

Maximising biodiversity and minimising unwanted plants and animals in stormwater ponds, wetlands and rain gardens in the Auckland region



Making the most of Auckland's stormwater ponds, wetlands and rain gardens



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A white faced heron landing in a stormwater pond filled with an unwanted weed, parrot's feather.



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1. INTRODUCTION



Introduction

Stormwater treatment devices are an increasingly common feature of Auckland's urban landscape. They play an important role in reducing the effects of urban development by controlling the quantity and quality of stormwater run-off before it reaches Auckland's streams and harbours.

Depending on their design they can be an asset to native wildlife and the local community or a headache if unwanted plants and animals settle in.

This guide draws together information and advice from a range of sources but has been written specifically for plants and animals native to the Auckland Region. General principles for maximising biodiversity values and minimising unwanted pests and animals are presented with illustrated examples. Where possible, links are provided for accessing more detailed information.

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2. BIODIVERSITY BASICS

What is biodiversity?

Biodiversity simply means the variety of life on earth. It includes the entire web of living organisms from the tiniest microbes to the tallest trees. The interactions between living things and their environment, underpins many important processes that help maintain the quality of our environment.

In the Auckland Region, natural habitats for native plants and animals have been greatly reduced or damaged as land has been developed to accommodate Auckland's constantly growing population. Some of the most depleted and degraded habitats are those with a watery element including streams and wetlands. An opportunity exists to address this loss by ensuring newly created water sources in urban areas, such as stormwater ponds and wetlands, are designed to benefit native plants and animals, increasing biodiversity and the quality of our environment.

General principles for increasing biodiversity

There are several general principles for creating an environment that will help increase the diversity of plants and animals. They include:

- **Size.** Bigger is better for the simple reason that there is more space for a variety of plants and animals.
- **Shape.** Maximising the core area of a site and reducing the amount of edge helps increase the variety of desirable species and reduce weed invasion.
- **Habitat variety.** Increasing the types of habitats in a site will increase the variety of plants and animals that will use it. In watery places the best way to increase habitat variety is to increase the diversity of flood depth and frequency of flooding.
- **Linkages.** Connect the site to other natural areas in the vicinity. This can be done through initial placement of the site, placing it close to other natural areas such as streams, forest remnants and natural wetlands or by extending the planting of a site to an adjacent natural area. Important linkages for stormwater wetlands and ponds are the connections with other waterways allowing unimpeded access for native fish.

3. STORMWATER PONDS



Stormwater ponds are designed to control water quantity and quality. There are two types, dry ponds and wet ponds. Dry ponds temporarily detain stormwater runoff and are normally dry between storm events. Wet ponds have a permanent pool of standing water and have potentially far greater benefits to wildlife than dry ponds. The rest of this section refers only to wet ponds.

A stormwater pond adjacent to the naturally occurring wetland in the foreground.



Stormwater ponds have two main components.

- 1. Sediment forebay.** This is a small pond before the main pond that receives run-off from an inlet. It is designed to take out the coarse sediments and requires regular dredging. It contains at least 15% of the total water volume and is at least 1 m deep.
- 2. Main pond.** The main pond contains the remaining water volume and is usually designed to have a maximum depth between 2 – 3 m. To facilitate sedimentation, ponds normally have a length to width ratio of 3 to 1.

These two components can be designed or modified to create a variety of habitats and environmental conditions in the ponds that will increase their use by native plants and animals without reducing their ability to treat stormwater.

Key design features

The following features all need to be considered at the initial stages of locating and designing the physical layout of stormwater ponds.

Placement of ponds

- Site ponds close to other natural areas if possible, particularly wetlands which will provide complementary habitat as similar plants and animals are found in both.
- Where possible, place ponds to fit within the contours of the site. This creates a more natural looking pond.

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For advice on design, construction and maintenance for controlling the quantity and quality of stormwater run-off see the ARC's Stormwater Design Guideline Manual (TP10).



Shoreline

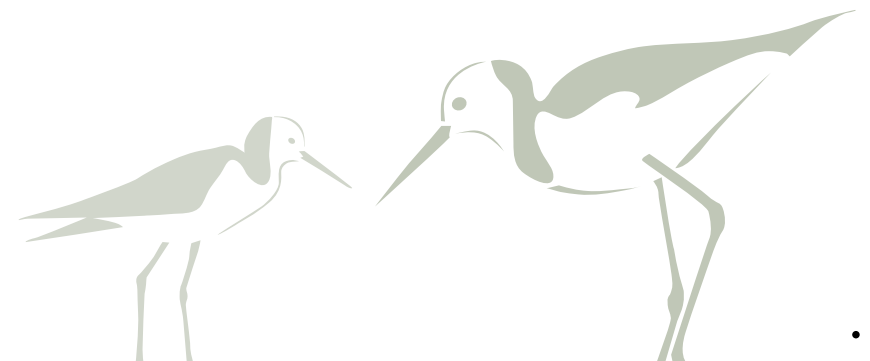
- Maximise the length of shoreline by making it an irregular shape instead of being oval or rectangular. This will substantially increase habitat for plants, fish and insects which will in turn attract birds.
- Create small bays along the shoreline of the main pond that enable pairs of birds to become visually isolated from each other. This will increase the number of birds that will inhabit this area.

An irregular shoreline with bays to isolate bird pairs.



Water depth and bank slope

- Create gently sloping banks on the edges of ponds to establish wetland plants. The gentler the slope the greater the variety of habitat created. Slopes should be at least 1 vertical to 10 lengths (1:10) and can be up to 1:20.
- Aim for between 25 – 50 % of the water surface area in the main pond to be less than 1.5 m. This provides a good ratio of wetland habitat to open water and will increase bird diversity.
- Ensure that 50 – 75% of the water surface in the main pond is greater than 1 m deep. This will help stabilise water temperatures. Water temperatures need to be below 25 °C for native fish.
- Create a refuge pool, a smaller deeper area in the main pond, which can hold fish and aquatic insects on the occasions that the pond needs to be drained for maintenance.





