# Part 2:

Practical guidance

# Introduction

Part 2 of the Haydon Park Investigation Study provides practical guidance on how to incorporate tree canopy cover within stormwater basins. It is intended to be used as a reference guide for anyone introducing tree canopy cover into dual-purpose open spaces that have a stormwater infrastructure function.

Part 2 of the study provides:

Quality tree canopy planting toolkit - outlines suitable tree and ground cover species to use within Greater Sydney.

Care and maintenance – considerations for stormwater detention basins and drainage corridors.

Considerations for infrastructure – technical aspects of stormwater infrastructure that need to be considered when incorporating trees.

Case studies – examples of different ways that trees have been successfully incorporated into stormwater infrastructure.

# Quality tree canopy planting toolkit

In order to provide quality tree canopy, there are several components that are critical to its success. This includes selection of the right:

1. tree species for the location, soil conditions and desired biodiversity outcomes.
2. groundcover planting that will supress weed growth and help establish a healthy biomass supporting tree growth.

Good-quality growing conditions enable plants to establish and create good habitat that supports a sustainable biodiversity outcome. This in turn retains nutrients in the soil, adding to the improved growing conditions.

The investigation study has identified typical biotopes and conditions that are most prevalent across the Sydney basin. These have been correlated with the conditions found in the different types of open space that are also required to function as stormwater infrastructure to identify the selections of tree species and ground covers that will provide the best outcome.

## Tree palette

The tree palette aims to represent two significant biotopes found within the Cumberland Plains – Riparian Woodland and Plains Open Woodland. In nature, these woodlands are separated based on soil type and water availability. The tree species have been selected for the specific growing conditions. This will improve tree health, potential tree canopy cover and increase tree life expectancy. This separation will also help to identify the presence of water. People will experience the division between a wet and dry landscape via the colours, shapes and sizes of the trees.

It is recommended that trees are planted out in different sizes, to introduce age diversity, economic viability and a natural aesthetic emulating successional growth patterns. The planting palette has been selected and specifically tailored to Haydon Park but may be modified to suit other Western Sydney district locations.

## Groundcover palette

The ground cover planting palette will include mowed grass for maintenance ease, familiarity and recreation along with tussock grasses, sedges and shrubs planted below many of the forested areas. These groundcovers will consist of species that feature in the Cumberland Plains as well as species with favourable aesthetic qualities, availability and longevity.

