagoon farm report - cleg.docx

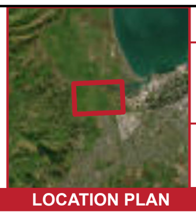
Customer Ref: 1018914.6001

Site Plan Generator Date: 17/02/2026 2:23 PM

**GEOTECHNICS**

NOTES:

CRS: NZGD 2000 New Zealand Transverse Mercator Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., Earthstar Geographics, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors



LOCATION PLAN

| | | |
|---|---|---|
| PROJECT No. | 1102259.0000 | |
| DESIGNED | LIMU | FEB.26 |
| DRAWN | -WEB- | FEB.26 |
| CHECKED | | |
| APPROVED | | DATE |

CLIENT **T+T**

PROJECT **LAGOON FARM DRI TESTING**

TITLE DOUBLE RING INFILTRATION TESTING

SCALE (A3) 1:6,459 FIG No. FIGURE 1. REV 0

GEOTECHNICS

1 Hill Street
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Auckland

p. +64 9 356 3510

Page 1 of 1

| | |
|---|---|
| Work Order ID | #N/A |

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 1 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.50 | 0.002 | 0.024 |
| 10 | 0.70 | 0.002 | 0.033 |
| 15 | 0.80 | 0.003 | 0.038 |
| 20 | 0.65 | 0.002 | 0.031 |
| 25 | 0.70 | 0.002 | 0.033 |
| 30 | 0.70 | 0.002 | 0.033 |
| 35 | 0.70 | 0.002 | 0.033 |
| 40 | 0.65 | 0.002 | 0.031 |
| 45 | 0.65 | 0.002 | 0.031 |
| 50 | 0.65 | 0.002 | 0.031 |
| 55 | 0.65 | 0.002 | 0.031 |
| 60 | 0.60 | 0.002 | 0.028 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

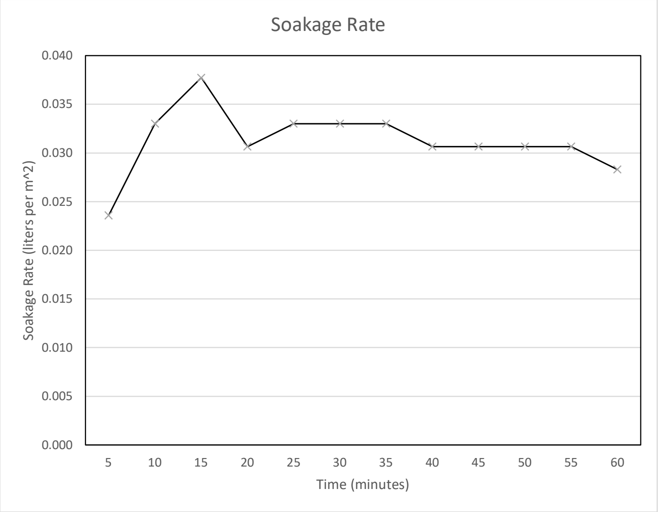
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | |
|---|---|---|---|---|
| Tested by | CLEG | Date | 11/02/2026 | **Notes** |
| Data Entry by | CLEG | Date | 17/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | Ground hard and dry. Weather warm overcast, light breeze. |
| Approved by | WIRO | Date | 17/02/2026 | |

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Page 1 of 1

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|---|---|
| Work Order ID | #N/A |

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 2 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.65 | 0.002 | 0.031 |
| 10 | 0.40 | 0.001 | 0.019 |
| 20 | 0.75 | 0.001 | 0.018 |
| 30 | 0.60 | 0.001 | 0.014 |
| 40 | 0.60 | 0.001 | 0.014 |
| 50 | 0.60 | 0.001 | 0.014 |
| 60 | 0.60 | 0.001 | 0.014 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

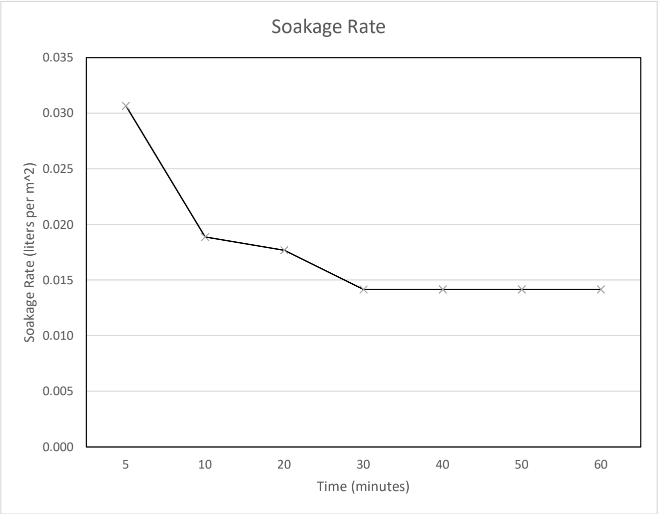
Water Levels Recorded at 30mins or less
Test continued for 4 hours or no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | CLEG | Date | 12/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Stripped turf. Ground soft, dry and sandy. Weather hot and sunny with moderate breeze.

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Work Order ID: #N/A

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 3 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.00 | 0.003 | 0.047 |
| 10 | 0.95 | 0.003 | 0.045 |
| 15 | 0.50 | 0.002 | 0.024 |
| 25 | 0.50 | 0.001 | 0.012 |
| 35 | 0.40 | 0.001 | 0.009 |
| 45 | 0.35 | 0.001 | 0.008 |
| 55 | 0.35 | 0.001 | 0.008 |
| 65 | 0.35 | 0.001 | 0.008 |

**Procedure**

Inner Ring kept full for 1 Hours

Water Levels Recorded at 30mins or less

Test continued for 4 hours or no drop in water level

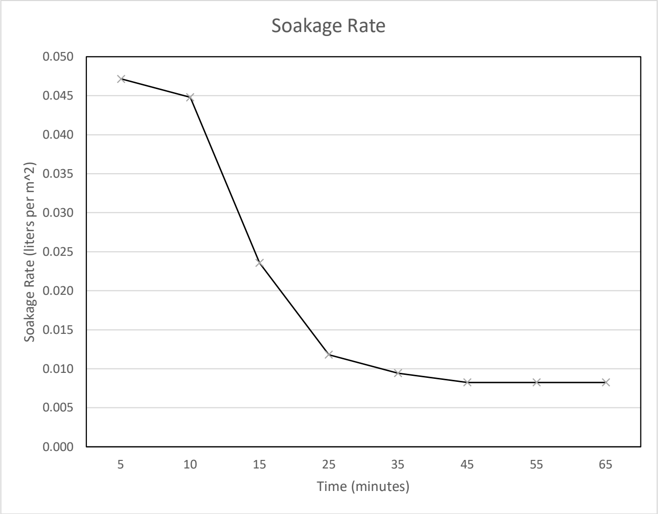
**Test Details**

Diameter of inner ring = D 0.3 m

Area of inner ring 0.071 m^2

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | |
|---|---|---|---|---|
| Tested by | MKAY | Date | 13/02/2026 | **Notes** |
| Data Entry by | CLEG | Date | 17/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | Ground soft, dry and sandy. Weather warm and overcast. |
| Approved by | WIRO | Date | 17/02/2026 | |

GEOTECHNICS

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Auckland

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Work Order ID
#N/A

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 4 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.60 | 0.005 | 0.075 |
| 10 | 1.25 | 0.004 | 0.059 |
| 15 | 1.20 | 0.004 | 0.057 |
| 20 | 1.10 | 0.004 | 0.052 |
| 25 | 1.00 | 0.003 | 0.047 |
| 30 | 1.00 | 0.003 | 0.047 |
| 35 | 1.00 | 0.003 | 0.047 |
| 40 | 1.00 | 0.003 | 0.047 |
| 45 | 0.95 | 0.003 | 0.045 |
| 50 | 1.00 | 0.003 | 0.047 |
| 55 | 1.00 | 0.003 | 0.047 |
| 60 | 1.00 | 0.003 | 0.047 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

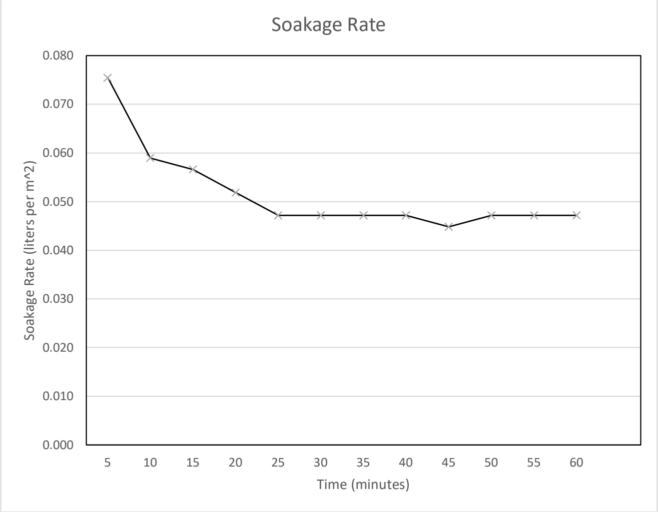
Water Levels Recorded at 30mins or less
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | Notes |
|---|---|---|---|---|
| Tested by | MKAY/CLEG | Date | 13/02/2026 | Ground soft, dry and sandy. Weather warm, overcast with a light breeze. |
| Data Entry by | CLEG | Date | 17/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | |
| Approved by | WIRO | Date | 17/02/2026 | |

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| | |
|---|---|
| Work Order ID | #N/A |

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 5 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.45 | 0.002 | 0.021 |
| 15 | 1.10 | 0.002 | 0.026 |
| 25 | 1.00 | 0.002 | 0.024 |
| 35 | 1.00 | 0.002 | 0.024 |
| 45 | 1.05 | 0.002 | 0.025 |
| 55 | 1.05 | 0.002 | 0.025 |
| 65 | 1.05 | 0.002 | 0.025 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

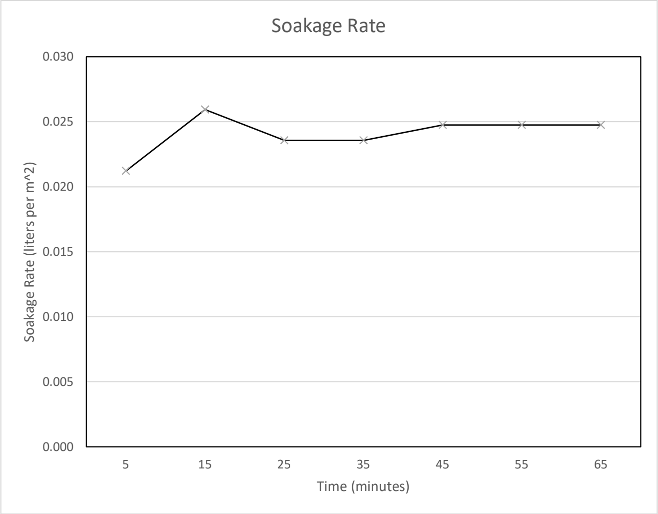
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | MKAY | Date | 13/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Stripped turf. Ground soft, dry and sandy. Weather warm and overcast. Light drizzle, rings covered during this period.