Mudflats, sandbars and islands

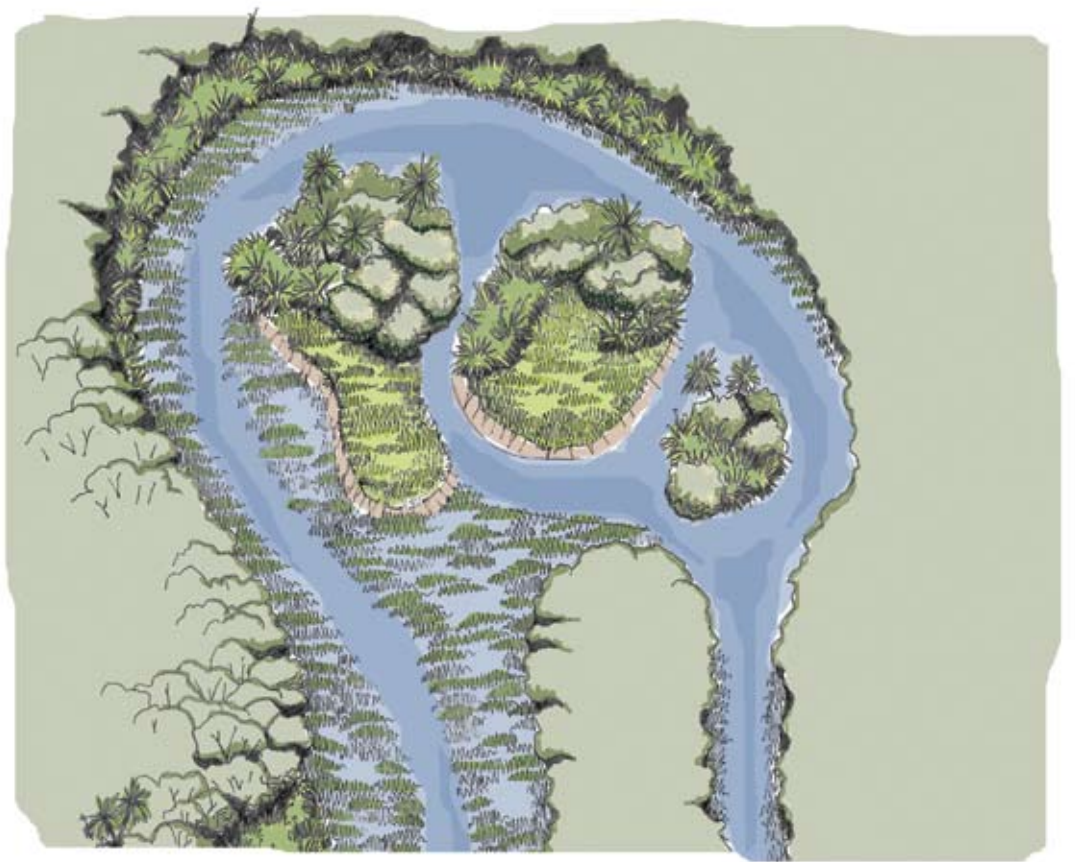
- Mudflats and sandbars are very shallow areas that are only exposed some of the time. They are important feeding habitat for wading birds such as pied stilt. Potential places to create them include the shallow shelf between the forebay and main pond, edges of islands and by extending peninsulas along the shoreline. They can also form naturally in on-line ponds (i.e. ponds located on the main stream network) where small streams enter the main pond.
- In ponds greater than 0.5 ha establish at least 1 island just above the water surface. This will increase marginal habitat for plants, fish and aquatic insects, break up sight lines to increase bird pairs and provide habitat that is less likely to be disturbed by humans and dogs.

- Position and shape the islands to help direct water flow within the lake to help oxygenate water and improve water quality.

A naturally occurring mudbank has formed where a small stream flows into a stormwater pond.



Islands positioned in a small pond to direct water flow.





Fish passage

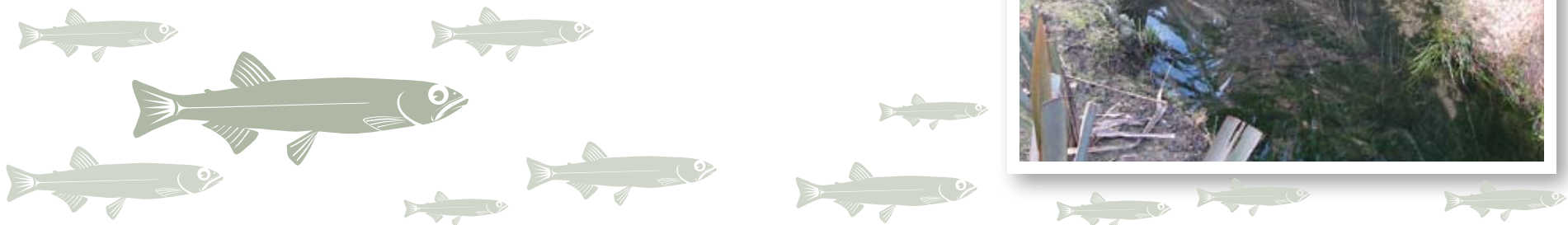
Thirteen of the 15 species of native freshwater fish in the Auckland Region spend part of their life cycle in the sea. Unimpeded access between stormwater treatment devices and the sea, both in an upstream and downstream direction, is therefore vital if these areas are to provide fish habitat. The type of culverts through which fish can migrate are described in the ARC's Fish Passage Guidelines (TP131). The general principles are ensuring constant, low velocity water flow of adequate depth, without steep weirs or free overfalls, and with resting pools. Other design considerations are listed below:

- Inlets from culverts or ponds into streams or wetlands need to be designed to dissipate flow, but this can result in a very shallow sheet of water in low flow conditions that prevents migration by some fish species. Dissipative aprons should include a small, low-flow channel to allow for migration when water levels are low.
- In some cases, fish passages may be able to be designed to allow the migration of agile, native species, while preventing migration of unwanted species such as koi, goldfish, gambusia, and trout. In upper catchments above barriers such as water falls, the only native fish present are those that can climb, such as banded kokopu, or that spend their entire life cycle in freshwater, such as Cran's bully. In this situation, if unwanted species such as goldfish and gambusia are present, these can be excluded by designing pond outlets that mimic natural waterfalls.

Culvert impassable by native fish.



Culvert passable by native fish.