**Figure 20**: Riparian woodland planting

**Figure 21**: Plains open woodland planting

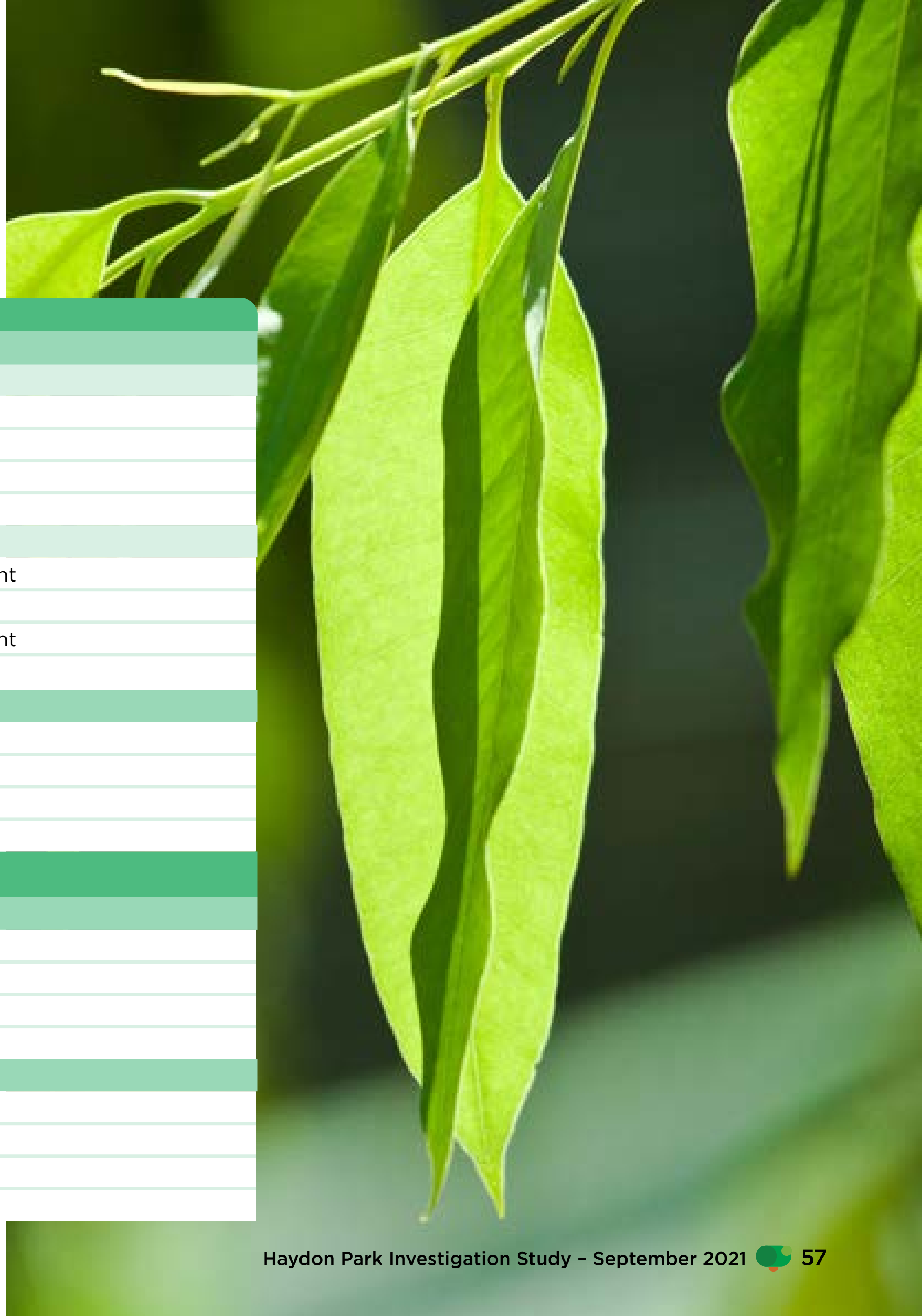


**Table 10**: Plains open woodland and riparian woodland planting schedule

# Plant information

| Suggested species | | | Maturity size | | Growth rate | | | Seasonality | |
|---|---|---|---|---|---|---|---|---|---|
| **Latin name** | **Common name** | **Family** | **Height** | **Width** | **Slow** | **Medium** | **Fast** | **Evergreen** | **Deciduous** |
| **Typology 1: Dry plains woodland** | | | | | | | | | |
| **Trees** | | | | | | | | | |
| Upper bank areas | | | | | | | | | |
| *Eucalyptus moluccana* | Grey Box | Myrtaceae | 25 | 15 | | | • | • | |
| *Eucalyptus crebra* | Narrow-leaved Ironbark | Myrtaceae | 25 | 25 | | • | | • | |
| *Allocasuarina littoralis* | Black Sheoak | Casuarinaceae | 15 | 8 | • | | | • | |
| *Acacia binervia* | Coastal Myall | Fabaceae | 15 | 10 | | | • | • | |
| Lower areas | | | | | | | | | |
| *Eucalyptus benthamii* | Camden White Gum | Myrtaceae | 20 | 15 | | • | | • | |
| *Brachychiton populneus* | Kurrajong | Malvaceae | 10 | 8 | | • | | • | |
| *Eucalyptus longifolia* | Woollybutt | Myrtaceae | 20 | 15 | | • | | • | |
| *Angophora bakeri* | Narrow-leaved Apple | Myrtaceae | 10 | 10 | • | | | • | |
| **Ground cover** | | | | | | | | | |
| *Aristida ramosa* | Purple Wire-grass | Poaceae | 0.8 | 0.8 | | | | • | |
| *Dianella longifolia* | Blue flax-lily | Asphodelaceae | 0.8 | 0.6 | | • | | • | |
| *Themida triandra* | Kangaroo Grass | Poaceae | 0.9 | 0.8 | | • | | • | |
| *Lomandra longifolia 'verday'* | Lomandra Verday | Asparagaceae | 0.6 | 0.6 | | • | | • | |
| **Typology 3: Riparian woodland** | | | | | | | | | |
| **Trees** | | | | | | | | | |
| *Melaleuca linariifolia* | Narrow-leaved Paperbark | Myrtaceae | 6 | 7 | | • | | • | |
| *Angophora subvelutina* | Broad-leaved Apple | Myrtaceae | 18 | 15 | | | | • | |
| *Eucalyptus amplifolia* | Cabbage Gum | Myrtaceae | 30 | 15 | • | | | • | |
| *Melaleuca decora* | White Feather Honeymyrtle | Myrtaceae | 12 | 5 | | • | | • | |
| **Ground cover** | | | | | | | | | |
| *Carex appressa* | Tall Sedge | Cyperaceae | 0.9 | 0.8 | | • | | • | |
| *Juncus usitatus* | Common Rush | Juncaceae | 1.2 | 1.5 | | • | | • | |
| *Microlaena stipoides* | Weeping Grass | Poaceae | 0.2 | indefinite | | | • | • | |
| *Themida triandra* | Kangaroo Grass | Poaceae | 0.9 | 0.8 | | • | | • | |

| Species mix | Comments |
|---|---|
| | |
| | |
| | |
| 30% | |
| 30% | |
| 20% | Local sheoak |
| 20% | Long lived acacia |
| | |
| 25% | Local native that has lost much of its range to development |
| 25% | Local native |
| 25% | Local native that has lost much of its range to development |
| 25% | |
| | |
| 20% | |
| 20% | |
| 30% | |
| 30% | |
| | |
| | |
| 40% | Vigorous roots and lollypop form if planted as specimen |
| 10% | |
| 10% | |
| 40% | Vigorous roots and lollypop form if planted as specimen |
| | |
| 20% | |
| 20% | |
| 30% | |
| 30% | |