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 6 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.90 | 0.003 | 0.042 |
| 10 | 1.00 | 0.003 | 0.047 |
| 15 | 1.10 | 0.004 | 0.052 |
| 20 | 1.10 | 0.004 | 0.052 |
| 25 | 1.20 | 0.004 | 0.057 |
| 30 | 1.30 | 0.004 | 0.061 |
| 35 | 1.30 | 0.004 | 0.061 |
| 40 | 1.25 | 0.004 | 0.059 |
| 45 | 1.25 | 0.004 | 0.059 |
| 50 | 1.30 | 0.004 | 0.061 |
| 55 | 1.30 | 0.004 | 0.061 |
| 60 | 1.30 | 0.004 | 0.061 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

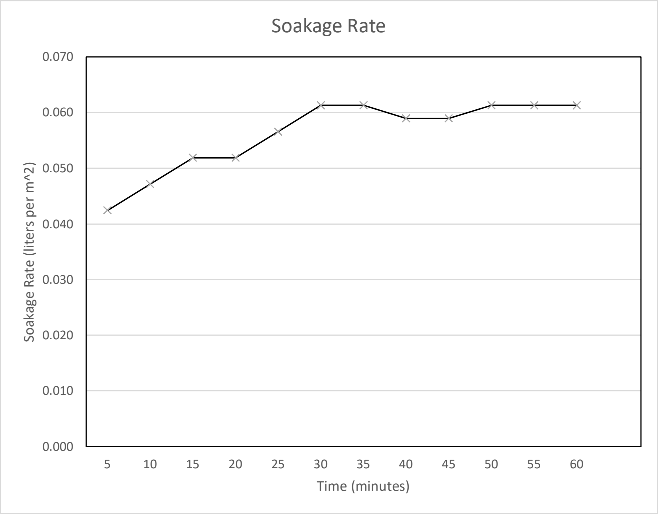
Test continued for 4 hours or no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | MKAY/CLEG | Date | 13/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Ground soft, dry and sandy. Weather warm, overcast. Light shower during test, rings covered during this period.

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 7 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.90 | 0.003 | 0.042 |
| 10 | 0.75 | 0.003 | 0.035 |
| 15 | 0.75 | 0.003 | 0.035 |
| 20 | 0.75 | 0.003 | 0.035 |
| 25 | 0.75 | 0.003 | 0.035 |
| 30 | 0.75 | 0.003 | 0.035 |
| 35 | 0.75 | 0.003 | 0.035 |
| 40 | 0.75 | 0.003 | 0.035 |
| 45 | 0.75 | 0.003 | 0.035 |
| 50 | 0.75 | 0.003 | 0.035 |
| 55 | 0.75 | 0.003 | 0.035 |
| 60 | 0.75 | 0.003 | 0.035 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

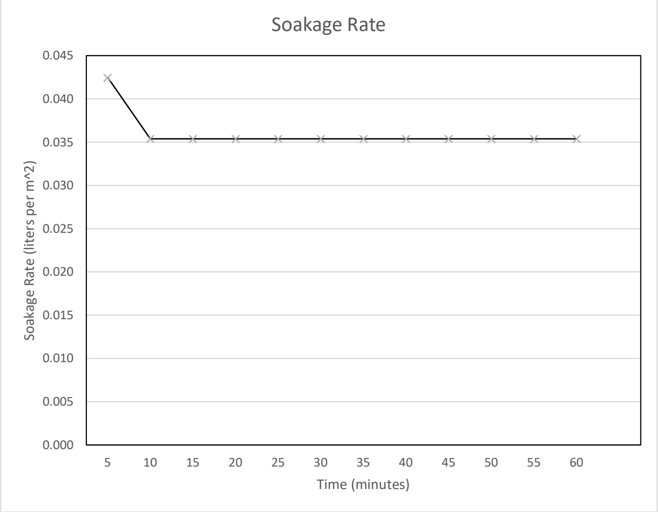
Water Levels Recorded at 30mins or less
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | |
|---|---|---|---|---|
| Tested by | CLEG | Date | 10/02/2026 | **Notes** |
| Data Entry by | CLEG | Date | 16/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | Ground hard and dry. Weather warm and sunny. Stripped turf |
| Approved by | WIRO | Date | 17/02/2026 | |

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 8 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.450 | 0.002 | 0.021 |
| 10 | 0.400 | 0.001 | 0.019 |
| 15 | 0.300 | 0.001 | 0.014 |
| 20 | 0.300 | 0.001 | 0.014 |
| 25 | 0.250 | 0.001 | 0.012 |
| 30 | 0.250 | 0.001 | 0.012 |
| 35 | 0.200 | 0.001 | 0.009 |
| 40 | 0.200 | 0.001 | 0.009 |
| 45 | 0.200 | 0.001 | 0.009 |
| 50 | 0.200 | 0.001 | 0.009 |
| 55 | 0.200 | 0.001 | 0.009 |
| 60 | 0.200 | 0.001 | 0.009 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

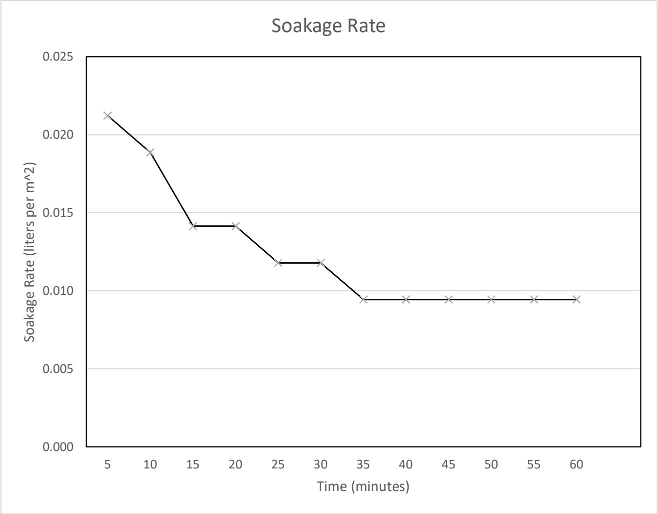
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | CLEG | Date | 10/02/2026 |
| Data Entry by | CLEG | Date | 16/02/2026 |
| Checked by | LIMU | Date | 16/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Stripped turf. Ground hard and dry. Weather warm and sunny.

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 9 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.80 | 0.006 | 0.085 |
| 10 | 1.50 | 0.005 | 0.071 |
| 15 | 1.30 | 0.004 | 0.061 |
| 20 | 1.35 | 0.005 | 0.064 |
| 25 | 1.20 | 0.004 | 0.057 |
| 30 | 1.20 | 0.004 | 0.057 |
| 35 | 1.15 | 0.004 | 0.054 |
| 40 | 1.20 | 0.004 | 0.057 |
| 45 | 1.20 | 0.004 | 0.057 |
| 50 | 1.25 | 0.004 | 0.059 |
| 55 | 1.25 | 0.004 | 0.059 |
| 60 | 1.25 | 0.004 | 0.059 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

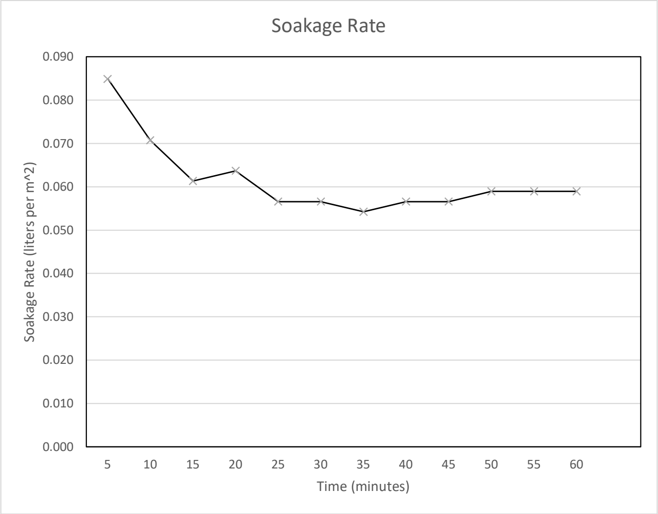
Water Levels Recorded at 30mins or less
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | Notes |
|---|---|---|---|---|
| Tested by | CLEG | Date | 10/02/2026 | |
| Data Entry by | CLEG | Date | 16/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | Ground hard and dry. Weather warm and sunny. |
| Approved by | WIRO | Date | 17/02/2026 | |

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**Soakage using Double Ring Infiltrometer**

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 10 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.50 | 0.005 | 0.071 |
| 10 | 1.35 | 0.005 | 0.064 |
| 15 | 1.55 | 0.005 | 0.073 |
| 20 | 1.50 | 0.005 | 0.071 |
| 25 | 1.50 | 0.005 | 0.071 |
| 30 | 1.50 | 0.005 | 0.071 |
| 35 | 1.50 | 0.005 | 0.071 |
| 40 | 1.50 | 0.005 | 0.071 |
| 45 | 1.50 | 0.005 | 0.071 |
| 50 | 1.50 | 0.005 | 0.071 |
| 55 | 1.50 | 0.005 | 0.071 |
| 60 | 1.50 | 0.005 | 0.071 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