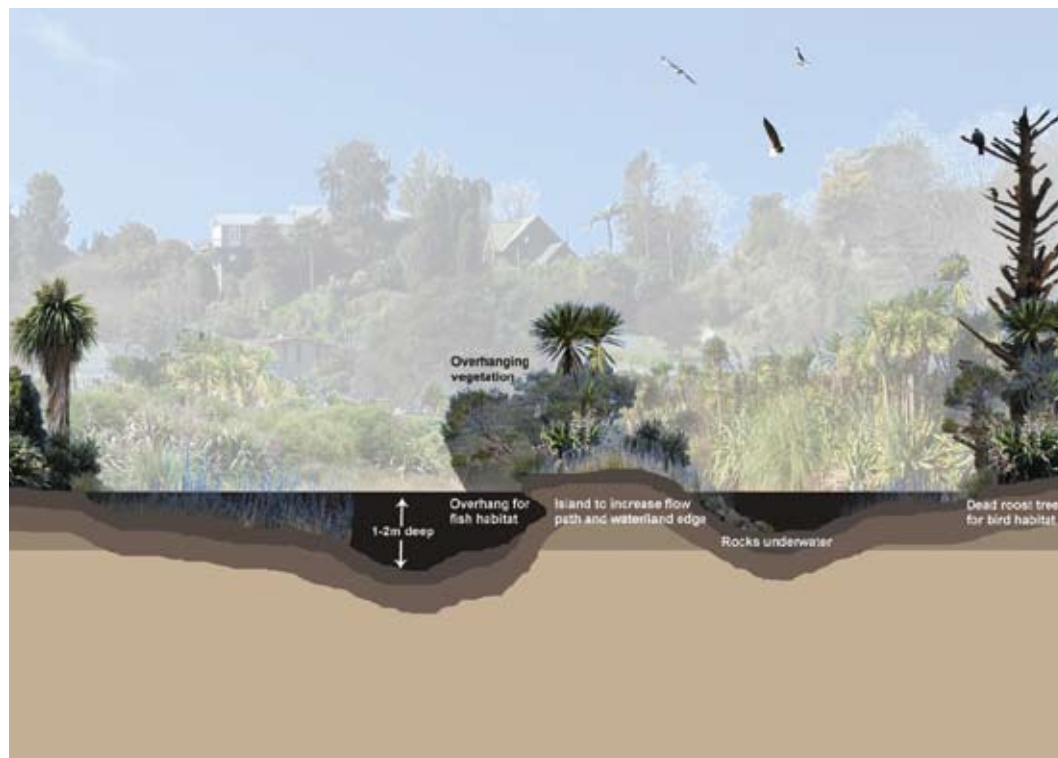




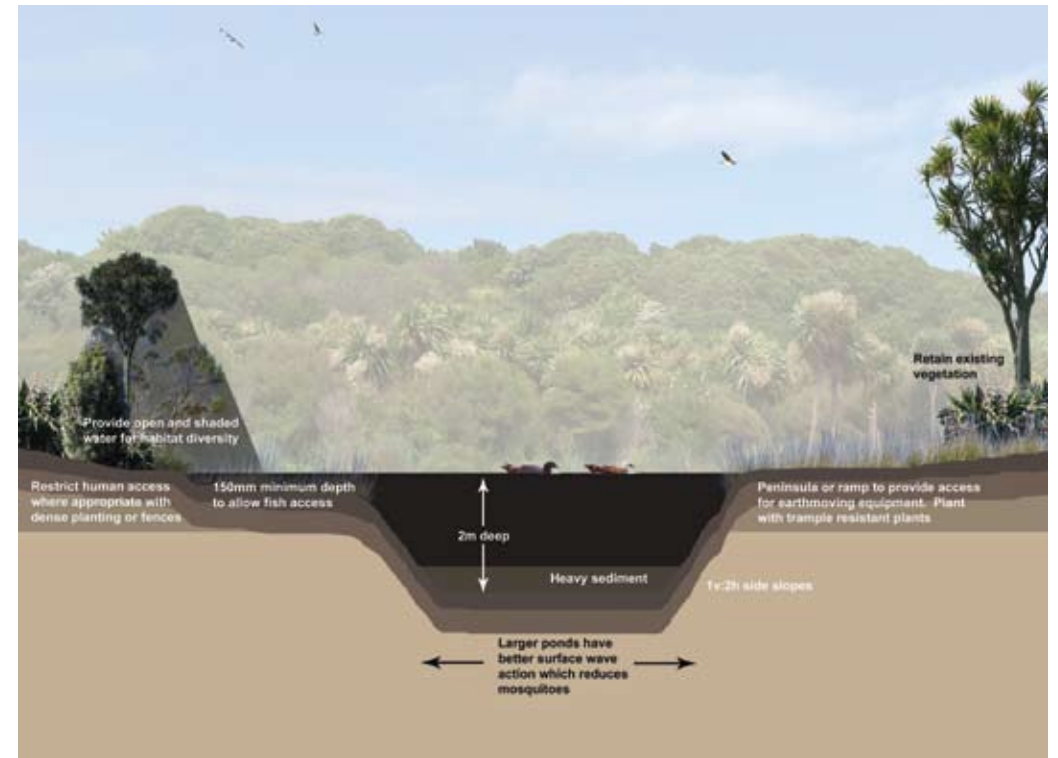
Habitat enrichment

Following the placement and shaping of a stormwater pond, there are other features of the design that need to be considered that will enrich the physical habitats created in the initial stages. These features can also be used to enhance existing stormwater ponds to increase biodiversity.

A stormwater pond with a range of habitat enrichment features.



A sediment forebay with a range of habitat enrichment features.





Plants

Plants are the most important habitat enrichment feature. They underpin the food web in ponds and wetlands, provide shelter, breeding sites and food for a range of birds and insects. The ARC strongly advocates ecosourcing native plants where possible.

- Plant a range of species according to their tolerance for water depth and frequency of inundation. **See section 5 for suitable native plants and where to plant them.**
- Aim for most of the shallow shelf to be planted in sedges and rushes that will help shade the water and keep the temperature low. Plant overhanging trees and shrubs along small sections of shoreline or on the edges of islands. These will introduce another habitat type, providing food and cover for fish from predatory birds.
- Where possible plant the full sequence of habitat zones, from open water habitat to upland slopes and extend planting zones to adjacent areas of native bush. This will dramatically increase the use of the ponds by wildlife. To ensure stability of pond embankments, woody vegetation must not be planted or allowed to grow in these areas. Pond embankments can be planted in low-growing sedges and rushes.
- Many wetland birds nest amongst sedges and rushes. Provide a natural barrier to the water edge by planting dense vegetation, such as flax, that will minimise disturbance from humans and dogs.

Flax overhanging the edge of a sediment forebay pond providing shade and cover for fish.



A dense wall of flax that discourages public access, minimising disturbance of sensitive areas of habitat where birds may be nesting.





Substrate

- Provide areas of gravel and larger rocks as these will provide habitat for fish and aquatic insects. Large rocks can be placed almost anywhere within the stormwater pond system. Place gravel in areas of higher water velocity such as at inlets and outlets, the channelised areas between islands and on the submerged shelf between the sediment forebay and main pond. This will help prevent them from becoming smothered in fine sediments.
- Place large logs in the pond that will gradually break down over time providing food as well as habitat for a range of aquatic animals. They can be either fully submerged or emergent, the latter providing perching sites for birds.
- Minimise concrete, metal and riprap. These are heat sinks and will increase the temperature of adjacent water. Where these substrates are necessary, such as at inflow and discharge points to avoid scour, plant trees or shrubs to create shade and prevent sunlight from directly heating them.

Gravel bars provide habitat for a range of aquatic insects and fish. This one is located between the forebay and the main stormwater pond.



Logs placed on the side of this stormwater pond provide perching sites for birds.



Excessive use of concrete and rock and no overhead shade, contributing to high water temperatures.





Floating wetlands

Floating wetlands provide similar habitat to islands and are a good option for enhancing biodiversity values in existing ponds that don't have islands. They also can provide additional removal of pollutants. Check out the following link for more detailed information, including construction materials and suitable native plants for floating wetlands in the Auckland Region.

Roosting sites and nest boxes

- Leave tall trees that are close to ponds, if they will not cause instability of pond embankments when they die. These provide roosting and nesting sites for herons, New Zealand kingfisher, and shags. New Zealand kingfisher need roosting sites that have a direct line of sight to the pond so they can scan for prey.
- Wooden structures that overhang water, such as viewing platforms and bridges, are good perching sites. Designs that include tall posts or horizontal railings beyond the reach of humans are preferable.
- Several wetland bird species nest in tree holes which are rarely present at a newly constructed site. Providing nesting boxes away from human activity will encourage them to take up residence.

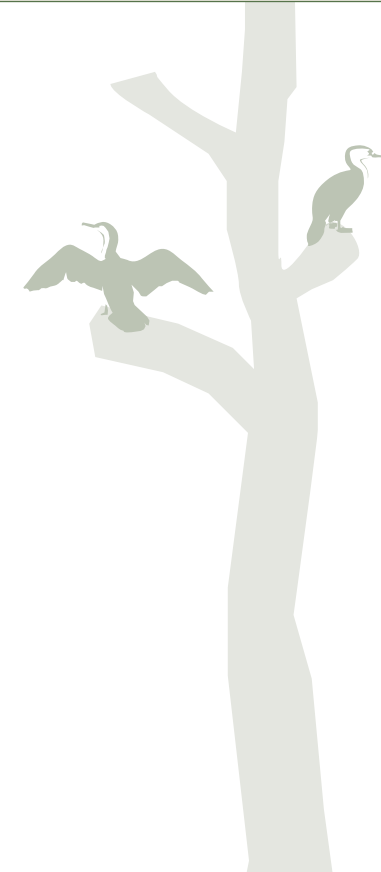
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For more detailed information, including construction materials and suitable native plants for floating wetlands in the Auckland Region.





Habitat requirements for specific native fish and some aquatic insects

There are 15 species of native freshwater fish in the Auckland Region. Whether they will take up residence in a pond depends on a range of factors, most importantly whether they are already present in the catchment, if there are no impediments to their movements, such as impassable culverts, and if they are tolerant of the typically lower water quality present in ponds. Local councils often have information about what fish are present in a catchment.