# Care and maintenance

## Maintenance

Increased maintenance costs are commonly cited as a key concern of vegetated stormwater systems. This is primarily due to two factors: the change in maintenance practice for these assets; and that councils often receive assets in poor condition.

Maintaining natural areas is a different cost base and skill set to formal turfed areas. When appropriate maintenance regimes are understood and followed, vegetated stormwater systems are viable. The establishment phase of these systems is critical so that standard maintenance can be implemented on an ongoing basis.

Maintenance of vegetated stormwater systems and natural waterways requires the right maintenance practices and an understanding of the correct way to apply them.

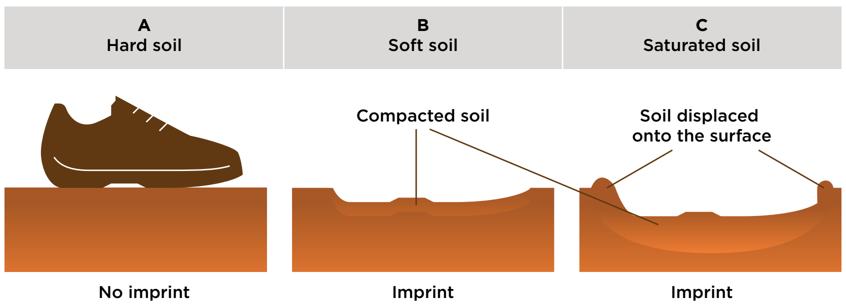
Converting existing grass drains or retarding basins into riparian corridors with trees presents a change to the existing maintenance regime. This may require different maintenance teams to take responsibility for managing these assets, which requires appropriate resourcing of these teams.

Normal retarding basin maintenance procedures (regular outlet inspection and maintenance) will mean trees in the floor of the basin do not represent a management issue. In some instances, urban litter is effectively captured prior to entering retarding basins. Where trees have the potential to introduce blockage risks, designers should consider retrofitting the outlet structure to increase protection against blockage. Designers should consider the size, angle and number of facets of the outlet and grill to maintain sufficient hydraulic effectiveness during blockage scenarios.

During the establishment of planting, maintenance requirements will increase to establish healthy growth of the new plants (for exampe, irrigation, replacement tube stock and suppress weeds). This establishment phase is usually 1 to 2 years. After this period, healthy vegetated systems should require a reduced level of maintenance.

**Figure 22**: Vegetated waterways and wetlands at Sydney Park, St Peters, Sydney. *NSW Department of Planning, Industry and Environment / Salty Dingo*

**Figure 24**: Waterlogging and soil displacement




## Erosion and soils

The risk of erosion can come from several factors and a combination of approaches are needed to prevent erosion.

Some soils tend to become dispersive in water, which can lead to significant erosion. In natural conditions, dispersive soils can remain in place undisturbed for long periods of time, protected by overlying natural topsoil and vegetation. However, exposing the surface of these soils risks erosion through dispersion in the presence of surface water or rainfall.

In many existing drainage assets, the treatment is simple mown grass. This is because historically they have not been viewed or valued as quality public open spaces. The default use for larger spaces that act as drainage assets has been low-grade sporting fields. These fields always struggle to maintain good quality turf growth as they experience waterlogging on a regular basis. The implications of water logging includes:

- water pooling on the surface causes layering and compaction of the upper sections of the soil profile
- soil layering and compaction that impacts ability of grass to spread roots and access nutrients
- foot traffic causes further compaction of waterlogged surface displacing nutrient-rich soil. Reducing the occurrence and impact of water logging is crucial to soil health and the ability for it to support turf growth.

To counteract this, the application of gypsum (CaSO4) is commonly recommended to prevent soil erosion where soils identified as being dispersive are exposed. After applying gypsum, subsoils should be covered with imported topsoil and vegetation to prevent exposure of the treated dispersive soil to surface water.

In the case of Haydon Park, field investigations undertaken by SESL in 2017 identified disturbed topsoils and natural underlying subsoils. Importantly, magnesic and sodic soils were consistently observed throughout the Haydon Park and Copperfield Drive boreholes. Sodic and magnesic soils are two types that tend to become dispersive in water. For Haydon Park, the application of gypsum is recommended, as well as using a layer of geotextile material to act as an additional protective barrier between the low-flow channel and the underlying soils.