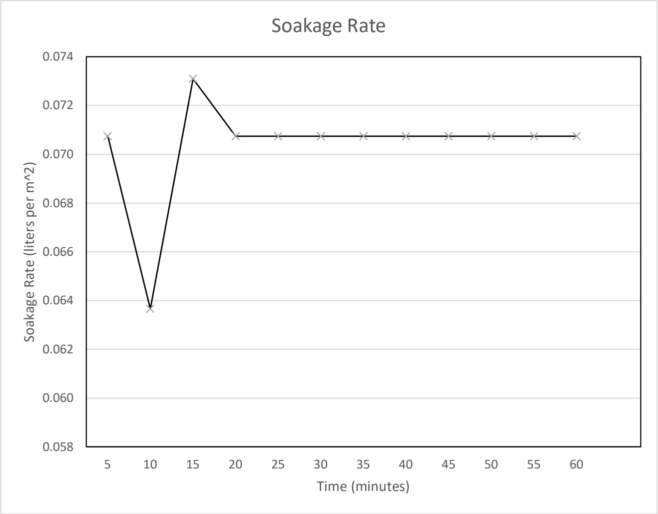
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | |
|---|---|---|---|---|
| Tested by | CLEG | Date | 11/02/2026 | **Notes** |
| Data Entry by | CLEG | Date | 17/02/2026 | Ground hard and dry. Weather warm overcast, moderate breeze. Light shower during test, rings covered druing this period. |
| Checked by | LIMU | Date | 17/02/2026 | |
| Approved by | WIRO | Date | 17/02/2026 | |

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 11 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.20 | 0.001 | 0.009 |
| 10 | 0.15 | 0.001 | 0.007 |
| 20 | 0.10 | 0.000 | 0.002 |
| 30 | 0.10 | 0.000 | 0.002 |
| 40 | 0.10 | 0.000 | 0.002 |
| 50 | 0.10 | 0.000 | 0.002 |
| 60 | 0.10 | 0.000 | 0.002 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

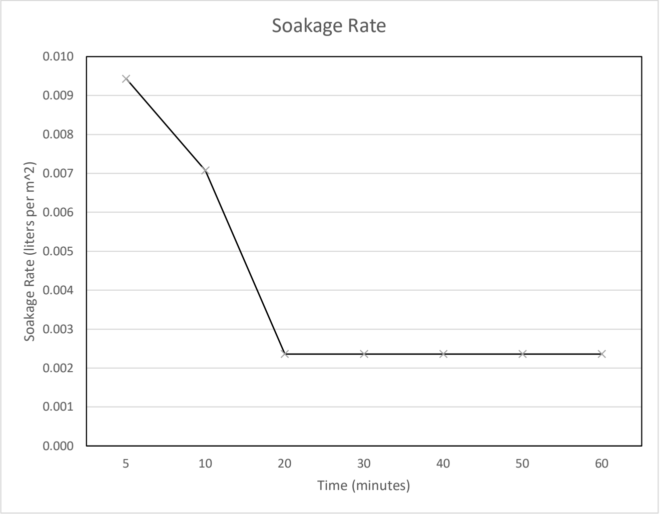
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | Notes |
|---|---|---|---|---|
| Tested by | CLEG | Date | 11/02/2026 | Stripped turf. Ground hard, dry and clayey. Weather warm overcast, light breeze. |
| Data Entry by | CLEG | Date | 17/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | |
| Approved by | WIRO | Date | 17/02/2026 | |

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 12 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.90 | 0.003 | 0.042 |
| 10 | 0.75 | 0.003 | 0.035 |
| 15 | 0.75 | 0.003 | 0.035 |
| 20 | 0.60 | 0.002 | 0.028 |
| 25 | 0.50 | 0.002 | 0.024 |
| 30 | 0.50 | 0.002 | 0.024 |
| 35 | 0.40 | 0.001 | 0.019 |
| 40 | 0.35 | 0.001 | 0.017 |
| 45 | 0.30 | 0.001 | 0.014 |
| 50 | 0.30 | 0.001 | 0.014 |
| 55 | 0.30 | 0.001 | 0.014 |
| 60 | 0.30 | 0.001 | 0.014 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

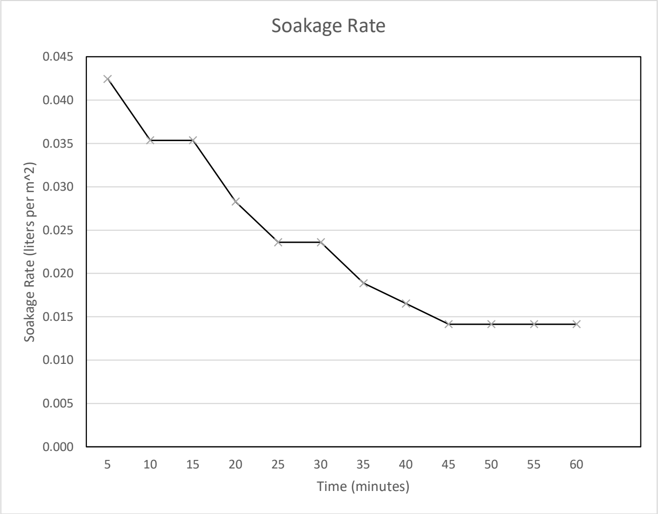
Test continued for 4 hours or no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | Notes |
|---|---|---|---|---|
| Tested by | CLEG | Date | 11/02/2026 | |
| Data Entry by | CLEG | Date | 17/02/2026 | |
| Checked by | LIMU | Date | 17/02/2026 | Ground hard, dry and clayey. Weather hot sunny, light breeze. |
| Approved by | WIRO | Date | 17/02/2026 | |

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**Soakage using Double Ring Infiltrometer**

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 13 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.80 | 0.006 | 0.085 |
| 10 | 1.90 | 0.006 | 0.090 |
| 15 | 1.85 | 0.006 | 0.087 |
| 20 | 1.80 | 0.006 | 0.085 |
| 25 | 1.50 | 0.005 | 0.071 |
| 30 | 1.50 | 0.005 | 0.071 |
| 35 | 1.50 | 0.005 | 0.071 |
| 40 | 1.50 | 0.005 | 0.071 |
| 45 | 1.50 | 0.005 | 0.071 |
| 50 | 1.50 | 0.005 | 0.071 |
| 55 | 1.50 | 0.005 | 0.071 |
| 60 | 1.50 | 0.005 | 0.071 |

**Procedure**

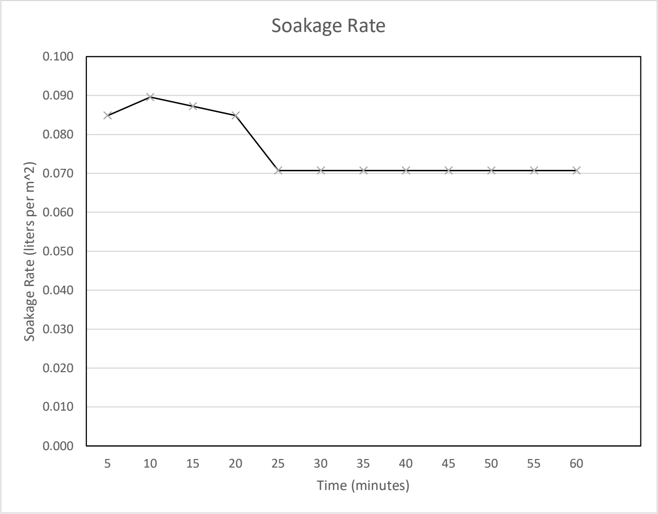
| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |
| Water Levels Recorded at 30mins or less | | |
| Test continued for 4 hours or no drop in water level | | |

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | |
|---|---|---|---|---|
| Tested by | CLEG | Date | 11/02/2026 | **Notes** |
| Data Entry by | CLEG | Date | 17/02/2026 | Stripped turf. Ground soft and dry. Weather hot sunny, light breeze. |
| Checked by | LIMU | Date | 17/02/2026 | |
| Approved by | WIRO | Date | 17/02/2026 | |

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 14 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.65 | 0.006 | 0.078 |
| 10 | 1.30 | 0.004 | 0.061 |
| 15 | 1.15 | 0.004 | 0.054 |
| 20 | 1.20 | 0.004 | 0.057 |
| 25 | 1.20 | 0.004 | 0.057 |
| 30 | 1.25 | 0.004 | 0.059 |
| 35 | 1.25 | 0.004 | 0.059 |
| 40 | 1.30 | 0.004 | 0.061 |
| 45 | 1.25 | 0.004 | 0.059 |
| 50 | 1.25 | 0.004 | 0.059 |
| 55 | 1.20 | 0.004 | 0.057 |
| 60 | 1.20 | 0.004 | 0.057 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

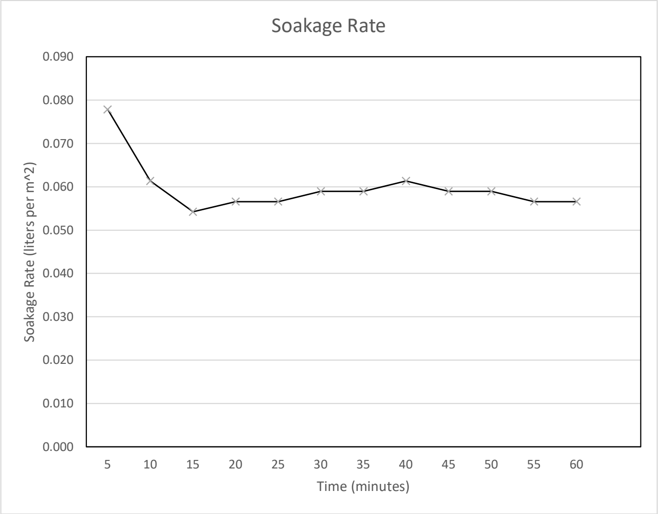
Water Levels Recorded at 30mins or less
Test continued for 4 hours or no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | | |
|---|---|---|---|---|
| Tested by | CLEG | Date | 11/02/2026 | **Notes** |
| Data Entry by | CLEG | Date | 17/02/2026 | Ground hard and dry. Weather hot, sunny, moderate breeze. |
| Checked by | LIMU | Date | 17/02/2026 | |
| Approved by | WIRO | Date | 17/02/2026 | |

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## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 15 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 0.90 | 0.003 | 0.042 |
| 10 | 0.70 | 0.002 | 0.033 |
| 15 | 1.20 | 0.004 | 0.057 |
| 20 | 1.30 | 0.004 | 0.061 |
| 25 | 1.35 | 0.005 | 0.064 |
| 30 | 1.35 | 0.005 | 0.064 |
| 35 | 1.40 | 0.005 | 0.066 |
| 40 | 1.40 | 0.005 | 0.066 |
| 45 | 1.40 | 0.005 | 0.066 |
| 50 | 1.40 | 0.005 | 0.066 |
| 55 | 1.40 | 0.005 | 0.066 |
| 60 | 1.40 | 0.005 | 0.066 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

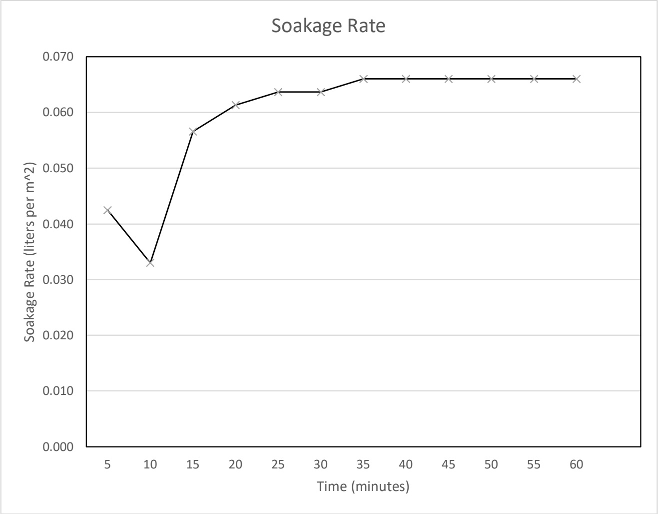
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | CLEG | Date | 12/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Stripped turf. Ground firm and dry. Weather sunny, warm with a light breeze.