Table 1 lists some of the most likely aquatic animals to take up residence in stormwater ponds in the Auckland Region and their specific habitat requirements.

| Species | Water Requirements | Vegetation Requirements | Specific Food Requirements | Other Design Considerations |
|----------------------------------|--|--|---|---|
| Shortfin and longfin eels | Still or gently flowing water with silty or fine gravel substrate. | Adults prefer cover which can be provided by overhanging vegetation. | Small invertebrates, adults also feeding on fish. | Requires access to and from the sea. Benefit from placement of submerged logs and rocks. Refuge pools. |
| Inanga | Still or gently flowing water > 0.1 m deep | Emergent reeds provide cover for juveniles, adults spawn in grasses and rushes on tidal banks. | Small aquatic invertebrates. | Requires access to and from the sea Unable to migrate past rapids or falls. Refuge pools. |
| Common bully | Shallow, flowing water 0.2-0.3 m deep, and in lakes and ponds | Aquatic plants for spawning. | Insect larvae, snails, small fish. | Requires access from the sea to colonise, but can then form non-migratory populations. Also spawns on rocks. Refuge pools. |
| Giant bully | Coastal waters, usually within 2 km of the sea. | Overhanging vegetation. | Takes invertebrates from the substrate. | Require boulders or large rocks to hide beneath during the day. |
| Giant kokopu | Still or gently flowing water including wetlands, streams and lakes. | Overhanging and emergent vegetation. | Mostly small invertebrates that fall in to the water e.g. spiders, wasps, and ants. | Requires access to and from the sea, and lots of cover from vegetation, overhanging banks, logs, and tree roots. Refuge pools. |
| Damselflies | Still or gently flowing waters, including lakes, ponds and streams. | Submerged aquatic plants, reeds, overhanging vegetation. | Insect larvae. | Often found in urban ponds. Can tolerate some nutrient enrichment and changes in oxygen levels. |
| Aquatic snails | Any body of permanent water. | Prefer areas with submerged aquatic plants. | Algae. | Often found in urban ponds and wetlands. Tolerant of nutrient enrichment, changes in oxygen levels, and high water temperatures. Important food source for other species. |

< Table 1

Design considerations for encouraging native fish, insects, and snails in ponds and wetlands.



Habitat requirements for specific native birds

Table 2 lists some of the bird species that use wetlands and ponds in the Auckland Region and their habitat requirements. The creation of bird habitat should be targeted for ponds within residential land or areas of light commercial land use. This will ensure that birds are not drawn to habitats that are likely to have high levels of contaminants.

Table 2 >

Design considerations for encouraging native birds in ponds and wetlands.

| Species | Water Requirements | Vegetation Requirements | Specific Food Requirements | Other Design Considerations |
|------------------------------|---|---|---|---|
| Shags | Open water 0.5-3 m deep. | Tall trees for roosting. | Fish. | Encouraged by placement of roosts and perches for drying feathers, prefer areas with low human usage. |
| Bitterns | Pools of shallow water. | Dense plantings on water margins and emergent reeds. | Fish, frogs, koura, insects. | Dislike human disturbance and prefer larger wetland areas. |
| Kingfisher | No specific requirements. | Trees for roosting. | Small prey items such as fish, tadpoles, koura, insects, mice, small birds. | Encouraged by placement of roosts and perches, may nest in dead trees with nest holes. |
| Hérons | Shallow water or areas of wet ground. | Tall trees for roosting and nesting. | Small prey items such as fish, tadpoles, koura, insects, mice, small birds. | Encouraged by placement of roosts and perches |
| Spotless crane | Shallow water and areas of wet ground | Dense plantings on water margins with raupo and Carex | Small prey items such as insects, snails, and worms, and fallen fruit. | Dislike human disturbance and prefer larger wetland areas. Vulnerable to predation by cats. |
| Australasian coot | Open water to 7 m deep | Emergent reeds on water margins | Submerged aquatic plants and insects | May also graze mown lawns if nearby |
| Pied stilt | Shallow water to 0.2 m deep and areas of wet ground | Low-growing wetland vegetation | Aquatic insects | Nest on low mounds in wetlands, roost on islands covered in low growing vegetation |
| Paradise shelduck | Open water less than 1 m deep | Tall trees or dense vegetation for nesting. | Submerged aquatic plants and grasses in mown or grazed areas | Probably encouraged by placement of nest boxes |
| North Island fernbird | Shallow water and areas of wet ground | Dense, low vegetation (e.g. rushes and sedges) interspersed with taller shrubs (e.g. manuka). | Insects such as flies, beetles, and caterpillars. | More likely to be present if other freshwater or estuarine wetlands are nearby. |
| Banded rail | Shallow water and areas of wet ground | Dense plantings on water margins dominated by rushes | Snails, spiders, beetles, worms, seeds, fruits, and leaves. | More likely to be present if the site is adjacent to mangroves or saltmarsh. |
| Welcome swallow | Any body of open water | Often roost at night in raupo | Flies, midges, and moths | Nest on structures such as culverts and bridges. Building these so that they are not fully submerged during floods will create nesting sites. |



Public access

Many stormwater ponds and wetlands occur in areas open to the public and often incorporate features to encourage access. To minimise disturbance from humans to native plants and animals the following design considerations are recommended:

- Create clearly defined accessways (e.g. paths or boardwalks) that will encourage people to stay on them.
- Provide viewing platforms and boardwalks that provide excellent opportunities to view wildlife while maintaining enough distance to minimise disturbance to wildlife.
- Provide signage that both educates people about local wildlife as well as encouraging appropriate behaviours such as keeping to pathways, not feeding birds and keeping dogs on leashes.
- Keep public accessways away from some areas of dense wetland plantings as these areas are frequented by disturbance-sensitive species such as Australasian bittern and banded rail which need this space to feed and breed.



This boardwalk provides clearly defined public access and allows good viewpoints for observing wildlife in the adjacent stormwater wetlands and ponds.

Maximising biodiversity during construction

The construction phase of a stormwater pond can be very disruptive to local wildlife. Listed below are a number of measures for protecting existing biodiversity values and to enable better establishment of plants during construction.

- If ponds are being constructed 'on-line', water from incoming streams will need to be diverted around the construction site. Temporary channels should be dug around the site and lined with erosion control fabric.
- Retain as much existing vegetation as possible.
- Avoid disturbing soils around the construction site to preserve topsoil which will facilitate much faster establishment of native plants.
- Clay soils and soils in areas designated for planting that become compacted during construction, should be chisel plowed.
- Topsoils need to be spread to a depth of at least 150 mm, and not be too coarse, rocky or infertile.
- Flood topsoils at least two weeks prior to planting. This will allow them to stabilise and for any harmful toxins to be released.

Maintaining biodiversity

Features of stormwater ponds that encourage biodiversity need to be regularly checked to ensure they are functioning as intended. Maintenance should include assessments of the following, especially following extreme events such as floods and droughts:

- The operation of fish passes to ensure adequate, unblocked flow.
- The identification of any areas that may need replanting.
- The integrity and or stability of any objects included for habitat enrichment, such as bird roosts, nest boxes, and rocks.
- Checking for invasion of unwanted plants and animals.
See Section 7 for more information about this topic.



Stormwater wetlands are becoming a more popular option for treating urban stormwater as they provide a wider range of benefits than stormwater ponds, and to some degree, replace the natural wetlands that have been lost from the Auckland region. They differ from stormwater ponds in that they are shallower, dominated by wetland plants and with much less open water. For advice on their design, construction and maintenance for treating stormwater run-off see the ARC's Stormwater Design Guideline Manual (TP10).