Changing the mown grass surface and introducing a channel requires management of scouring to prevent erosion. Surface treatments should be selected in response to estimated water velocities. For Haydon Park, a combination of rock lining and concrete weirs will be required to protect the channel from erosive flows.

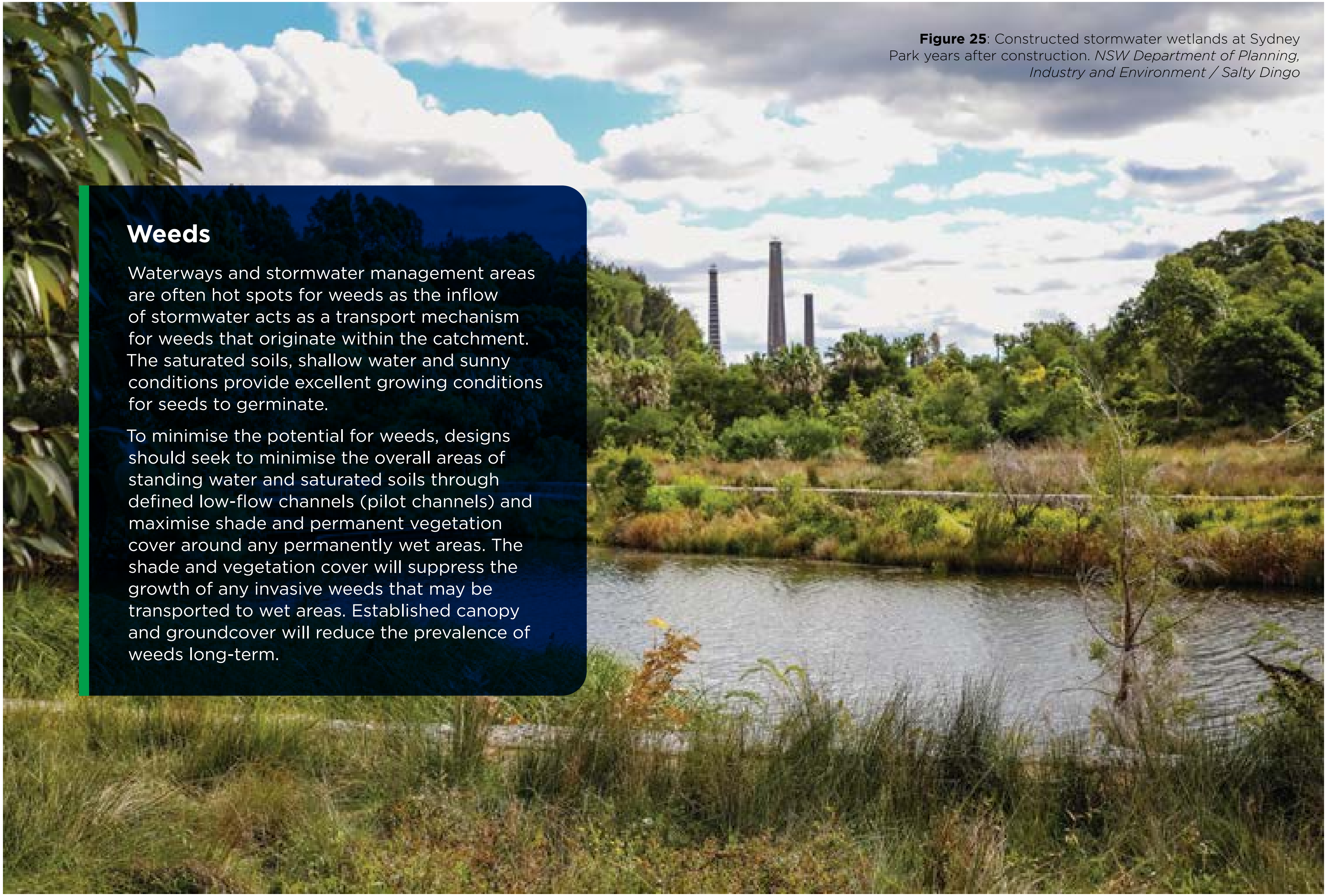


**Figure 25**: Constructed stormwater wetlands at Sydney Park years after construction. *NSW Department of Planning, Industry and Environment / Salty Dingo*

## Weeds

Waterways and stormwater management areas are often hot spots for weeds as the inflow of stormwater acts as a transport mechanism for weeds that originate within the catchment. The saturated soils, shallow water and sunny conditions provide excellent growing conditions for seeds to germinate.

