# Appendix 24

# Powerhouse Fast-track Application

## Zealandia Predator-free Fence Design

**Prepared in 2021 by Karori Sanctuary Trust – Te Mārā a Tāne**

15 December 2025

# Zealandia Te Māra a Tāne: Predator Exclusion Fence Design and Maintenance

KARORI SANCTUARY TRUST™
TE MĀRA A TĀNE

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This document can be referred to as:
Zealandia, 2021. Zealandia Te Māra a Tāne predator exclusion fence design and maintenance. Karori Sanctuary Trust, Wellington, New Zealand.

Zealandia, 2021. Zealandia Te Māra a Tāne predator exclusion fence design and maintenance. Karori Sanctuary Trust, Wellington, New Zealand.

## 1. Purpose of this document

This document has been created to share the key design and maintenance considerations associated with the highly effective Zealandia predator exclusion fence. The information outlined in this document was originally patented, but Zealandia has now chosen to share it freely under a Creative Commons licence. This means people are welcome to share and use the information free of charge. Zealandia's vision is that this technology can be replicated in other locations to achieve significant conservation gains.

## 2. Background to the fence

Zealandia is a 225ha ecosanctuary surrounded by an 8.6km fence that excludes all introduced mammals that occurred in or around the sanctuary, except mice.

The Zealandia fence was the first of its type, and a significant design phase was conducted in 1993, followed by an extensive programme of live animal trials in 1994. The trials tested the ability of a range of animals to cross the fence through jumping, climbing, digging and penetration through varying mesh sizes.

The eventual design was simple, robust, effective and relatively easy to install. Major consideration was given to the materials, installation costs, maintenance costs, wind and visual effects. It needed to be durable with robust materials that could withstand the Wellington climate and the daily wear and tear of an urban environment. The resulting design does not rely on electrification.

Construction of the fence took six months and was completed in August 1999. It is supported by approximately 5,800 posts ranging in height from 1.8-2.2m. The fence was originally designed to exclude introduced mammals, and to prevent entry by domestic pets. The animals consistently excluded include: cats, goats, deer, pigs, Norway rats, ship rats, stoats, weasels, ferrets, hedgehogs, possums, rabbits and hares. The fence has been ineffective in excluding mice, but it has been very highly effective for all other target species with few incursions recorded.

The Zealandia fence is a critical piece of infrastructure and, when constructed, had an estimated life expectancy between 25 and 50 years. This document details the structure of the fence, key maintenance considerations, and key learnings that improve the longevity of the structure.

## 3. Structure of fence

There are four key components of the fence (Figures 1-3): the posts (on which the structure is mounted), the hood (designed to prevent climbing animals), the wall (providing a broad barrier to all target species), and the skirt (prevents access for burrowing animals).

### 3.1 Posts

The fence system is mounted on 5,800 H5 treated posts sunk 800mm-1200mm, or in some areas further, into the ground (Figure 1). Posts are located at approximately 1.5m intervals (depending on changes in angle or elevation) alternating between full round and half round cross-sections.

### 3.2 Hood

The hood consists of a zincalume half pipe, and affords an upper barrier designed to prevent climbers such as possums, cats and stoats from passing over the fence (Figure 2). The hood is designed to be clear of items that could provide purchase for animals attempting climb over. Where this has not been possible (i.e. where bolts fix the hood bracket to the fence), an extended guard is attached to the hood to prevent mice or rats from gaining purchase.

### 3.3 Wall

The wall is comprised of 6mm x 50mm woven wire mesh. This mesh diameter was selected as the most effective following extensive animal trials. The wall panels are 2.2m from ground level, extending 100-200mm below ground.

It should be noted that two years after the complete eradication of all targeted pest species from within the sanctuary, it was discovered that juvenile mice were able to breach the fence through gaps that had widened slightly to 7mm or more.

### 3.4 Skirt

The skirt (Figure 3) is a ground-level barrier designed to prevent burrowing animals such as rats, ferrets, rabbits and mice from passing beneath the fence. It is also comprised of 6mm x 50mm woven wire mesh laced and tied to the wall wire mesh, extending outward 400mm from the base of the fence. The skirt is designed to sit 100-200mm below ground level and should ideally have a covering of grass to minimise erosion.