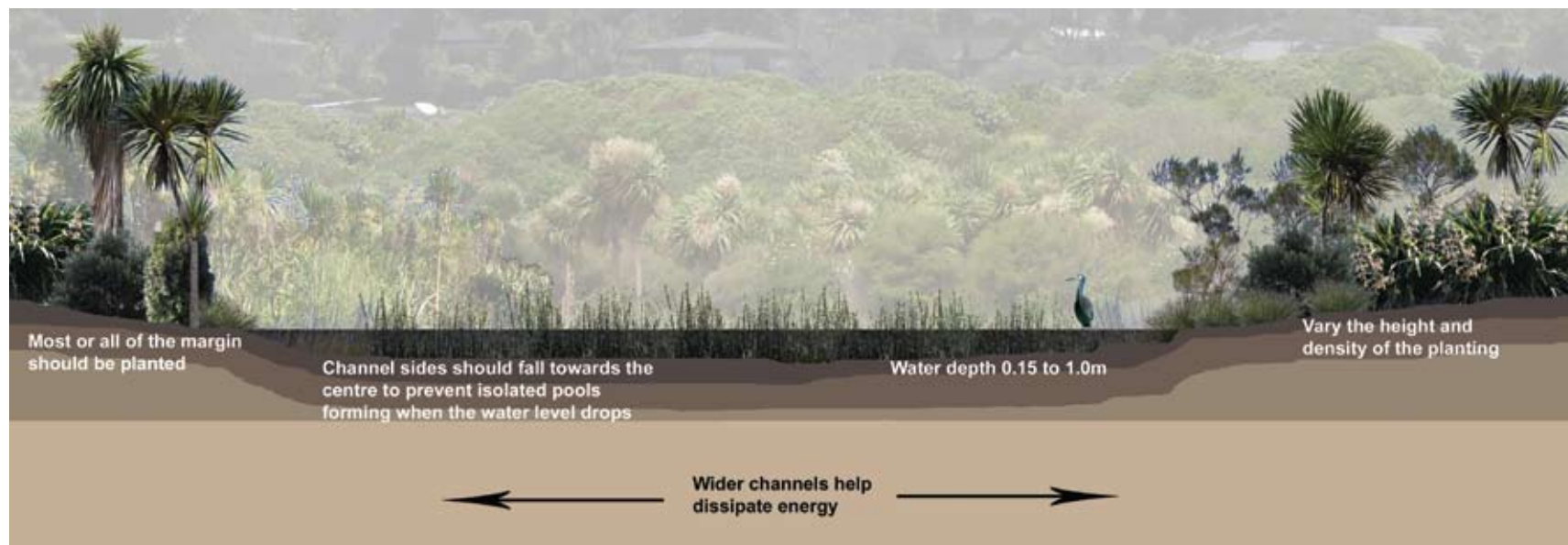
Stormwater wetlands have two main components.

1. Sediment forebay. This is a small pond before the wetland that receives run-off from an inlet. It is designed to take out coarse sediments and requires regular dredging. It contains at least 15% of the total water volume with a maximum depth of 2 m.

2. Wetland. The wetland contains the remaining water volume and is densely vegetated with wetland plants. Maximum depth is about 1 m, allowing wetland plants to establish across the entire area.

Almost all of the design features that maximise biodiversity in stormwater ponds also apply to stormwater wetlands especially if the latter incorporates areas of open water. The guidelines in section 3 can therefore be used to maximise biodiversity in stormwater wetlands. Some of the key design features are summarised below.

- A dense reed bed across most of the width of the channel will increase the uptake of contaminants, reduce water temperatures, and provide better cover for fish and secretive wetland birds.
- A minimum water depth of 150 mm across the full width of the channel will allow for fish access to all water areas and reduce the abundance of mosquitoes.
- A gradual slope towards the low-flow channel will ensure that no isolated pools of water, which could act as mosquito breeding areas, will occur in low-flow conditions.
- Dense plantings of appropriate native species on the margin of the wetland will create a continuous change of habitat types from the water to dry land, and provide nesting areas for wetland species that nest on the margins of water bodies.



- Areas of reeds and sedges with scattered taller manuka will create a two-tiered habitat favoured by wetland birds such as North Island fernbird.

< wetland cross-section



Site preparation

Ensure weeds have been controlled before planting is carried out. Be especially vigilant about the aggressive mat forming grasses, reed sweet grass (*Glyceria maxima*) and Mercer grass (*Paspalum distichum*), which will prevent wetland sedges and rushes from establishing.

Topsoil should be covered to a depth of 15 – 20 cm and lightly compacted so that it doesn't become suspended when flooded. It should be free of weed species (see section 7) and reasonably organic without too much clay or sand.

There are several key factors to successfully establish desirable plants in stormwater ponds and wetlands. These are summarised below with more detailed information available, including maintenance checklists, in the New Zealand Constructed Wetland Planting Guide.

Check out:

http://www.nzwwwa.org.nz/Constructed_Wetland_Planting_Guidelines.pdf



< Reed Sweet Grass

The shallow shelf of these two stormwater ponds are dominated by reed sweet grass and Mercer grass.