To minimise the potential for weeds, designs should seek to minimise the overall areas of standing water and saturated soils through defined low-flow channels (pilot channels) and maximise shade and permanent vegetation cover around any permanently wet areas. The shade and vegetation cover will suppress the growth of any invasive weeds that may be transported to wet areas. Established canopy and groundcover will reduce the prevalence of weeds long-term.

# Considerations for infrastructure

## Stormwater infrastructure suited to tree planting

The study identified there are typically two kinds of stormwater systems that have potential for tree planting programs.

1. Flood-retarding basins (also known as detention basins)
2. Drainage channel easements

This section looks at the technical aspects that need to be considered when incorporating trees into these types of stormwater infrastructure.

## Trees in retarding basins

Flood retarding basins are designed to temporarily hold water during major storm events, to reduce the downstream flooding impacts. The primary function of a flood-retarding basin is to provide storage to hold flood water and control the release of the water through a designed outlet. Such basins are constructed to reduce the cost of downstream channel upgrades, to reduce downstream flooding impacts or to meet requirements restricting urban catchment outflow peaks.

Retarding basins are typically not limited in their conveyance capacity due to their wide expansive area for flows to spread. Basins fill via back watering effect when the outlet reaches capacity. As such, locating trees in the basin does not affect the hydraulic function of retention basins. An exception to this is where open channels are located within retarding basins (for example, high early discharge designs), in this instance, further consideration for hydraulic capacity may be needed.

Adding trees to an existing retarding basin requires consideration of:

1. Storage volume
2. Outlet structure
3. Embankments.

### Storage volume

Retarding basins are designed to create a large storage volume to store water during storm events. Ensuring the storage volume is maintained is important for the effective functioning of the basin. Ways storage volume can be compromised include repositioning of embankment walls that reduce the overall footprint of the basin, filling within the basin, and gradual sediment accretion within the floor of the basin.

Depending on the number of trees being planted, the biomass of the trees will occupy some of the available storage for flooding. While the effects of trees' biomass on the overall volume of storage will in most cases be small, this can be managed by some compensatory excavation. Designers can compensate for any loss in storage associated with the tree biomass in various ways, such as:

- planting trees within depressed zones of the basin (for example, localised depressions around each tree)
- using excavated channels to route flows to the trees for passive irrigation from regular rainfall events.

In both cases, the volume of excavation should be equal to or greater than the volume of the trees' biomass (measured below the 1% AEP flood level, plus 0.5m freeboard).

There is evidence that trees can improve soil hydraulic conductivity and help store additional water in the soils of a retarding basin during the start of a rainfall event. This is beneficial for frequent storm events throughout the year as absorbing stormwater in the soils will decrease the total volume of runoff to receiving waterways, easing hydraulic stress and reducing pollutant loads to waterways. However, the effect of improving soil hydraulic conductivity on major flood events, such as the 5% AEP, is likely to be insignificant. Unfortunately, while models like MUSIC (Model for Urban Stormwater Improvement Conceptualisation) exist that could allow engineers to estimate the total annual flow reduction provided by trees in flood basins, these results are not transferable to flooding impacts.

### Outlet structure

Regular maintenance is a critical factor to ensure the long-term safe operation of retarding basins. In NSW, regular maintenance of retarding basin outlets is a major concern of the Dam Safety Committee, acknowledging outlets are often 'allowed to clog up with trash, and/or become completely overgrown, severely limiting the capacity of the basin and increasing the probability of its failure under flood conditions'. When located appropriately, trees in retarding basins don't represent extra risk of outlet blockage

### Embankments

Retarding basins are typically either cut into the surrounding landscape or can be bunded on one or more sides to create a large volume for storing water. When basins store water, they become temporary reservoirs, storing significant volumes of water, and therefore they impose dam safety risks on communities downstream. The structural integrity of the embankments is therefore critical. Because of this, trees should not be planted on fill embankments as during extreme storms trees can be uprooted, taking part of the embankment with them. This can cause issues downstream where increased flooding can occur risking damage to properties and safety risks.

Regular geotechnical inspections of the basin embankments are necessary to check the structural integrity of the wall. For these inspections to occur, most councils prefer short mowed grass to other vegetation types on embankments, allowing cracks and other geotechnical defects to be easily observed and measured during inspections. The New South Wales Dam Safety Committee recommends embankments 'should be protected by a uniform, robust, grass cover that can be routinely mowed'. Trees can, however, be freely planted within the floor of the basin and on slopes cut into the surrounding landscape.