GEOTECHNICS

1 Hill Street
Onehunga
Auckland

p. +64 9 356 3510

Page 1 of 1

Work Order ID
#N/A

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 16 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

### Test method used: Double Ring Infiltrometer

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 2.10 | 0.007 | 0.099 |
| 10 | 2.00 | 0.007 | 0.094 |
| 15 | 2.00 | 0.007 | 0.094 |
| 20 | 1.80 | 0.006 | 0.085 |
| 25 | 1.45 | 0.005 | 0.068 |
| 30 | 1.35 | 0.005 | 0.064 |
| 35 | 1.25 | 0.004 | 0.059 |
| 40 | 1.20 | 0.004 | 0.057 |
| 45 | 1.25 | 0.004 | 0.059 |
| 50 | 1.20 | 0.004 | 0.057 |
| 55 | 1.30 | 0.004 | 0.061 |
| 60 | 1.30 | 0.004 | 0.061 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

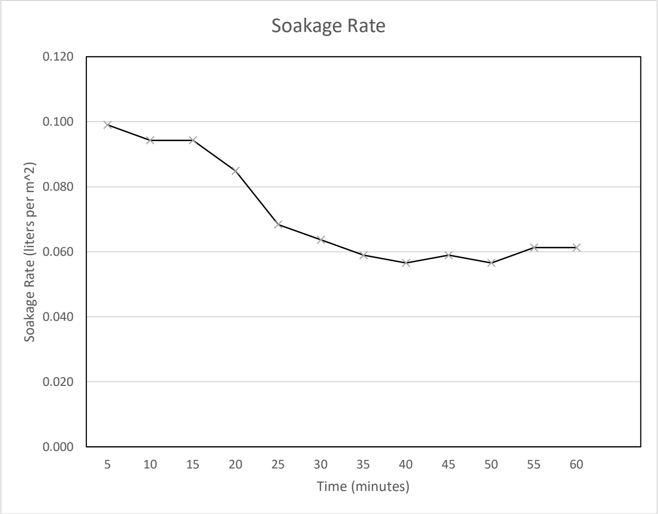
Test continued for 4 hours or no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | CLEG/MKAY | Date | 12/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Ground firm and dry. Weather sunny, warm with a light breeze.

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Auckland

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Page 1 of 1

Work Order ID
#N/A

**Soakage using Double Ring Infiltrometer**

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 17 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| **Time (mins)** | **Water Added (L)** | **Soakage Rate (L/s)** | **Soakage Rate per m^2 (L/s)** |
|---|---|---|---|
| 5 | 2.10 | 0.007 | 0.099 |
| 10 | 1.95 | 0.007 | 0.092 |
| 15 | 2.00 | 0.007 | 0.094 |
| 20 | 1.70 | 0.006 | 0.080 |
| 25 | 1.40 | 0.005 | 0.066 |
| 30 | 1.25 | 0.004 | 0.059 |
| 35 | 1.30 | 0.004 | 0.061 |
| 40 | 1.30 | 0.004 | 0.061 |
| 45 | 1.35 | 0.005 | 0.064 |
| 50 | 1.40 | 0.005 | 0.066 |
| 55 | 1.40 | 0.005 | 0.066 |
| 60 | 1.40 | 0.005 | 0.066 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

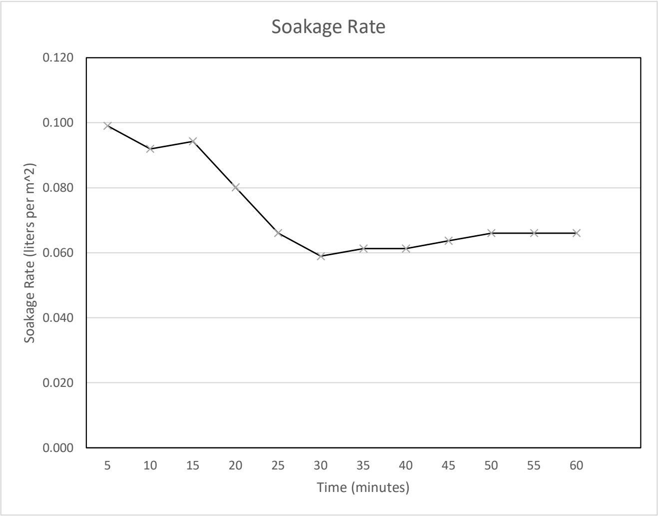
Water Levels Recorded at 30mins or less
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | CLEG/MKAY | Date | 12/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Stripped turf. Ground soft, dry and sandy. Weather sunny, warm with a light breeze.

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Page 1 of 1

Work Order ID
#N/A

## Soakage using Double Ring Infiltrometer

| | | | |
|---|---|---|---|
| Project Name | Lagoon Farm DRI | Project ID | 1102259.0000 |
| Client Project ID | 1018914.6001 | BH No | Test 18 |
| Site Location | Lagoon Farm, 401 Prebensen Drive, Hawkes Bay | | |

**Test method used: Double Ring Infiltrometer**

| Time (mins) | Water Added (L) | Soakage Rate (L/s) | Soakage Rate per m^2 (L/s) |
|---|---|---|---|
| 5 | 1.70 | 0.006 | 0.080 |
| 10 | 1.70 | 0.006 | 0.080 |
| 15 | 1.60 | 0.005 | 0.075 |
| 20 | 1.55 | 0.005 | 0.073 |
| 25 | 1.65 | 0.006 | 0.078 |
| 30 | 1.70 | 0.006 | 0.080 |
| 35 | 1.65 | 0.006 | 0.078 |
| 40 | 1.75 | 0.006 | 0.083 |
| 45 | 1.70 | 0.006 | 0.080 |
| 50 | 1.70 | 0.006 | 0.080 |
| 55 | 1.70 | 0.006 | 0.080 |
| 60 | 1.70 | 0.006 | 0.080 |

**Procedure**

| | | |
|---|---|---|
| Inner Ring kept full for | 1 | Hours |

Water Levels Recorded at 30mins or less

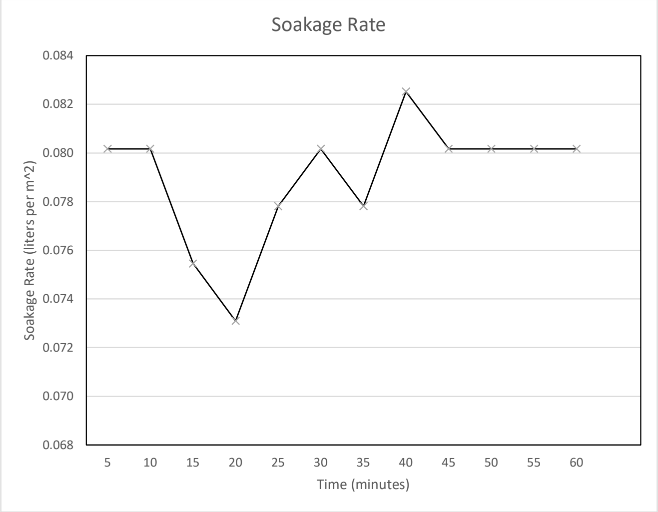
Test continued for 4 hours or  no drop in water level

**Test Details**

| | | |
|---|---|---|
| Diameter of inner ring = D | 0.3 | m |
| Area of inner ring | 0.071 | m^2 |

**Constant Head Methodology**

Water level maintained with measuring cylinder.



| | | | |
|---|---|---|---|
| Tested by | CLEG | Date | 12/02/2026 |
| Data Entry by | CLEG | Date | 17/02/2026 |
| Checked by | LIMU | Date | 17/02/2026 |
| Approved by | WIRO | Date | 17/02/2026 |

**Notes**

Stripped turf. Ground soft, dry and sandy. Weather hot and sunny with moderate breeze.