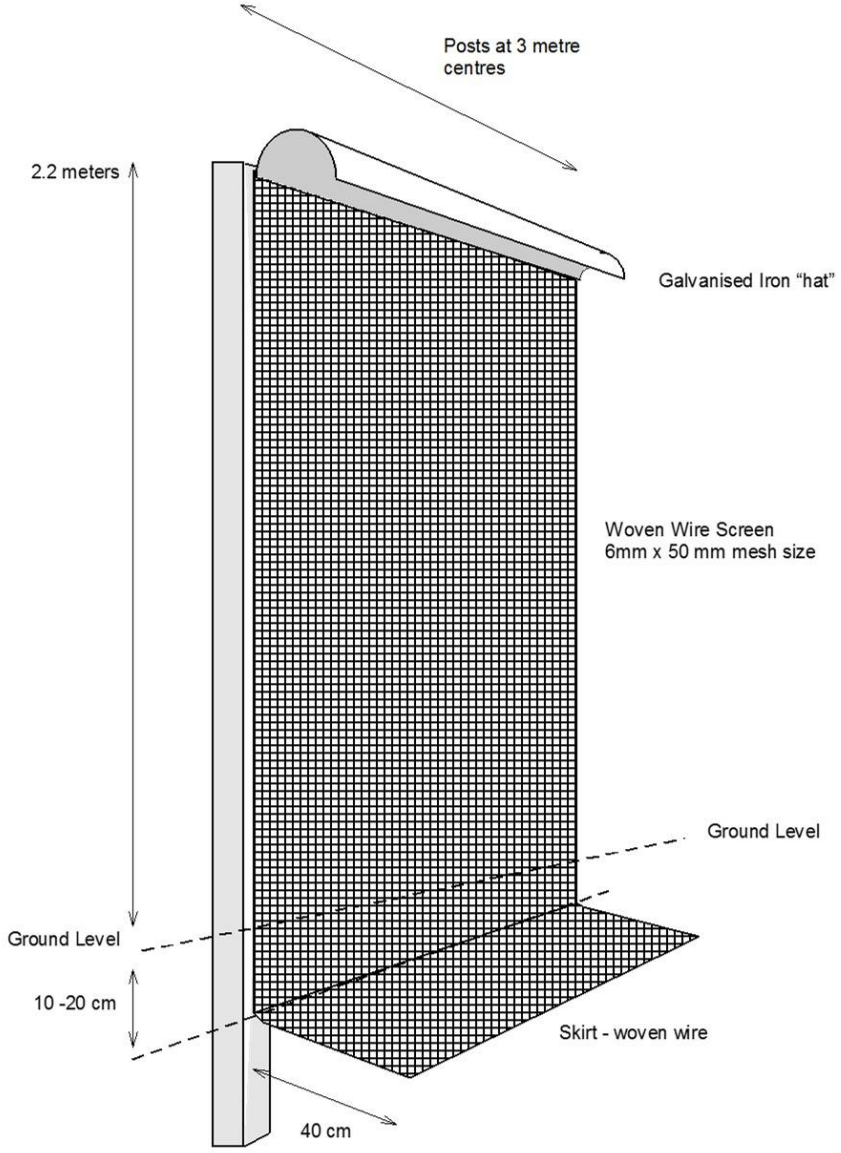


Figure 1. Overview of the fence components.

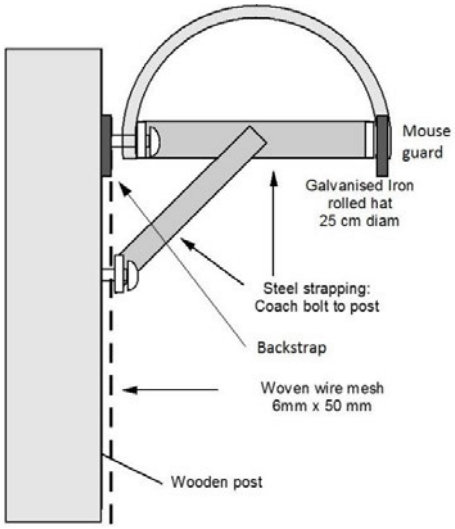


Figure 2. Overview of the hood area components.

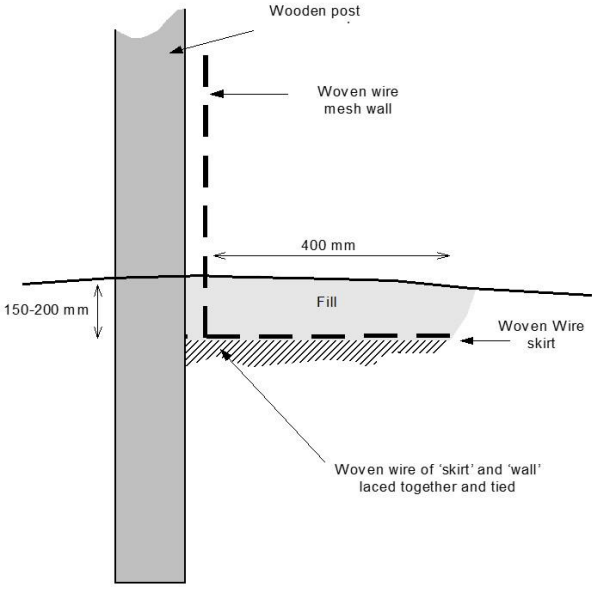


Figure 3. Overview of the skirt area components.