**Figure 26**: Photograph of the existing Haydon Park cut embankment

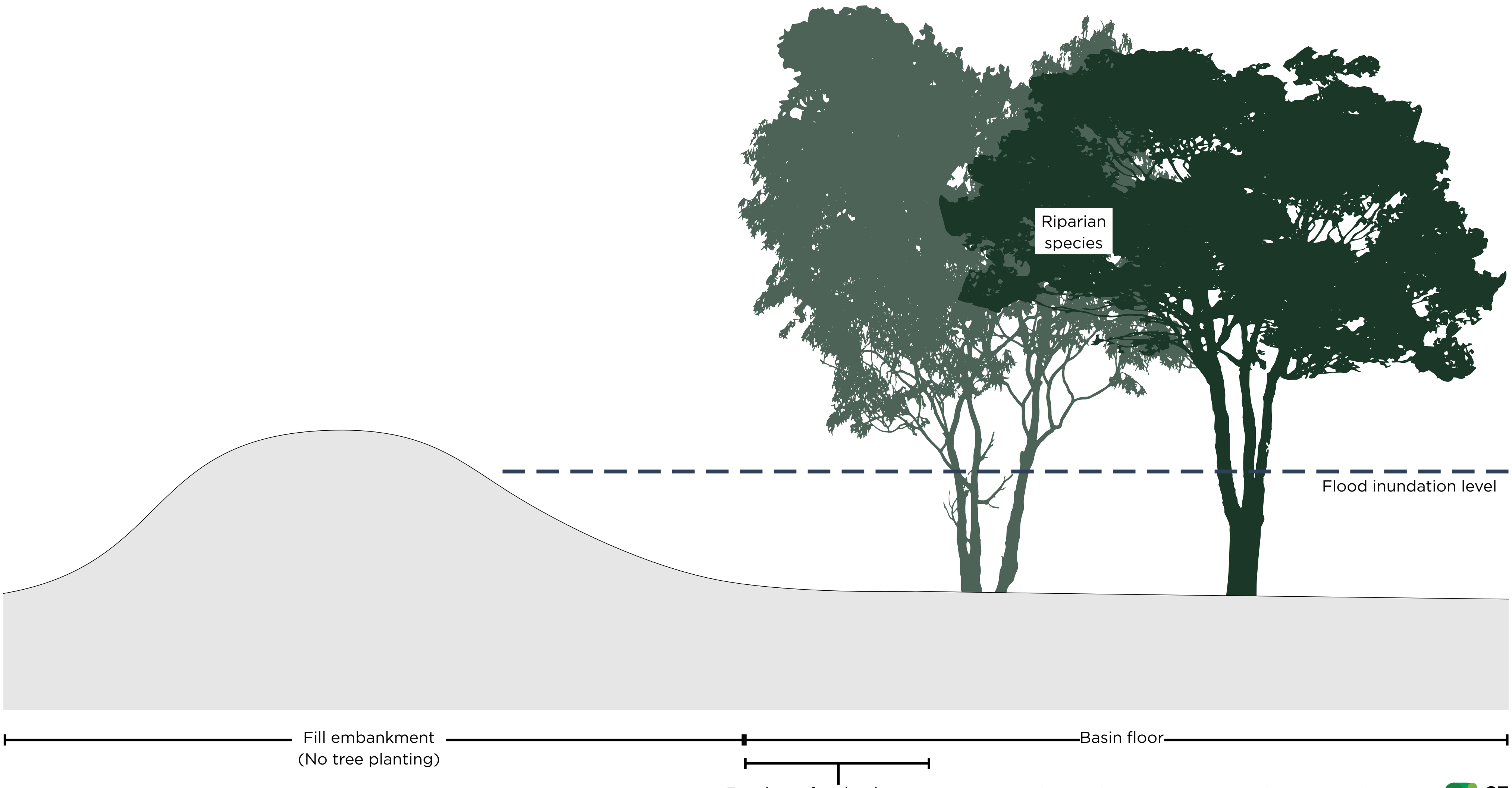
**Figure 27**: Photograph from the top of existing Haydon Park fill embankment

**Table 11**: Planting trees in flood-retarding basins

| Flood-retarding basin location | Trees | Species selection |
|---|---|---|
| Basin floor (min. 3m clear of fill and outlet structures) | ✓ | Tolerant of both saturated soil conditions and dry spells. Where planting within dedicated frequent flow paths or wet zones, opt for riparian species. |
| Fill embankment (dam walls) | ✗ | n/a |
| Cut embankments (slope areas in cut) | ✓ | Wet/dry tolerant species. |

Figure 28: Tree planting on cut embankments

**Figure 29**: Tree planting on fill embankments



## Trees in channels

### Open channels

In urban stormwater catchments, open channels are a common form of stormwater conveyance where waterways, ephemeral creeks and natural overland flow paths have been replaced with constructed engineered channels. These channels are designed to convey water efficiently in a constrained space. Given these systems are often constrained spatially, their conveyance capacity is critical to protecting adjacent areas from what is known as fluvial flooding during major and extreme flood events.