# Appendix B Test pit logs

**Legend:**

🟥 Test Pit

**GEOTECHNICS LTD.**
92 Old Ford Road, Onekawa, Napier,
New Zealand.
ph. +64 (0)9 356 3510

e. enquiry@geotechnics.co.nz

w. www.geotechnics.co.nz

GEOTECHNICS

## Location Plan

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site: | Lagoon Farm Stormwater | Job Name: | Lagoon Farm Stormwater | Drawn: | MKAY | Date: | 10/02/ |
| | | Job No.: | 1018914.6001 | Tested: | MKAY | Date: | 26/01/ |
| | | Test pit No.: | TP101 – TP108 | Scale: | Not to Scale | Rev.: | 1 |

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP101**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

PROJECT: Lagoon Farm Stormwater
LOCATION: Lagoon Farm Napier
JOB No.: 1018914.6001

| | | | | | |
|---|---|---|---|---|---|
| CO-ORDINATES: (NZTM2000) | 5622271 mN<br>1930950 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | -1m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS — ENGINEERING DESCRIPTION — GEOLOGICAL

| PENETRATION (1 2 3) | SUPPORT | WATER | SAMPLES, TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | WEATHERING CLASSIFICATION | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) (VS 12 S 25 F 50 St 100 VSt 200 H) | DEFECTS, STRUCTURE, COMMENTS | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.00 | TS | *0.00m:* SILT, minor sand, trace organics; brown. Firm, moist, non-plastic; sand, fine; rootlets and peat. | | M | F | | | |
| | | | | | | 0.10 | | *0.10m:* SILT, minor gravel, trace sand; brown. Firm, moist, low plasticity; gravel, fine to coarse, sub-rounded to sub-angular, shells; sand, fine. | | | | | | |
| | | | | | -1 | 0.5 | | | | | | | | |
| | | | | | | 0.70 | | *0.70m:* Silty CLAY; greyish brown mottled orange. Stiff, wet, high plasticity. | | W | St | | | |
| | | 26/01/2026 ▼ | | | | 1.0 | | *1.10 - 1.50m:* Saturated. | | S | | | | |
| | | | | | -2 | 1.5 | | 1.5m: Target depth | | | | | | |

SKETCH / PHOTO:

0.0 - 1.5m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth** 1.5m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:11 am - Produced with Core-GS by GeRoc

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP102**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: Lagoon Farm Stormwater | | LOCATION: Lagoon Farm Napier | | JOB No.: 1018914.6001 | |
| CO-ORDINATES: (NZTM2000) | 5621933 mN<br>1930997 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | -1m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS | ENGINEERING DESCRIPTION | GEOLOGICAL

| PENETRATION 1 2 3 | SUPPORT | WATER | SAMPLES, TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | WEATHERING CLASSIFICATION | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) VS 12 S 25 F 50 St 100 VSt 200 H | DEFECTS, STRUCTURE, COMMENTS | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TS | *0.00m:* SILT, trace organics and trace sand; brown. Firm, moist, non-plastic; rootlets and peat; sand, fine. | | M | F | | | |
| | | | | | | | | *0.10m:* SILT, minor gravel, trace rootlets; brown. Firm, moist, non-plastic; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | | | | | |
| | | | | | -1 | 0.5 | | *0.50m:* Silty CLAY; greyish brown mottled orange. Stiff, wet, high plasticity. | | W | St | | | |
| | | | | | | 1.0 | | | | | | | | |
| | | 26/01/2026 ▼ | | | | | | *1.10 - 1.50m:* Saturated. | | S | | | | |
| | | | | | | | | *1.20 - 1.50m:* Mottled light blue. | | | | | | |
| | | | | | -2 | 1.5 | | 1.5m: Target depth | | | | | | |

SKETCH / PHOTO:

0.0 - 1.5m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth**
1.5m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:19 am - Produced with Core-GS by GeRoc

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP103**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lagoon Farm Stormwater | LOCATION: | Lagoon Farm Napier | JOB No.: | 1018914.6001 |
| CO-ORDINATES: (NZTM2000) | 5621383 mN<br>1930912 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | 0m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS | ENGINEERING DESCRIPTION | GEOLOGICAL

| PENETRATION 1 2 3 | SUPPORT | WATER | SAMPLES, TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | WEATHERING CLASSIFICATION | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) VS 12 S 25 F 50 St 100 VSt 200 H | DEFECTS, STRUCTURE, COMMENTS | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TS | *0.00m:* SILT, minor sand, trace organics; brown. Firm, moist, non-plastic; sand, fine; roolets and peat. | | M | F | | | |
| | | | | | 0 | 0.5 | | *0.10m:* SILT, minor sand, trace gravel; brown. Firm, moist, low plasticity; sand, fine; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | | | | | |
| | | 26/01/2026 very slow inflow ▼ | | | | | | *0.70m:* Highly weathered, silty sandy LIMESTONE. Weak. . Recovered as: sandy GRAVEL, minor silt and minor cobbles, trace boulders; light brown mottled orange and yellow, moist. Digger scraping and pulling out cobbles and boulders. | HW | | W | | | |
| | | | | | | 1.0 | | 0.8m: Target depth | | | | | | |
| | | | | | -1 | 1.5 | | | | | | | | |

SKETCH / PHOTO:

0.0 - 0.8m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth**
0.8m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:23 am - Produced with Core-GS by GeRoc

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP104**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

PROJECT: Lagoon Farm Stormwater
LOCATION: Lagoon Farm Napier
JOB No.: 1018914.6001

| | | | | | |
|---|---|---|---|---|---|
| CO-ORDINATES: (NZTM2000) | 5621353 mN<br>1931276 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | -0m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS — ENGINEERING DESCRIPTION — GEOLOGICAL

| PENETRATION 1 2 3 | SUPPORT | WATER | SAMPLES, TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | WEATHERING CLASSIFICATION | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) VS 12 S 25 F 50 St 100 VSt 200 H | DEFECTS, STRUCTURE, COMMENTS | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TS | *0.00m:* SILT, minor sand, trace rootlets; brown. Firm, moist, non-plastic; sand, fine. | | M | F | | | |
| | | | | | -1 | 0.5 | | *0.20m:* SILT, minor clay, trace rootlets; greyish brown. Firm, moist, low plasticity. | | | | | | |
| | | | | | | 1.0 | | *1.00m:* SILT, minor sand, trace rootlets and trace gravel; greyish brown. Firm, moist, non-plastic; sand, fine to medium; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | | | | | |
| | | DRY<br>26/01/2026 | B1 @ 1.20m | | | 1.5 | | *1.20m:* Silty fine to medium SAND; greyish brown mottled orange and blue. Tightly packed, moist, poorly graded. | | | TP | | | |
| | | | | | -2 | | | 1.5m: Target depth | | | | | | |

SKETCH / PHOTO:

0.0 - 1.5m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth**
1.5m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:27 am - Produced with Core-GS by GeRoc
V4.0.04

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP105**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lagoon Farm Stormwater | LOCATION: | Lagoon Farm Napier | JOB No.: | 1018914.6001 |
| CO-ORDINATES: (NZTM2000) | 5620982 mN<br>1931283 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | 0m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS — ENGINEERING DESCRIPTION — GEOLOGICAL

| DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | WATER |
|---|---|---|---|---|---|
| 0.00 | TS | *0.00m:* SILT, minor sand, trace rootlets; brown. Firm, moist, non-plastic; sand, fine. | M | F | |
| 0.20 | | *0.20m:* SILT, minor clay, trace rootlets and trace gravel; greyish brown. Firm, moist, low plasticity; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | | |
| 0.80 | | *0.80m:* SILT, some gravel; greyish brown. Stiff, moist, non-plastic; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | St | |
| 1.00 | | *1.00m:* Fine to coarse SAND, some silt, trace gravel; greyish brown mottled orange and blue. Tightly packed, wet, well graded; gravel, fine to coarse, sub-rounded to sub-angular, shells.<br>*1.20 - 1.50m:* Saturated. | W<br>S | TP | ▼ 26/01/2026 |
| 1.5 | | 1.5m: Target depth | | | |

SKETCH / PHOTO:

0.0 - 1.5m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth** 1.5m

Scale 1:25

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:31 am - Produced with Core-GS by GeRoc

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP106**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

PROJECT: Lagoon Farm Stormwater
LOCATION: Lagoon Farm Napier
JOB No.: 1018914.6001

| | | | | | |
|---|---|---|---|---|---|
| CO-ORDINATES: (NZTM2000) | 5621326 mN<br>1931758 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | -0m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS — ENGINEERING DESCRIPTION — GEOLOGICAL

| PENETRATION (1 2 3) | SUPPORT | WATER | SAMPLES, TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | WEATHERING CLASSIFICATION | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) (VS 12 S 25 F 50 St 100 VSt 200 H) | DEFECTS, STRUCTURE, COMMENTS | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TS | *0.00m:* SILT, minor sand, trace organics; brown. Firm, moist, non-plastic; sand, fine; rootlets and peat. | | M | F | | | |
| | | | | | | | | *0.20m:* SILT, minor sand and minor gravel; greyish brown. Firm, moist, low plasticity; sand, fine; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | | | | | |
| | | | | | | 0.5 | | | | | | | | |
| | | | | | -1 | | | | | | | | | |
| | | | | | | | | *0.80m:* Silty CLAY, trace gravel; greyish brown mottled orange and blue. Stiff, wet, high plasticity; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | W | St | | | |
| | | | B1 @ 1.00m | | | 1.0 | | | | | | | | |
| | | 26/01/2026 | | | | | | *1.20 - 1.60m:* Saturated. | | S | | | | |
| | | | | | | 1.5 | | | | | | | | |
| | | | | | -2 | | | 1.6m: Target depth | | | | | | |

SKETCH / PHOTO:

0.0 - 1.6m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth**
1.6m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:35 am - Produced with Core-GS by GeRoc

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP107**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

PROJECT: Lagoon Farm Stormwater
LOCATION: Lagoon Farm Napier
JOB No.: 1018914.6001

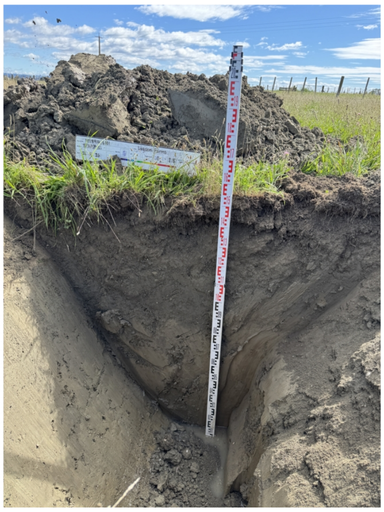
| | | | | | |
|---|---|---|---|---|---|
| CO-ORDINATES: (NZTM2000) | 5621877 mN<br>1931635 mE | METHOD: | Trial pit/trench | EXCAV. STARTED: | 26/01/2026 |
| | | EQUIPMENT: | Excavator | EXCAV. FINISHED: | 26/01/2026 |
| R.L.: | -1m | OPERATOR: | Slick Civil Ltd | LOGGED BY: | MKAY |
| DATUM: | NZVD2016 | DIMENSIONS: | 3m by 2m | CHECKED BY: | HOMA |

EXCAVATION TESTS — ENGINEERING DESCRIPTION — GEOLOGICAL

| PENETRATION | SUPPORT | WATER | SAMPLES, TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | WEATHERING CLASSIFICATION | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION | ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) | DEFECTS, STRUCTURE, COMMENTS | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.00 | TS | *0.00m:* SILT, trace organics and trace sand; brown. Firm, moist, non-plastic; rootlets and peat; sand, fine. | | M | F | | | |
| | | | | | -1 | 0.10 | | *0.10m:* SILT, minor sand, trace rootlets and trace gravel; brown. Firm, moist, low plasticity; sand, fine; gravel, fine to coarse, sub-rounded to sub-angular, shells. | | | | | | |
| | | | | | | 0.70 | | *0.70m:* Silty CLAY; greyish brown mottled orange. Stiff, wet, high plasticity. | | W | St | | | |
| | | | B1 and B2 @ 1.00m | | | 1.0 | | | | | | | | |
| | | 26/01/2026 ▼ | | | | 1.20 | | *1.20 - 1.50m:* Saturated. | | S | | | | |
| | | | | | -2 | 1.40 | | *1.40 - 1.50m:* Mottled blue. | | | | | | |
| | | | | | | 1.5 | | 1.5m: Target depth | | | | | | |

Penetration scale: 1 2 3. Shear strength scale: VS S F St VSt H; 12 25 50 100 200.