### 3.5 Other elements

#### 3.5.1 *Gates*

There are seven fire exits around the fence which allow entrance for emergency services and exit in the event of emergency. These remain locked unless access is required. The gates are designed with overlapping metal plating around the edges to prevent access for target animals, and the base is concreted.

#### 3.5.2 *Drains*

There are several drains around the perimeter that allow the drainage of water from the outside tracks to natural waterways. These drains have mesh barriers at both ends (inside and outside the fence), to ensure biosecurity.

#### 3.5.3 *Flapper gates*

The lower and upper lakes drain down to the Kaiwharawhara Stream and, at the point they exit the sanctuary, flapper gates have been installed to prevent animals from climbing in. These are large metal frames containing mesh, weighted by concrete slabs, which cover the exit points. Attached to the wall via a pivot mechanism, they are pushed out from the wall by flowing water and remain closed or near closed when there is no or low flow.

## 4. Monitoring and maintenance protocol

Maintenance of the fence as a secure barrier against re-invasion of pest species is crucial. There are several anticipated causes of a fence breach which are monitored regularly and frequently, including:

- vegetation overhang, particularly from the outside, allowing a mammal to climb over
- tree fall which crushes part of the fence
- major earthquake which could result in changes in tension, or movements of earth that create gaps or holes
- cavities emerging under the skirt, which could occur due to erosion, animals burrowing from the inside out, tree roots rotting as the forest matures (there is a particularly problematic section for this latter issue along Highbury Road under the grid wall)
- damage from vehicles
- anything leaning against or located within 3m of the fence (allowing an animal to jump over)
- new gaps created between wall mesh sheets due to undetected tension in the fence, or separation of the mesh and hood from the backstrap that fixes it in place
- fence joints rusting out, causing either holes or additional purchase for climbing animals
- failure of drainage pipe covers.

A system of fence checks ensures thorough and frequent scanning along with rapid detection of any biosecurity issues which then triggers a biosecurity response. Flapper gates are checked daily to ensure they do not become jammed with debris. Because of

the constant water flow and exposure to the air, the mesh on the flapper gates is prone to corrosion. A replacement cycle minimises the chance of failure. Other elements of fence checks are described below.

### 4.1 Bi-weekly checks

The Zealandia fence is checked by a team of volunteer fence checkers at least twice weekly, and this is supported by a highly aware and engaged local community. The process is guided by a fence checking training document which is periodically updated. In brief, the volunteers walk along the outside of the fence checking for:

- anything leaning (or close to leaning) against the fence
- identifying any rivets, bolts or other fence elements that have broken leaving a gap
- any areas of skirt that have become exposed or are becoming undermined
- any other obvious issues that are causing a biosecurity threat or have the chance to cause a threat.

Volunteers provide an update on the status of their section each time it is done, reporting any issues into the Infrastructure team to follow-up.

### 4.2 Zealandia team check every two weeks

While the volunteer checks provide an excellent overview of new and emerging issues, they are unable to detect problems that are only visible from above. A two-weekly check (under normal circumstances) by trained staff provides additional insurance that potential issues are detected before they become a problem. This check involves:

- An additional check of the same items examined by the volunteers
- Looking along the top of the fence with a mirror. This check reveals rivets or bolts that have come away from the back of the fence.
- Repair of any non-urgent elements that have been raised by the fence checkers.

### 4.3 Regular fence audit

The Zealandia team conducts a complete audit once a year including drains, posts, mesh, top hat, the skirt and gates. This check involves:

- Visual inspection of joints, rivets, bolts, brackets
- Physical checks through applying pressure to ensure the backstrap on which the hood is fixed is secure
- At least five sections of skirt in areas of different soil types are exposed over a 1-metre length to check for any signs of deterioration
- Checks to identify emerging issues associated with hood joints.

### 4.4 Other checks as needed

The team always conducts a check of the whole fence following high wind/storm events, fire or major earthquakes. These checks are also triggered as needed in any circumstances where a fence issue could be anticipated. The check takes place as soon as is practicable after the event.

Current systems allow for “emergency” volunteer fence checkers to be called upon to check all six sections of the fence. Operations staff are required to check the sections not covered by usual fence checking.

## 4.5 Vegetation management

Ongoing tree and vegetation management is crucial to reduce the chance of fence issues emerging. There are multiple layers to this process.

### 4.5.1 *Perimeter vegetation*

Given that overhanging vegetation is one of the key biosecurity threats for the fence, the vegetation is kept cleared in a 3m (plus) strip around the outside of the perimeter fence. Vegetation inside the perimeter is also kept clear as it presents a biosecurity risk if it falls on the fence. The cleared area was changed from 3m to 5m in 2016 due to the growing height of the maturing forest.