Fluvial flooding (flooding when channels, creeks and rivers exceed their capacity) is influenced by channel capacity, sinuosity (that is, how much a channel bends and its related bed slope) and roughness. Projects that involve planting trees in open channels can influence all three of these factors.

### Roughness

Trees placed within the extent of inundation will increase roughness and slow flows, so too can other vegetation as well as rock and wood. The greater extent and/or height of the roughness, the slower water flow during flood events, which will increase water levels and may cause unacceptable flooding.

### Channel bends

On larger projects where there is room to change the planar shape of a channel, designs can influence the sinuosity of the system, introducing a meandering form. This is desirable to slow flows down and create diversity of flow patterns typical in a healthy riparian system. The straighter the channel, the more efficient the flow path. As such, the degree of bends will influence the depth of flooding, similarly to how increasing roughness influences flooding.

### Channel capacity

The geometry of the channel and its physical capacity naturally changes the conveyance capacity of the system. Usually, the channel capacity will be altered in a channel naturalisation project (or where significant new volumes of trees are introduced within the inundation extent) to compensate for increased roughness and meandering, ensuring that the works maintain or improve existing flood protection. This can be done by steepening the side slopes of the channel to create more cross-sectional capacity.

**Figure 30**: Relationship between channel roughness and capacity

## Where to plant trees

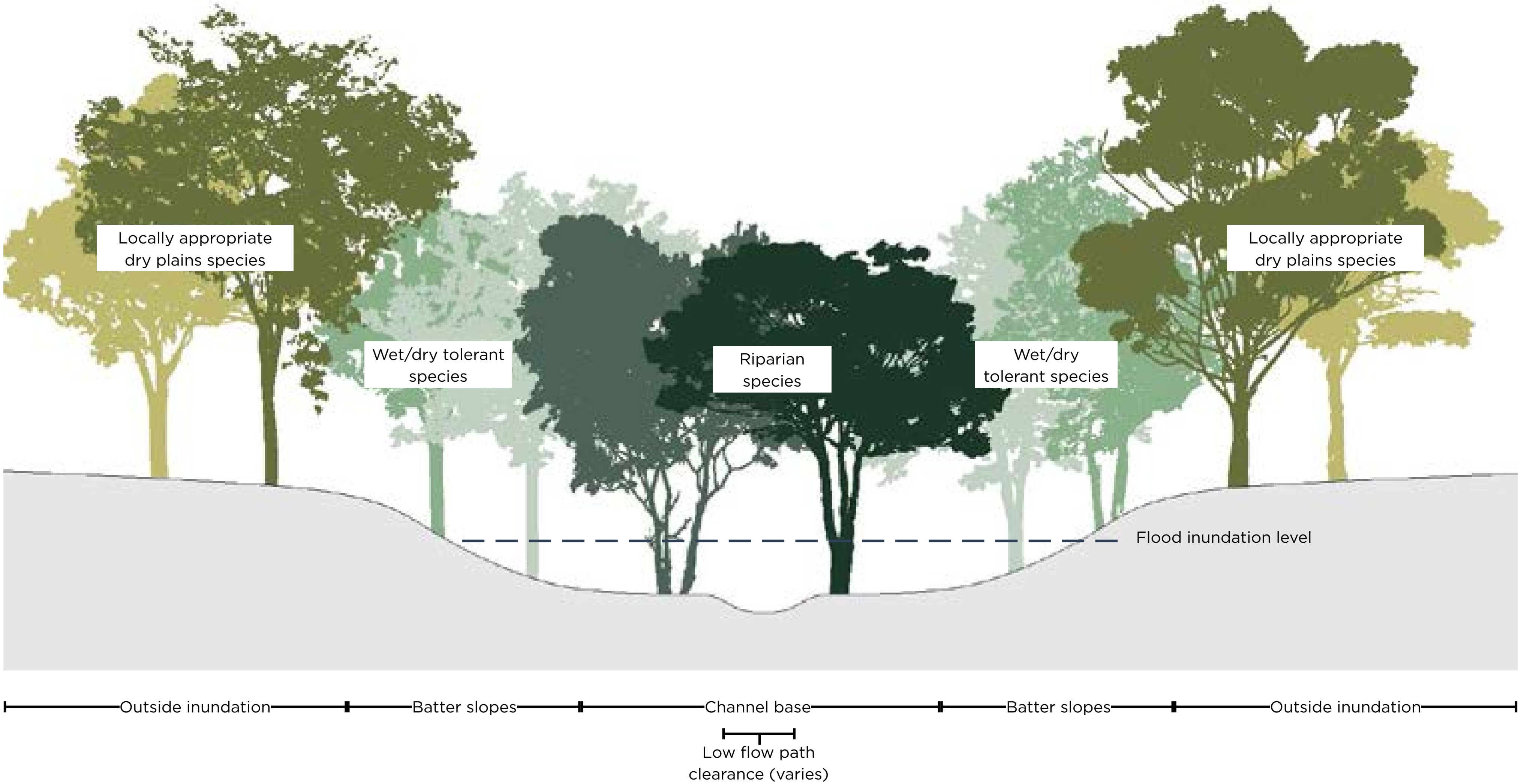
The placement of trees within open channels is essentially limited by the site's spatial and hydraulic constraints. The more space, the more freedom to plant trees while maintaining flood protection. Other site factors such as underground and overhead services will also influence where trees can be located.