SKETCH / PHOTO:



0.0 - 1.5m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth** 1.5m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:39 am - Produced with Core-GS by GeRoc

Tonkin+Taylor

# EXCAVATION LOG

Excavation Id.: **TP108**

**Hole Location:** Please refer to the Test Location Plans.

SHEET: 1 OF 1

PROJECT: Lagoon Farm Stormwater
LOCATION: Lagoon Farm Napier
JOB No.: 1018914.6001

CO-ORDINATES: (NZTM2000) 5622334 mN 1931487 mE
R.L.: -1m
DATUM: NZVD2016

METHOD: Trial pit/trench
EQUIPMENT: Excavator
OPERATOR: Slick Civil Ltd
DIMENSIONS: 3m by 2m

EXCAV. STARTED: 26/01/2026
EXCAV. FINISHED: 26/01/2026
LOGGED BY: MKAY
CHECKED BY: HOMA

EXCAVATION TESTS | ENGINEERING DESCRIPTION | GEOLOGICAL

| WATER | SAMPLES, TESTS | DEPTH (m) | SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS | MOISTURE CLASSIFICATION | CONSISTENCY / DENSITY CLASSIFICATION |
|---|---|---|---|---|---|
| | | 0.00 | *0.00m:* SILT, trace organics; brown. Firm, moist, non-plastic; rootlets and peat. | M | F |
| | | 0.10 | *0.10m:* SILT, minor sand; brown. Firm, moist, low plasticity; sand, fine. | | |
| | | 0.50 | *0.50m:* SILT, minor gravel, trace sand; brown. Firm, moist, non-plastic; gravel, fine to coarse, sub-rounded to sub-angular, shells; sand, fine. | | |
| | | 0.60 | *0.60m:* Silty CLAY; light greyish brown. Stiff, wet, high plasticity. | W | St |
| 26/01/2026 | | 0.90 | *0.90 - 1.50m:* Saturated. | S | |
| | B1 @ 1.00m | 1.0 | | | |
| | | 1.30 | *1.30 - 1.50m:* Bluish grey slight mottled orange. | | |
| | | 1.5 | 1.5m: Target depth | | |

RL (m): -1, -2

SKETCH / PHOTO:

0.0 - 1.5m:

COMMENTS: No Shear Vane conducted. Strength estimated using NZGS guidelines.

**Hole Depth**
1.5m

Scale 1:17

Rev.: A

TTNZ_20251211 - ExcavationLog - 23/02/2026 9:34:43 am - Produced with Core-GS by GeRoc

# Appendix C Laboratory testing results

GEOTECHNICS

20 March 2026
Our Ref: 1102362.0000.2.0/Rep1

Tonkin & Taylor Limited
PO BOX 5271
AUCKLAND 1141

Attention: Jia Hong

Dear Jia

## Lagoon Farm

## Laboratory Test Report

Samples from the above-mentioned site have been tested as received according to your instructions and the results are included in this report. Results apply only to the sample(s) tested.

Descriptions are enclosed for your information but are not covered under the IANZ endorsement of this report.

This report has been prepared for the benefit of Tonkin & Taylor Limited, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

This report may be reproduced only in full.

Samples not destroyed during testing will be retained for one month from the date of this report before being discarded. If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of this page.

Geotechnics Ltd
1 Hill Street, Onehunga, Auckland, 1061 | PO Box 13171, Onehunga, Auckland, 1643
+64-9-356 3510 | enquiry@geotechnics.co.nz | www.geotechnics.co.nz

GEOTECHNICS LTD

| Report approved by: | Authorised for Geotechnics by: |
|---|---|
| .................................................... | .................................................... |
| Fergus Goldie<br>Laboratory Technician<br>Key Technical Person | Charlotte Mellar<br>Project Director |

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

20-Mar-26

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GEOTECHNICS

1 Hill Street
Onehunga
Auckland 1061
New Zealand

p. +64 9 356 3510

**Geotechnics Project ID** 1102362.0000.2.0
**Customer Project ID**

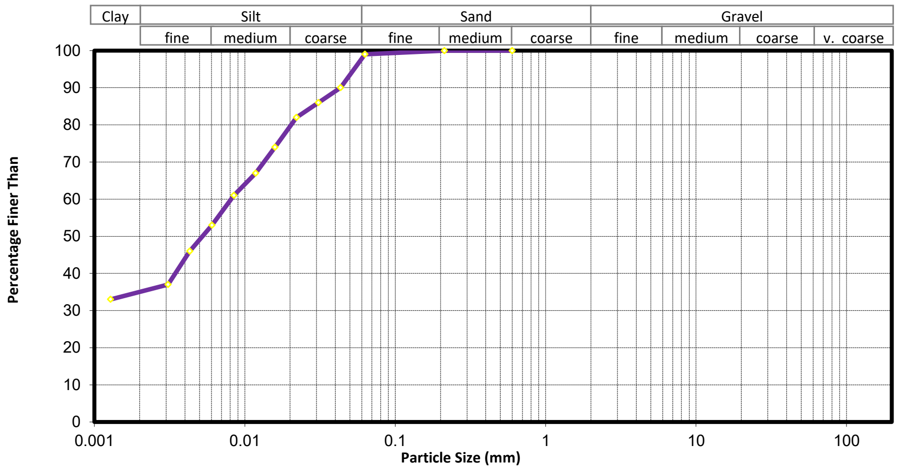
## Determination of the Particle Size Distribution - NZS 4402:1986 Test 2.8.4 (Hydrometer Method)

### TEST DETAILS

| | | | | |
|---|---|---|---|---|
| **LOCATION** | **ID** | TP107 | | |
| | **Description** | Lagoon Farm | | |
| | **Data** | N/A | | |
| **SAMPLE** | **Geotechnics ID** | AKL1328.01 | | |
| | **Reference** | - | **Depth** | 1.0-1.5 m |
| | **Description** | Clayey SILT; grey. Wet, very soft, high plasticity. | | |
| **SPECIMEN** | **Reference** | - | **Depth** | - |
| | **Description** | - | | |

### TEST RESULTS

**PARTICLE SIZE ANALYSIS**



| Sieve Size (mm) | Percentage Passing (%) | Sieve Size (mm) | Percentage Passing (%) | Sieve Size (mm) | Percentage Passing (%) |
|---|---|---|---|---|---|
| 150.0 | - | 16.0 | - | 0.600 | 100 |
| 100.0 | - | 13.2 | - | 0.425 | - |
| 75.0 | - | 9.50 | - | 0.300 | - |
| 63.0 | - | 6.70 | - | 0.212 | 100 |
| 53.0 | - | 4.75 | - | 0.150 | - |
| 37.5 | - | 3.35 | - | 0.090 | - |
| 26.5 | - | 2.00 | - | 0.075 | - |
| 19.0 | - | 1.18 | - | 0.063 | 99 |

| Equivalent Particle Diameter D (mm) | Percentage of Particles Finer than D (%) | Equivalent Particle Diameter D (mm) | Percentage of Particles Finer than D (%) |
|---|---|---|---|
| 0.0417 | 90 | 0.0033 | 37 |
| 0.0300 | 86 | 0.0014 | 33 |
| 0.0216 | 82 | | |
| 0.0158 | 74 | | |
| 0.0118 | 67 | | |
| 0.0085 | 61 | | |
| 0.0062 | 53 | | |
| 0.0045 | 46 | | |

### TEST REMARKS

• The material used for testing was natural, whole soil. • The percentage passing the <0.063 mm was obtained by difference. • An assumed solid density value of 2.75 t/m³ was used. We do not take responsibility for misrepresentation or misinterpretation arising from the use of this assumed value.

Date tested: 04/03/2026

This test result is IANZ accredited.

**Approved by KTP** **GEGO** **Date** **9/03/2026**

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1 Hill Street
Onehunga
Auckland 1061
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| | |
|---|---|
| **Geotechnics Project ID** | 1102362.0000.2.0 |
| **Customer Project ID** | |

# Determination of the Dry Density / Water Content Relationship - NZS 4402:1986 Test 4.1.1 (Standard Compaction)

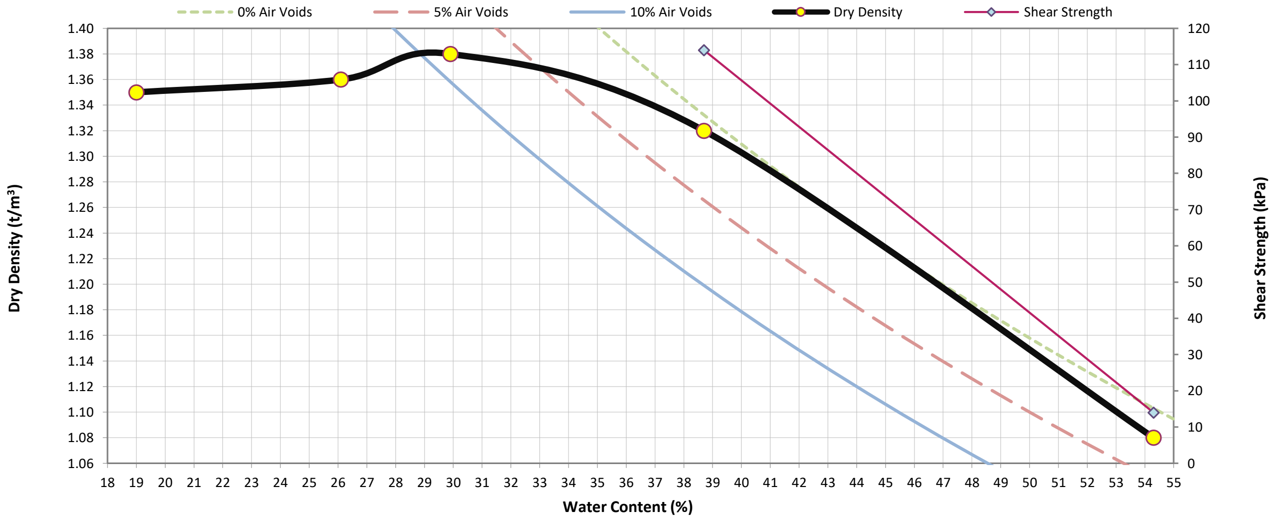
Vane Shear Strength of Cohesive Soil - NZGS Guideline for Hand Held Shear Vane Test - 2001