A volunteer team manages vegetation on the inside of the fence.

Given there is limited vehicle access around the inside perimeter the work is done with hand tools and hence is a time-consuming process.

High grass against the fence prevents issues being spotted and is a health and safety risk (trip hazard) for staff and visitors as they cannot see hazards under the grass. Grass on the inside of the perimeter directly adjacent to the fence is also cut at least once a year (early summer, and if needed early autumn) with a scrub bar or heavy duty mower. As the sanctuary became more established, this needed to be done with a view to protecting and preventing injury to native species including burrowing animals.

## 5. Emergency response protocol

All fence breaches identified by the fence check mechanisms are reported immediately by phone or radio. In the past, two major tree-fall events have required fence rebuild or repair in sections.

While the extent, number and type of breaches determines the response, the procedures include:

1) Zealandia staff member receives report of breach.
2) A coordinating officer is assigned, and biosecurity response mounted.
3) The coordinating office decides on response requirements (repair or replacement), priorities and personnel. This will depend on extent, nature, number and accessibility of breaches. Key considerations include health and safety of staff, lights and generators, food and water and warm and dry clothing for staff and volunteers, size of the tree and how it has fallen.
2) Temporary fencing may be put in place if needed.
3) The teams then:
    - coordinate and conduct the clearance of debris, such as fallen trees
    - remove damaged sections of fence, retrieving or retaining reusable materials where appropriate
    - repair fence (temporary or final)
    - clear site once repair completed

## 6. Key considerations for long term maintenance of the fence

The fence was constructed in 1999 and had an estimated minimum working life of 25 years. At this point Zealandia anticipates some components of the fence will last significantly longer than this, with other components requiring more rapid replacement. Below is a summary of key learnings to support long-term maintenance of future fences.

### 6.1 The hood

The original hood in some instances rusted out prematurely. The annual fence audit prioritises its assessment and replacement where issues are appearing. Joints are welded and treated with zinc blasting. Where the hood shows early indications of rusting, but not warranting full replacement, the rust prevention product Alumastic from Resenes is applied to prevent further deterioration.

Where hood angles were welded, corrosion has occurred and if this becomes advanced it could provide purchase for animals or lead to other deterioration challenges. The solution to this issue has been to replace them with angles that had been zinc blast sprayed (shown on image to right).

Image 1: Zinc blasted welded join on the fence hood.

## 6.2 Skirt

Due to surface erosion caused by runoff from the 4WD perimeter track outside the fence there are areas of exposed skirting—this poses a risk of cavities appearing, and can cause more rapid deterioration and rusting of the skirt itself.

One solution for this issue is the need to avoid doing fence checks using vehicles (these can cause the deterioration), and the perimeter track must be maintained to a very high standard, with appropriate camber to avoid water stripping away protecting soils and vegetation.


*Section of the skirt uncovered for a fence audit.*


Image showing rust forming on skirt.

### 6.3 Erosion of banks

In some areas around the inside fence line there has been erosion, instability and cracking in the soils, particularly where substantial amounts of fill were used and on which the fence was built. In some instances, this has caused the inside ground level to be lower than the outside, and in others it presents the potential risk of rapid loss of the bank below the fence. These areas are managed at Zealandia through gaining and acting on advice from engineering firms.

This issue can be avoided first by minimising the use of fill when the fence is being built (rather working with the contours of the land), and/or ensuring fence posts enter the ground below fill. Second, installation of appropriate drain types, and close maintenance of those drains, is critical.

### 6.4 Posts

Some posts in vulnerable locations have starting to show signs of rot on top, and others under the soil level (particularly where drainage of water may not have been optimum). This is very rapid for H5 treated timber.

To maximise longevity of the posts in future projects we recommend that drainage is very carefully planned and maintained, and the posts are capped to prevent water infiltration. Checking the quality of post timber is also critical.

### 6.5 Mouse exclusion

Mice are not currently excluded by the fence. Replacing the wall mesh with a finer weave is one option, but this would best be considered at the establishment of the fence. Other fences across New Zealand have managed to exclude mice, and design elements from these may be appropriate for inclusion into the Zealandia style fence.

Horizon scanning for future possible problem species is also needed. For example, the plague skink is now common in Auckland and surrounds, and it outcompetes other lizard species. It is likely to reach Wellington at some point in the future. Consideration should be given to whether any modification to the fence might exclude such species, and whether this is considered of sufficient benefit.

## 7. Acknowledgements

The knowledge contained in this document and others associated with the Zealandia predator exclusion fence are the product of years of dedicated hard work by many people, including countless staff, volunteers, and supporting organisations. The establishment of the fence project was driven by key people who established the Karori Wildlife Sanctuary Trust, led by Jim Lynch. These people have all been key to transforming how we do conservation in Aotearoa New Zealand.