Mercer grass >

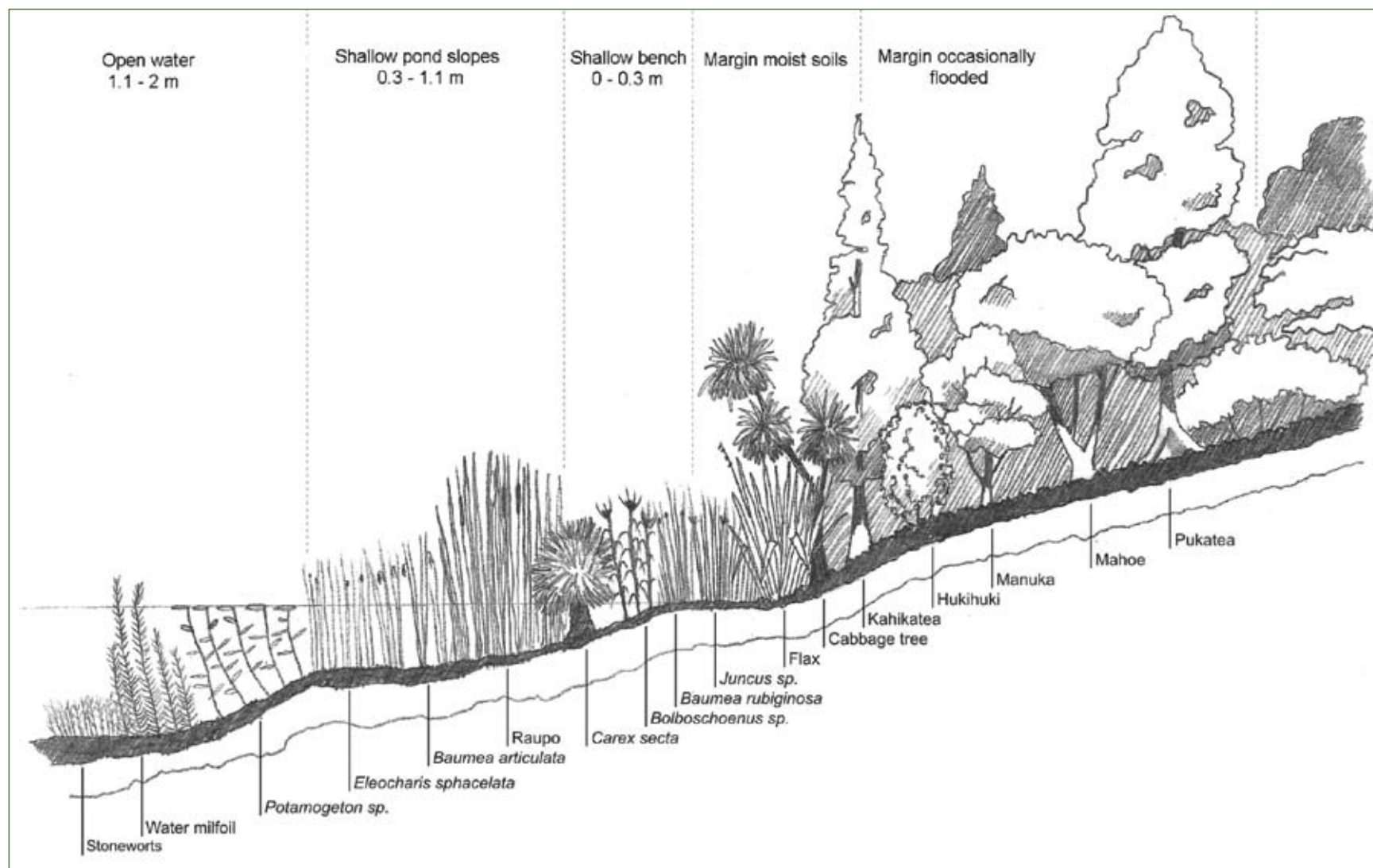




Plant species in the right place

Pond and wetland plants vary in their ability to tolerate the depth of the water table and frequency of inundation. It is crucial to plant species within their tolerance ranges.

Figure 1 shows the main planting zones with species suitable for each zone listed in the following tables.



< Figure 1: planting zones

Planting zones with common pond and wetland plant species shown in order of their tolerance to water table depth.



Shallow bench 0 - 0.3 m

- This planting zone includes the shallow shelf in a stormwater pond or wetland. The shelf is usually 3 m wide.
- This zone will usually contain standing water but the margins may dry out during dry periods and in summer.

Recommended plants for shallow bench.

< Table 3

| Plant Species | Common Name | Depth Range | Average Height | Plant Type |
|------------------------------------|-------------------------------------|-------------|----------------|------------|
| <i>Apodasmia similis</i> * | oioi | 0 – 0.3 m | 1.5 m | rush |
| <i>Baumea arthropphylla</i> | | 0 – 0.1 m | 1 m | sedge |
| <i>Baumea rubiginosa</i> | | 0 – 0.1 m | 0.9 m | sedge |
| <i>Bolboschoenus fluviatilis</i> * | marsh clubrush, kukuraho | 0 – 0.15 m | 1.5 m | sedge |
| <i>Carex secta</i> | rautahi | 0 – 0.4 m | 1.5 m | sedge |
| <i>Carex virgata</i> | purei, makura | 0 – 0.4 m | 1 m | sedge |
| <i>Cyperus ustulatus</i> | upoko tangata, giant umbrella sedge | 0 – 0.1 m | 0.8 m | sedge |
| <i>Eleocharis acuta</i> | sharp spike sedge | 0 – 0.1 m | 0.5 m | sedge |
| <i>Isolepis prolifer</i> | clubrush | 0 – 0.1 m | 0.4 m | sedge |
| <i>Schoenoplectus pungens</i> * | three square | 0 – 0.3 m | 0.8 m | sedge |

* Tolerant of saline conditions

Shallow pond slopes 0.3 – 1.1 m

- This planting zone includes the upper part of the pond slopes between the shallow bench and maximum pond depth. This slope needs to have a maximum gradient of 4:1 for safety reasons. This planting zone has tall reed-like sedges and rushes.
- This planting zone will almost always contain standing water but may dry out during exceptionally dry periods.

Recommended plants for shallow pond slopes.

< Table 4

| Plant Species | Common Name | Depth Range | Average Height | Plant Type |
|---------------------------------------|--------------------------|-------------|----------------|-------------|
| <i>Baumea articulata</i> | jointed twig rush | 0 – 0.6m | 1.5 m | sward sedge |
| <i>Eleocharis sphacelata</i> | bamboo spike sedge, kuta | 0 – 1.5 m | 1.3 m | sward sedge |
| <i>Schoenoplectus tabernaemontani</i> | lake clubrush | 0 – 1.2 m | 1.5 m | sward sedge |
| <i>Typha orientalis</i> | raupo | 0 – 1 m | 2 m | reed |



Open water 1.1 m – 2 m

- This planting zone includes plants that grow under water. They are often overlooked when preparing planting plans however they are a useful addition as they provide good habitat for fish and insects and food for wetland birds.
- Under water plants can help improve water clarity by reducing the movement of sediment in the pond. However they do need light to grow. A general rule of thumb is to plant them to about twice the depth of a mid-summer black disc reading.

Recommended plants for open water.

< Table 5

| Plant Species | Common Name | Depth Range | Average Height | Plant Type |
|---------------------------------|----------------------|-------------|----------------|--------------|
| <i>Chara globularis</i> | stonewort | 0.3 – 10 m | 2 m | aquatic herb |
| <i>Myriophyllum propinquum</i> | water milfoil | 0 – 3.5 m | 0.5 m | aquatic herb |
| <i>Nitella hookerii</i> | stonewort | 0.3 – 10 m | 2 m | aquatic herb |
| <i>Nitella pseudoflabellata</i> | stonewort | 0.3 – 10 m | 2 m | aquatic herb |
| <i>Potamogeton cheesemani</i> | red pondweed, manihi | 0.1 - 8 m | 1 m | aquatic herb |
| <i>Potamogeton ochreatus</i> | blunt pondweed | 0.1 – 3.5 m | 1 m | aquatic herb |
| <i>Ruppia polycarpa</i> | horse's mane weed | 0.1 – 3 m | 0.5 m | aquatic herb |

- Most of these species will not tolerate being smothered by excessive sediment. Therefore do not plant in the forebay of a pond or wetland. The further they are planted from the inlet the more likely they are to survive and thrive.
- Planting is usually carried out by divers who insert small (5 cm diameter) seedling pots into the bottom of the pond so they are flush with the bed. Alternatively, if water levels can be dropped, then lower the water levels and plant. From there plants will spread rapidly in spring and autumn either vegetatively or by seed / oospores.
- Order plants in bio-degradable pots. These cost more but have less impact on the environment.



Margin - moist soils

- This planting zone occurs where the water table sits at or just below the ground surface.
- Plants in this zone are very tolerant of saturated soils and can withstand being flooded for short periods.

Recommended plants for occasionally flooded margins.

< Table 6

| Plant Species | Common Name | Average Height | Plant Type |
|---|------------------------|----------------|---------------|
| <i>Alectryon excelsus</i> | titoki | 12 m | tree |
| <i>Carex dipsacea</i> * | | 0.5m | tussock sedge |
| <i>Carex flagellifera</i> * | | 0.5m | tussock sedge |
| <i>Carpodetus serratus</i> | putaputaweta | 4 m | tree |
| <i>Coprosma robusta</i> * | karamu | 3 m | shrub |
| <i>Cordyline australis</i> * | cabbage tree, ti kouka | 5 m | tree |
| <i>Dacrycarpus dacrydioides</i> | kahikatea | 30 m | tree |
| <i>Hebe stricta</i> var. <i>stricta</i> * | koromiko | 2m | shrub |
| <i>Kunzea ericoides</i> * | kanuka | 8 m | tree |
| <i>Leptospermum scoparium</i> * | manuka | 5 m | tree |
| <i>Macropiper excelsum</i> | kawakawa | 4 m | shrub |
| <i>Meliccytus ramiflorus</i> * | mahoe | 8 m | tree |
| <i>Pittosporum tenuifolium</i> * | kohuhu | 6m | tree |
| <i>Podocarpus totara</i> | totara | 30 m | tree |
| <i>Prumnopitys taxifolia</i> | matai | 30 m | tree |
| <i>Schefflera digitata</i> | pate | 3 m | tree |
| <i>Sophora chathamica</i> | kowhai | 6 m | tree |
| <i>Vitex lucens</i> | puriri | 12 m | tree |

* Hardy, fast growing plants. Plant these species first to get a dense cover of plants and then interplant with other species.