## TEST DETAILS

| | | | | |
|---|---|---|---|---|
| **LOCATION** | **ID** | TP107 | | |
| | **Description** | Lagoon Farm | | |
| | **Data** | N/A | | |
| **SAMPLE** | **Geotechnics ID** | AKL1328.1 | | |
| | **Reference** | - | **Depth** | 1-1.5 m |
| | **Description** | Clayey SILT; grey. Wet, very soft, high plasticity. | | |
| **SPECIMEN** | **Reference** | - | **Depth** | - |
| | **Description** | - | | |

## TEST RESULTS

### Dry Density / Water Content Relationship



| Maximum Dry Density | Optimum Water Content | Solid Density* | Whole Sample NWC |
|---|---|---|---|
| 1.38 t/m³ | 30% | 2.75 t/m³ | 54.6% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Natural Water Content | (NWC) | | | | | ✓ | | |
| Water Content | (%) | 19.0 | 26.1 | 29.9 | 38.7 | 54.3 | | |
| Dry Density | (t/m³) | 1.353 | 1.356 | 1.381 | 1.317 | 1.079 | | |
| Undrained Shear Strength | (kPa) | | | | 114 | 14 | | |

## TEST REMARKS

- The material used for testing was natural, fraction <19mm sieve. • An assumed solid density value of 2.75 t/m³ was used. We do not take responsibility for misrepresentation or misinterpretation arising from the use of this assumed value. • The amount of material retained on a 19mm sieve was 0% by wet mass. • Date Tested 11/03/2026.

This test result is IANZ accredited.

| | | | |
|---|---|---|---|
| **Approved by KTP** | GEGO | **Date** | 20/03/2026 |

GEOTECHNICS

1 Hill Street
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Auckland 1061
New Zealand

p. +64 9 356 3510

**Geotechnics Project ID** 1102362.0000.2.0

**Customer Project ID**

## Determination of the Particle Size Distribution - NZS 4402:1986 Test 2.8.1 (Wet Sieve Method)

## Determination of the Particle Size Distribution - NZS 4402:1986 Test 2.8.4 (Hydrometer Method)

### TEST DETAILS

**LOCATION**

**ID** TP108

**Description** Lagoon Farm

**Data** N/A

**SAMPLE**

**Geotechnics ID** AKL1328.02

**Reference** - **Depth** 1.0-1.5 m

**Description** Clayey SILT; grey. Wet, very soft, high plasticity.

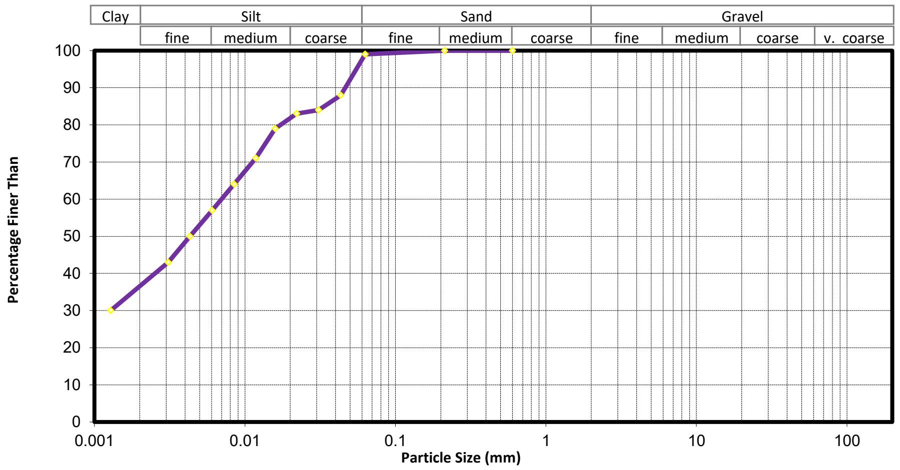
**SPECIMEN**

**Reference** - **Depth** -

**Description** -

### TEST RESULTS

**PARTICLE SIZE ANALYSIS**



| Sieve Size (mm) | Percentage Passing (%) | Sieve Size (mm) | Percentage Passing (%) | Sieve Size (mm) | Percentage Passing (%) |
|---|---|---|---|---|---|
| 150.0 | - | 16.0 | - | 0.600 | 100 |
| 100.0 | - | 13.2 | - | 0.425 | - |
| 75.0 | - | 9.50 | - | 0.300 | - |
| 63.0 | - | 6.70 | - | 0.212 | 100 |
| 53.0 | - | 4.75 | - | 0.150 | - |
| 37.5 | - | 3.35 | - | 0.090 | - |
| 26.5 | - | 2.00 | - | 0.075 | - |
| 19.0 | - | 1.18 | - | 0.063 | 99 |

| Equivalent Particle Diameter D (mm) | Percentage of Particles Finer than D (%) | Equivalent Particle Diameter D (mm) | Percentage of Particles Finer than D (%) |
|---|---|---|---|
| 0.0401 | 88 | 0.0032 | 43 |
| 0.0289 | 84 | 0.0014 | 30 |
| 0.0207 | 83 | | |
| 0.0149 | 79 | | |
| 0.0113 | 71 | | |
| 0.0082 | 64 | | |
| 0.0060 | 57 | | |
| 0.0044 | 50 | | |

### TEST REMARKS

- The material used for testing was natural, whole soil.
- The percentage passing the <0.063 mm was obtained by difference.
- An assumed solid density value of 2.75 t/m³ was used. We do not take responsibility for misrepresentation or misinterpretation arising from the use of this assumed value.

Date tested: 04/03/2026

This test result is IANZ accredited.

**Approved by KTP** **GEGO** **Date** **9/03/2026**

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Auckland 1061
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**Geotechnics Project ID** 1102362.0000.2.0

**Customer Project ID**

## Determination of the Dry Density / Water Content Relationship - NZS 4402:1986 Test 4.1.1 (Standard Compaction)

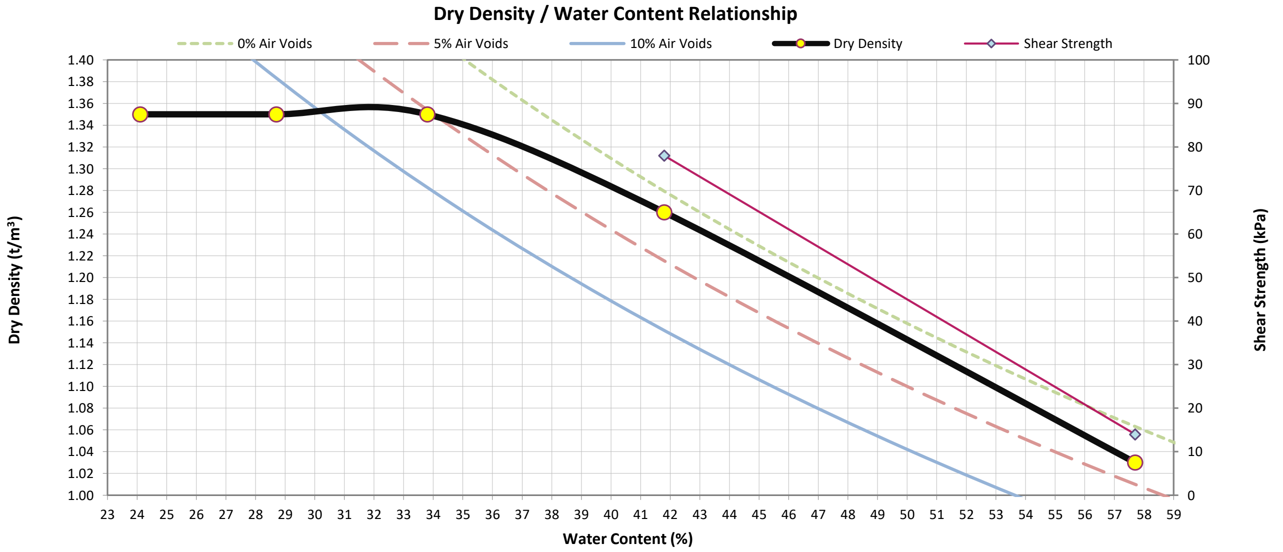
Vane Shear Strength of Cohesive Soil - NZGS Guideline for Hand Held Shear Vane Test - 2001

### TEST DETAILS

| | | | | |
|---|---|---|---|---|
| **LOCATION** | **ID** | TP108 | | |
| | **Description** | Lagoon Farm | | |
| | **Data** | N/A | | |
| **SAMPLE** | **Geotechnics ID** | AKL1328.2 | | |
| | **Reference** | - | **Depth** | 1-1.5 m |
| | **Description** | Clayey SILT; grey. Wet, very soft, high plasticity. | | |
| **SPECIMEN** | **Reference** | - | **Depth** | - |
| | **Description** | - | | |

### TEST RESULTS

Dry Density / Water Content Relationship



| Maximum Dry Density | Optimum Water Content | Solid Density* | Whole Sample NWC |
|---|---|---|---|
| 1.35 t/m³ | 34% | 2.75 t/m³ | 56.1% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Natural Water Content | (NWC) | | | | | ✓ | | | |
| Water Content | (%) | 24.1 | 28.7 | 33.8 | 41.8 | 57.7 | | | |
| Dry Density | (t/m³) | 1.347 | 1.353 | 1.348 | 1.255 | 1.033 | | | |
| Undrained Shear Strength | (kPa) | | | | 78 | 14 | | | |

### TEST REMARKS

• The material used for testing was natural, fraction <19mm sieve. • An assumed solid density value of 2.75 t/m³ was used. We do not take responsibility for misrepresentation or misinterpretation arising from the use of this assumed value. • The amount of material retained on a 19mm sieve was 0% by wet mass. • Date Tested 11/03/2026

This test result is IANZ accredited.

**Approved by KTP** GEGO **Date** 20/03/2026

GEOTECHNICS

21 April 2026
Our Ref: 1102362.0000.03.0/Rep1

Tonkin & Taylor Limited
PO BOX 5271
AUCKLAND 1141

Attention: Jia Hong

Dear Jia

# Lagoon Farm

# Laboratory Test Report

## Customer's Instructions

Detailed testing instructions were provided by the customer.