**Table 12**: Planting trees in channels

| Open channel location | Trees | Species selection |
|---|---|---|
| Outside flood inundation extent | ✓ | Locally appropriate, avoid deciduous trees |
| Batter slopes | ✓ | Wet/dry tolerant species |
| Base of channel (provide clearance for low flow path, width will vary for each site/ design) | ✓ | Riparian species |

Note: Hydraulic conveyance capacity checks needed. Excavation may be required to maintain flood performance.

Figure 31: Tree allocation within drainage channel



# Case studies

## Detention basins

**Case study: detention basins**

The following examples demonstrate vegetated retarding basin systems used to manage peak stormwater flows and flooding as a result of urban development.

Most of these systems have been operating for many years. All the provided examples have different contexts but demonstrate that retarding basins can be vegetated and form part of the local and regional open space system. These are a selection of examples that are simple and effective and include a number of relatively old systems to demonstrate that trees can be easily maintained in retarding basins in the long term.

**Figure 32**: Yarraman Creek retarding basin, Springvale. *Source: E2 Design Lab*

**Figure 33:** Hidden Grove retarding basin, Keyborough. *Source: E2 Design Lab*

**Figure 34**: Greens Road retarding basin, Mooroolbark. *Source: E2 Design Lab*

## Channels

**Case study: Clear Paddock**

Clear Paddock Creek was a concrete stormwater drain in Fairfield, New South Wales, that was restored to a beautiful living stream through a rich landscape in 2000. The project developed an urban landscape of biodiversity with clean, clear waters and a rich new habitat. In a 2011 review of the works, to see whether it still met creek naturalisation best practice at the time and to see where any design improvements could be identified, the works were proven to be 'outstandingly resilient, providing excellent visual amenity and biodiversity and to be consistent with current best practice'. The rehabilitated waterway now has vastly improved ecological value, using riparian planting, while still providing flood protection for the local community.

**Figure 35**: Clear Paddock Creek stormwater drain before works. *Source: E2 Design Lab*

**Figure 36**: Clear Paddock Creek after restoration (2001). *Source: E2 Design Lab*

**Figure 37**: Clear Paddock (2010). *Source: E2 Design Lab*

**Figure 38**: Clear Paddock (2017). *Source: E2 Design Lab*

**Case study: Small Creek**

Small Creek in Ipswich, Queensland, was once a meandering stream surrounded by large iconic tree species and an understorey of native grasses and rushes. During the early 1980s the creek was replaced with a concrete drain. The local council is currently in the process of transforming Small Creek into a living waterway once again, with native vegetation and pools and riffles of shallow running water. The project is delivering a large stream of benefits for the environment and community including water quality improvement, improved aesthetics, habitat for native fish and animals, and a cooler corridor for people to enjoy. In 2019, a fish survey confirmed that Small Creek had become a functioning ecosystem with numerous native fish and other aquatic species detected.

These images show Small Creek in its early weeks, months and years of establishment following construction and planting of tube stock. While there are no trees visible in most of these photos, the saplings are a mixture of groundcovers and tree species, which are designed to eventually form a closed canopy over the creek as the trees mature.

**Figure 39**: Small Creek. *Source: E2 Design Lab*

**Figure 40**: Small Creek shortly after renaturalization. *Source: E2 Design Lab*

**Figure 41**: Trees growing after project. *Source: E2 Design Lab*

**Figure 42**: Large woody debris and saplings after planting. *Source: E2 Design Lab*

## Precedents

### Precedent: Blind Creek

Blind Creek was a piped low-flow system, much like Haydon Park. Daylighting the stormwater was seen as a way to reconnect the waterway with the community by bringing the water to the surface. Additionally, creek flows are captured, cleansed and stored for irrigation of nearby sports ovals and native vegetation.

The daylighted creek also creates in-stream habitat for local flora and fauna while providing a higher quality amenity asset for the community to experience. An urban forest takes advantage of increased soil moisture and provides shading for the community and mitigation of the urban heat island effect.

**Figure 43**: Concept plan for Blind Creek renaturalization project. *Source: Realm Studios.*


**Figure 44**: Illustrative perspective of a renaturalized Blind Creek with a focus on facilitating community connection to water. *Source: Realm Studios.*

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