Margin - occasionally flooded

- This planting zone occurs on soils that are flooded occasionally for very short periods.

Recommended plants for moist soils on water margin.

< Table 7

| Plant Species | Common Name | Average Height | Plant Type |
|---------------------------------|-------------------------------------|----------------|------------|
| <i>Carex geminata</i> * | purei, makura | 1 m | sedge |
| <i>Carex lessoniana</i> * | rautahi | 0.5 m | sedge |
| <i>Coprosma propinqua</i> * | | 3 m | shrub |
| <i>Coprosma tenuicaulis</i> | swamp coprosma, hukihuki | 3 m | shrub |
| <i>Cortaderia fulvida</i> * | toetoe | 2 m | tall grass |
| <i>Cordyline australis</i> * | cabbage tree, ti kouka | 8 m | tree |
| <i>Cyprus ustulatus</i> * | giant umbrella sedge, upoko tangata | 0.8 m | sedge |
| <i>Dacrycarpus dacrydioides</i> | kahikatea | 60 m | tree |
| <i>Dicksonia squarrosa</i> | wheki | 4 m | tree fern |
| <i>Gahnia xanthocarpa</i> * | tupari maunga | 2 m | sedge |
| <i>Juncus pallidus</i> * | wiiwii | 1.8 m | rush |
| <i>Juncus sarophorus</i> * | wiiwii | 1.8 m | rush |
| <i>Laurelia novae-zelandiae</i> | pukatea | 20 m | tree |
| <i>Leptospermum scoparium</i> * | manuka | 4 m | tree |
| <i>Phormium tenax</i> * | flax, harakeke | 1.5 m | shrub |
| <i>Syzygium maire</i> | maire tawake, swamp maire | 20 m | tree |

* Hardy, fast growing plants. Plant these species first to get a dense cover of plants and then interplant with other species.



Timing

The open water and shallow shelf planting zones should be planted between September to February to ensure a long period of rapid growth. If possible keep water levels almost at ground surface over the shallow shelf while plants are being planted out and then immediately raise the water level so plants along the shallow shelf are flooded by 5 -10 cm of water but not submerged. This will help plants establish quickly and suppress weeds. Water levels can then be slowly raised as plants grow.

The margin planting zones can usually be planted throughout autumn, winter and spring as long as soils are moist.

Sourcing plants

The ARC recommends ecosourcing plants where possible. Check out our website for some of the suppliers of ecosourced plants – your local nursery may also supply them on request.

To find out where to source native plants in the Auckland region go to www.arc.govt.nz

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Managing pests

Pukeko and some waterfowl can destroy hours of planting in a surprisingly short time. They pull root trainer sized plants out of the ground, feeding on roots or the insects associated with them. Options for controlling pukeko and waterfowl are limited in urban areas. The most successful and acceptable options involve fencing the planted areas often using a series of electric trip wires spaced 20 – 30 cm apart and 10 cm off the ground. However often the only option is to replant plants which are pulled out. Pukekos will generally stop removing plants about six weeks after planting.





Rain gardens are small-scale stormwater devices that collect run-off from a small area such as a carpark, driveway or tennis court. The plants and soil filter pollutants in the run-off as it soaks into the rain garden resulting in cleaner water being discharged to the water table below or an outlet pipe. While rain gardens take the form of small depressions their porous soils prevent water from ponding for more than 24 hours.

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Construction guidelines for rain gardens in Auckland are described in chapter 7 of the ARC's stormwater design guideline manual (TP10).

Maximising biodiversity in rain gardens

The biodiversity of rain gardens is often limited by their small size, extreme changes in soil moisture and water levels, and their location in urban areas. There are however a number of opportunities for maximising biodiversity in rain gardens.

- Plant a diverse range of native plant species. **Appropriate species are listed in Table 8.**
- Plant a mix of dense ground cover species and taller species as this will provide more types of habitat for birds and insects.
- Include plants that will provide food for birds and insects all year round. **See Table 8.**
- Incorporate threatened plant species. Over 170 plants in Auckland are threatened and having plants grown outside of their wild habitats provides a back-up source if wild populations are destroyed. **Suitable plants are listed in Table 8.**

- Some rocks or driftwood incorporated into the rain garden will provide habitat for lizards.
- Leave rotting logs, twigs and leaves as they provide habitat for both insects and lizards.

< Rain garden cross section.



A densely planted rain garden with a diversity of ground cover and taller native plants.



Native plants for rain gardens

The Auckland Regional Council has produced a brochure on native plants for rain gardens, many of which are attractive garden plants that are easily available.

Less common plants, including threatened plants (🌿), that would increase biodiversity in rain gardens are listed in the table below.

Maintaining biodiversity

The diversity and density of plants are crucial to maintaining biodiversity in rain gardens. They should be regularly checked (every 3-4 months) and include assessments of the following:

- The identification of any areas that may need replanting.
- The integrity and or stability of any objects included for habitat enrichment, such as logs and rocks.
- Check for invasion of unwanted plants and animals.

Table 8 >

See Section 7 for more information about this topic.

Recommended plants for rain gardens.