## Sampling Procedure

Samples have been tested as received.

## Sample Location Plan

Not applicable.

## Samples

We received two bulk samples labelled with the location ID and sample depth.

## Date(s) of Sample Receipt

27 February 2026

## Test Method(s)

ISO 17892:2019 Part 11 - Permeability Tests

NZS 4402: 1986 Test 2.1 - Water Content

## Material Description

Descriptions are provided in the attached presentation pages.

## Test Results

Test results are attached.

## Test Remarks

Test remarks are detailed on the presentation page.

## General Remarks

Samples not destroyed during testing, will be retained for one month from the date of this report before being discarded.

Descriptions are enclosed for your information but are not covered under the IANZ endorsement of this report.

This report has been prepared for the benefit of Tonkin & Taylor Limited, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of the letterhead page.

GEOTECHNICS LTD

| Report approved by: | Authorised for Geotechnics by: |
|---|---|
| Helen Wang | |
| ...................................................... | ...................................................... |
| Helen Wang<br>Triaxial Laboratory Manager<br>Key Technical Person | Steven Anderson<br>Project Director |

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

21-Apr-26
t:\geotechnicsgroup\projects\1102362\3 triaxial\issueddocuments\20260421.lagoon farm.pihe.rep1.docx

Our Ref: 1102362.0000.03.0/Rep1

GEOTECHNICS

1 Hill Street
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New Zealand
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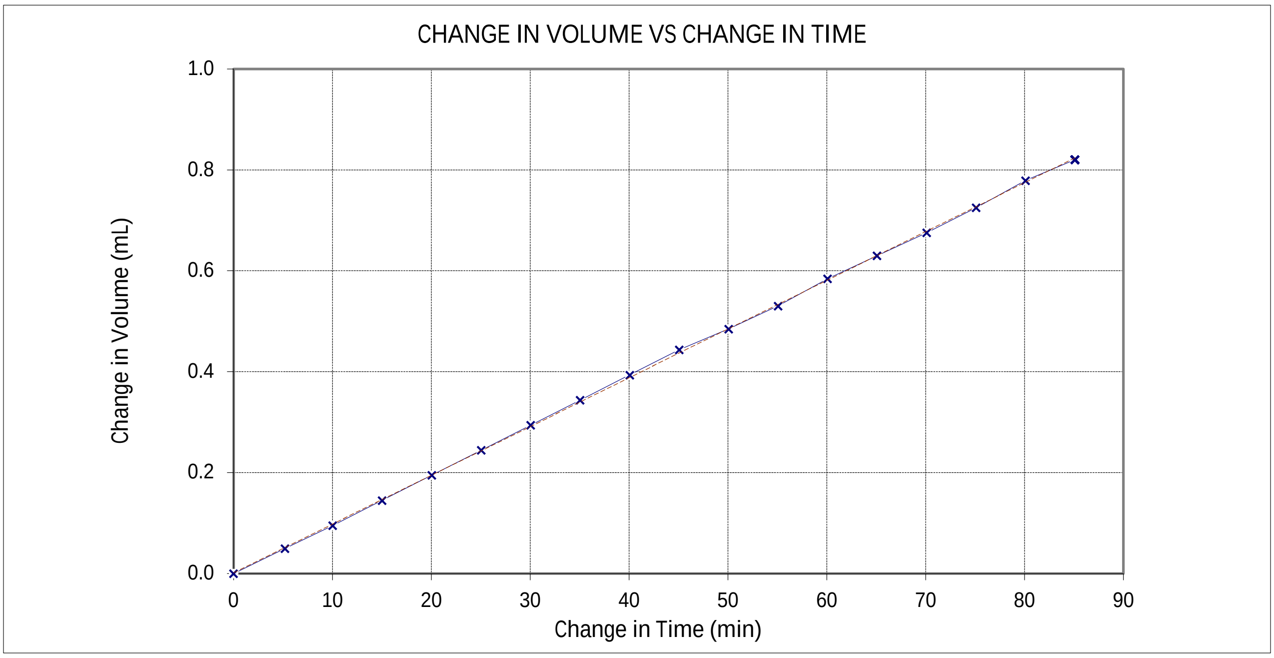
| | |
|---|---|
| Geotechnics Project ID: | 1102362.0000.03.0 |
| Customer Project ID: | -- |
| Test Schedule Reference: | -- |

Site/Location: Lagoon Farm — Location ID: TP107

Sample Ref.: B2 — Geotechnics ID: -- — Depth (m): 1 - 1.5

Test Method Used: ISO 17892-11:2019 Part 11 Permeability Tests
NZS 4402:1986 Test 2.1 Determination of Water Content



Coefficient of Permeability at 20.5 °C = 1.86E-09 (m/s)

| | | | | | |
|---|---|---|---|---|---|
| Initial sample height | 66 | (mm) | Initial bulk density | 1.80 | (t/m³) |
| Initial sample diameter | 60 | (mm) | Initial dry density | 1.36 | (t/m³) |
| Saturation at test (B) | 92 | (%) | Initial water content | 32.0 | (%) |
| Back pressure level | 310 | (kPa) | Final water content | 39.6 | (%) |
| Consolidation stress level | 30 | (kPa) | Final dry density | 1.27 | (t/m³) |
| Head difference | 20 | (kPa) | Hydraulic gradient | 31 | |

## SAMPLE DESCRIPTION

Clayey SILT; grey, dry to moist.

## SAMPLE HISTORY

The sample was remoulded at the target water content of 32.0 % to the target dry density of 1.370 t/m³.

The test was performed on whole soil.

## TEST REMARKS

Constant-head permeability test in a triaxial cell. De-aired tap water was used in the test.
The sample was saturated by increments of cell pressure and back pressure.

Tested by: PIHE — Date: 10/04/2026 — Approved by KTP: — Date: 21/04/2026

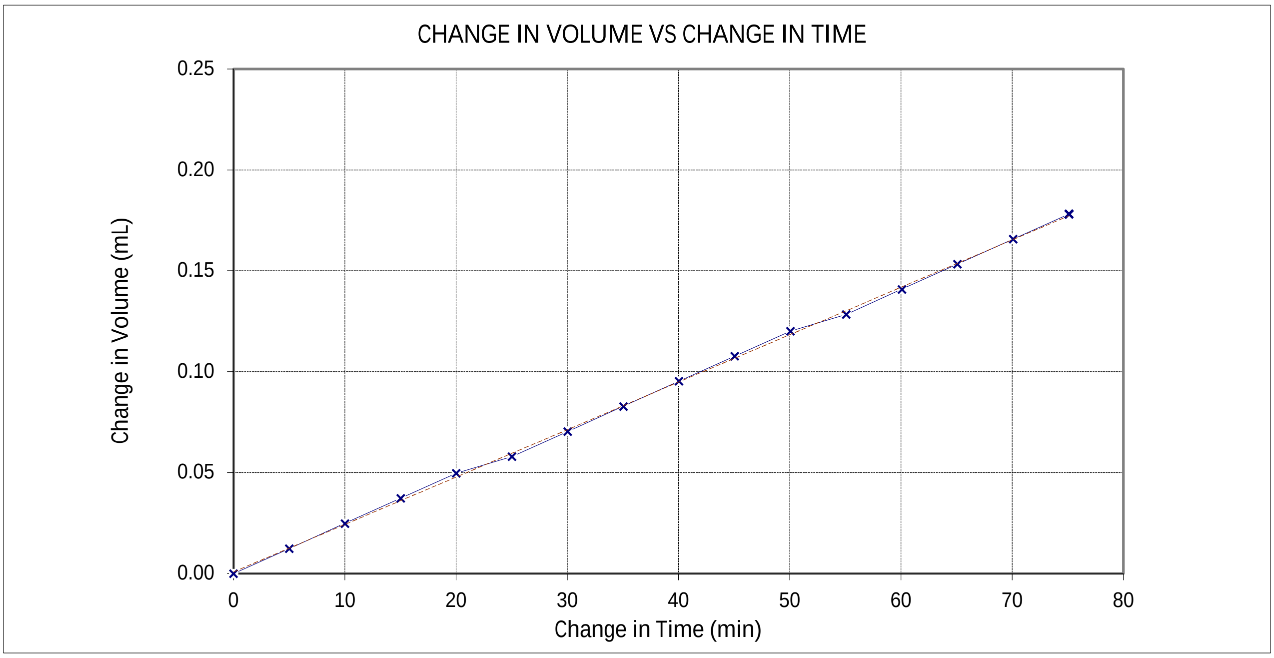
Our Ref: 1102362.0000.03.0/Rep1 Page 4 of 4

GEOTECHNICS

1 Hill Street
Onehunga
Auckland
New Zealand
p. +64 9 356 3510

| | |
|---|---|
| Geotechnics Project ID: | 1102362.0000.03.0 |
| Customer Project ID: | -- |
| Test Schedule Reference: | -- |

Site/Location: Lagoon Farm Location ID: TP108
Sample Ref.: B1 Geotechnics ID: -- Depth (m): 1 - 1.5
Test Method Used: ISO 17892-11:2019 Part 11 Permeability Tests
NZS 4402:1986 Test 2.1 Determination of Water Content



Coefficient of Permeability at 20.5 °C = 4.46E-10 (m/s)

| | | | | | |
|---|---|---|---|---|---|
| Initial sample height | 66 | (mm) | Initial bulk density | 1.81 | (t/m³) |
| Initial sample diameter | 60 | (mm) | Initial dry density | 1.34 | (t/m³) |
| Saturation at test (B) | 94 | (%) | Initial water content | 34.5 | (%) |
| Back pressure level | 410 | (kPa) | Final water content | 39.0 | (%) |
| Consolidation stress level | 30 | (kPa) | Final dry density | 1.32 | (t/m³) |
| Head difference | 20 | (kPa) | Hydraulic gradient | 31 | |

SAMPLE DESCRIPTION

Clayey SILT; grey, dry to moist.

SAMPLE HISTORY

The sample was remoulded at the target water content of 34.0 % to the target dry density of 1.350 t/m³.

The test was performed on whole soil.

TEST REMARKS

Constant-head permeability test in a triaxial cell. De-aired tap water was used in the test.
The sample was saturated by increments of cell pressure and back pressure.

Tested by: PIHE Date: 7/04/2026 Approved by KTP: Date: 21/04/2026