| Plant species | Common name | Average Height | Plant type | Nectar / Pollen | Fruits, seeds & leaves | Good for insects |
|--|--------------------------------------|----------------|---------------|-----------------|------------------------|------------------|
| <i>Apodasmia similis</i> | jointed rush, oioi | 1.5 m | rush | | | |
| 🌿 <i>Astelia grandis</i> | mauri | 1.5 m | shrub | | | |
| <i>Carex secta</i> | purei, makura | 1 m | sedge | | | |
| <i>Carex testacea</i> | | 1 m | sedge | | | |
| <i>Carex virgata</i> | rautahi | 0.5 m | sedge | | | |
| <i>Cortaderia fulvida</i> | toetoe | 2 m | tussock grass | | | |
| 🌿 <i>Carmichaelia williamsii</i> | tree broom | 4 m | shrub | All year | | |
| 🌿 <i>Coprosma rigida</i> | mikimiki | 2 m | shrub | | Mar | |
| <i>Cordyline australis</i> | cabbage tree, ti kouka | 5 m | tree | Nov | Jan-April | ✓ |
| <i>Cyperus ustulatus</i> | giant umbrella sedge, upoko tangata, | 0.8 m | sedge | | | |
| 🌿 <i>Empodisma minus</i> | wirerush | | rush | | | |
| 🌿 <i>Euphorbia glauca</i> | Waiu-atua, New Zealand sea spurge | 0.8 m | shrub | Sep-March | Dec-July | |
| <i>Gahnia xanthocarpa</i> | tupari maunga | 2 m | sedge | | | |
| <i>Ficinia nodosa</i> | wiiwii | 1 m | sedge | | | |
| 🌿 <i>Hebe bishopiana</i> | | | shrub | Mar-Aug | | |
| 🌿 <i>Hebe speciosa</i> | | 2 m | shrub | Jan-Oct | | ✓ |
| <i>Juncus pallidus</i> | wiiwii | 1 m | tussock rush | | | ✓ |
| <i>Juncus sarophorus</i> | wiiwii | 1 m | tussock rush | | | |
| <i>Leptospermum scoparium</i> | manuka | 4 m | tree | | | |
| 🌿 <i>Lophomyrtus obcordata</i> | ramarama | 5 m | shrub | Dec-Feb | Jan-Apr | ✓ |
| <i>Machaerina sinclairii</i> | tuhara | 1 m | sedge | Oct-Nov | Dec-Jan | |
| <i>Muehlenbeckia complexa</i> | pohuehue | 1.5 m | shrub | Nov-Jun | Nov-Jun | |
| 🌿 <i>Myrsine divaricata</i> | weeping mapou | 3 m | tree | | | ✓ |
| <i>Pittosporum cornifolium</i> | | 2 m | shrub | Jun-Sep | Oct-Mar | |
| 🌿 <i>Pimelea longifolia</i> | native daphne | 1 m | shrub | Sep-Jan | Sep-Jan | |
| 🌿 <i>Pimelea tomentosa</i> | native daphne | 0.5 m | shrub | Sep-Dec | Oct-Jan | |
| <i>Phormium tenax</i> | harakeke, flax | 2 m | shrub | Nov-Jan | | |
| 🌿 <i>Pomaderris aff. phyllicifolia</i> | tauhinu | 1 m | shrub | Oct-Nov | Nov-Jan | ✓ |
| 🌿 <i>Plagianthus regius</i> | manatu, lowland ribbonwood | 12 m | tree | Oct-Jan | Dec-Feb | |
| <i>Pseudopanax crassifolius</i> | horoeka, lancewood | 5 m | tree | | | |
| <i>Sophora microphylla</i> | kowhai | 10 m | tree | Sep-Nov | Sep-Oct | ✓ |
| <i>Sophora chathamica</i> | kowhai | 10 m | tree | Sep-Nov | Sep-Oct | |



Far too often stormwater ponds, wetlands and rain gardens become home to a range of unwanted plants and animals. They can be unwanted for a range of reasons the most common being:

- They reduce the diversity and abundance of native plants and animals that inhabit the area.
- They pollute waterways, create unpleasant odours and are a visual eyesore (e.g. algal blooms, rotting water weeds, over-abundance of faeces from too many waterfowl).

Careful planning and ongoing checks are necessary at all stages of designing, constructing and maintaining stormwater ponds, wetlands and rain gardens to reduce the chances of unwanted plants and animals establishing. Table x, lists the most troublesome plants and animals, and what to do, to prevent them from establishing and becoming a nuisance.

Regular checks

The most cost-effective and efficient way to reduce unwanted plants and animals is to stop them from becoming established at a site. Most invasions of unwanted plants and animals start with the arrival of only a few individuals to a site. Early detection is therefore crucial to keep problems to a minimum. Recommendations for conducting checks include:

- Carry out a thorough survey of adjacent natural areas, especially upstream of ponds and wetlands, to identify unwanted fish and weeds in the vicinity before construction begins. Implement a plan based on the survey to reduce the risk of invasion.
- Once construction begins conduct regular checks for unwanted plants and animals. Check monthly during construction, then every 3 months for the first 2 years. Thereafter checks 2-3 times a year are recommended.
- In addition to regular checks, check ponds and wetlands after major flooding events as these can wash down unwanted plants and fish from upstream water bodies.

Eradicate or control unwanted plants and animals if possible before construction begins For more information check out our website:
www.arc.govt.nz

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Advice can be obtained from the ARC on the control and management of many pest species ph 09 366 2000 or visit www.arc.govt.nz

The ARC has produced a series of information sheets on unwanted plants and animals. These can be found on our website at www.arc.govt.nz

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| Species | Design stage | Construction stage | Maintenance stage |
|--|---|--|--|
| Algae | Locate ponds at the downstream end of wetlands so that cleaner water enters the ponds. Densely plant shallow water areas in emergent species. Plant tall trees on pond margins to increase shading. | | |
| Mosquitoes | Minimum water depth of 0.15 m. Create riffle areas. Allow for fish migration. Encourage mosquito predators with plantings. | Avoid the creation of ponding in vehicle ruts. Remove rubbish that may trap water (e.g. vehicle tyres). | Ensure grass clippings and other cut vegetation doesn't enter water. |
| Gambusia (mosquito fish) | Reduce water temperatures by minimising use of concrete and metal, and by planting. Allow for drainage of water so that eradication is possible. | | Regularly check for presence and eradicate if they arrive. |
| Koi, perch, tench, rudd and catfish | Discourage introduction by public by including appropriate signage. | If present in catchment upstream, eradicate if possible. | Regularly check for presence and eradicate if they arrive. |
| Exotic waterfowl (e.g. mallards, swans, geese) | Densely plant margins to reduce sunny, loafing areas. Discourage feeding by public by including appropriate signage. | | |
| Aquatic weeds | Discourage introduction by public by including appropriate signage. Allow for drainage to facilitate control. | If present in catchment upstream, eradicate if possible. Ensure construction equipment is cleaned before transport to site. Ensure topsoil and plants transported to site are weed free. Rapidly establish desirable species. | Regularly check for presence and eradicate if they arrive. |
| Other weeds | | Ensure construction equipment is cleaned before transport to site. Ensure topsoil and plants transported to site are weed free. Rapidly establish desirable species. | Regularly check for presence and eradicate if they arrive. |

Table 9 >

Ways to minimise unwanted plants and animals in stormwater ponds, wetlands and rain gardens.



Site hygiene

Site hygiene is about ensuring that unwanted plants and animals don't arrive and contaminate the site during the construction phase. Seeds, plant fragments and even fish eggs have been known to hitch a ride with materials and equipment brought to a site. These guidelines will help keep the site clean:

- Water blast or steam-clean construction machinery prior to being transported to the site.
- Check the source site for topsoil, rocks, and gravel for undesirable plants.
- Plant stock should be inspected both to verify its correct identification, and to ensure that only the intended species are growing in the planting medium.
- If wild-collected plant material is to be transferred to the site this material should be quarantined for a period to check for unwanted plants.
- Oversight of construction is recommended to ensure that the contractor complies with these guidelines.



These flax bushes have been planted too far apart and now several weed species dominate the area.

Rapidly establish desirable plants

One of the best ways to prevent weeds establishing at a site is to rapidly establish desirable plants.

- Plant fast-growing native species appropriate to the site (see the planting section).
- Plant species close together to ensure they grow into the gap between them in 2-3 years thereby keeping weeds from establishing. Plant sedges and rushes 0.5 m apart, trees and shrubs 1 -1.1 m apart, and flax 1.2 m apart.
- Use good quality seedlings that have been hardened for the open conditions.
- Use PB2 and PB3 sized seedlings of trees and shrubs. The smaller root trainer size can be used for species that are known to do well from this size. These include sedges and rushes, flax, kanuka, manuka, karamu and cabbage tree.
- If planting with native species is going to be delayed, the site should temporarily be sown in grasses to suppress weed growth, it will also help reduce erosion.
- Where possible avoid exposing substrates when nearby weeds that produce prolific wind dispersed seeds are seeding. Well known problematic species in Auckland include grey willow and pampas.
- Pest animal control, particularly of rabbits, hares, and possums, may be required to ensure successful establishment. In areas with high numbers of animal pests, planting root trainer sized plants is not recommended.



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