Windsor Bridge Replacement

Roads and Maritime

Vegetation Management Plan

IA98200-NEM-RP-313 | Rev 0

June 2018

Contents

Glossary/Abbreviations

ASS	Acid sulfate soils
CEMP	Construction Environmental Management Plan
Compliance audit	Verification of how implementation is proceeding with respect to an environmental management plan (EMP) (which incorporates the relevant approval conditions).
CoA	Conditions of approval
DoE	Commonwealth Department of the Environment
DP&E	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
Ecologically sustainable development	Using, conserving and enhancing the community's resources so that the ecological processes on which life depends are maintained and the total quality of life now and in the future, can be increased (Council of Australian Governments, 1992).
EEC	Endangered Ecological Communities
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
Environmental aspect	Defined by AS/NZS ISO 14001:2004 as an element of an organisation's activities, products or services that can interact with the environment.
Environmental impact	Defined by AS/NZS ISO 14001:2004 as any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects.
Environmental incident	An unexpected event that has, or has the potential to, cause harm to the environment and requires some action to minimise the impact or restore the environment.
Environmental objective	Defined by AS/NZS ISO 14001:2004 as an overall environmental goal, consistent with the environmental policy, that an organisation sets itself to achieve.
Environmental policy	Statement by an organisation of its intention and principles for environmental performance.
Environmental target	Defined by AS/NZS ISO 14001:2004 as a detailed performance requirement, applicable to the organisation or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives.
Environmental Representative (ER)	A suitably qualified and experienced person independent of Project design and construction personnel employed for the duration of construction. The principal point of advice in relation to all questions and complaints concerning environmental performance.
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence under the *Protection of the Environment Operations Act 1997*.
Minister, the	Minister for Planning and Infrastructure
Non-compliance	Failure to comply with the requirements of the Project approval or any applicable license, permit or legal requirements.

Non-conformance	Failure to conform to the requirements of Project system documentation including this CEMP or supporting documentation.
NOW	NSW Office of Water
OEH	NSW Office of Environment and Heritage
OOH	Out of Hours (works outside standard work hours)
SCMP	Strategic Conservation Management Plan
SPIR	Submissions Preferred Infrastructure Report
PoEO Act	*Protection of the Environment Operations Act 1997*
Project, the	The Windsor Bridge Replacement Project
RMS	Roads and Maritime Services
SAP	Sensitive Area Plans
SOC	Statement of Commitments
Secretary	Secretary of the Department of Planning and Environment
SSI	State Significant Infrastructure
Thompson Square Conservation Area	Also known as the Thompson Square Precinct, this is the area of Thompson Square listed on the State Heritage Register of NSW. One of the oldest public squares in Australia, constructed in 1811. Surrounding buildings were constructed between 1815 and 1880 in the colonial Georgian style. The Square consists of George Street, Bridge Street, Thompson Square and The Terrace.

1. Introduction

This Vegetation Management Plan describes the methods and standards for revegetation required as part of the Windsor Bridge Replacement Project at Windsor in the Hawkesbury Local Government Area (LGA) (refer Figure 1-1).

1.1 Background and need

The Windsor Bridge Replacement Project (the Project), involves replacement of an existing bridge with a new road bridge over the Hawkesbury River at Windsor being delivered by NSW Roads and Maritime Services.

The Project has been assessed as State Significant Infrastructure under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

An environmental impact statement (EIS) *Windsor Bridge Replacement Project Environmental Impact Statement* was prepared by Sinclair Knight Merz in November 2012 for Roads and Maritime Services. The EIS was on public exhibition until 17 December 2012.

A submissions report (and preferred infrastructure report) was finalised in May 2013 and addressed all stakeholder submissions received during the EIS exhibition period. The Project was subsequently approved in December 2013 by the Minister for Planning and Infrastructure.

This Vegetation Management Plan (VMP) has been prepared to satisfy Director General's Conditions of Approval (CoA) and the associated Statement of Commitments (SOCs) for the Project (see Table 1-1). The VMP was developed with consideration to the Project Urban Design and Landscape Detailed Design Report, and the Strategic Conservation Management Plan (SCMP), which includes policy on tree plantings (Spackman Mossop and Michaels 2017).

Table 1-1 Director General's Condition of Approval

No.	Requirement	Document Reference
C34	A riparian corridor consisting of vegetation from the relevant local native vegetation communities shall be established along the Hawkesbury River bank areas disturbed by the project with the exception of those areas required for scour protection for the safety of the bridge. The riparian corridor is to be consistent with the Controlled Activities on Waterfront Land: Guidelines for Riparian Corridors on Waterfront Land (NSW Office of Water, July 2012b).	Windsor Bridge Replacement Urban design and landscape plan and Landscape Design Drawings Chapter 3
C35	A Vegetation Management Plan (VMP) is to be prepared consistent with the *Controlled Activities on Waterfront Land: Guidelines for Vegetation Management Plan on Waterfront Land* (NSW Office of Water, July 2012a) that demonstrates the protection of remnant native riparian vegetation and the rehabilitation of the riparian corridor. The VMP must be complied with.	This plan
C36	Seed sources used for the rehabilitation of the riparian corridor are to be from local native botanical provenance where possible.	Section 6.3
C37	A minimum two year monitoring and maintenance period is required for the riparian zone commencing after final planting, or until such time as a minimum 80 per cent survival rate of each species planted and a maximum 5 per cent weed cover for the treated riparian corridor is achieved. The monitoring program is to include weed control monitoring.	Chapter 9 and Chapter 11

The Project is being delivered in three stages with indicative timeframes for completion outlined below:

- **Stage 1** – 'before pre-construction' activities (June 2016 to December 2017)
- **Stage 2** – pre-construction and construction of replacement bridge and ancillary works (March 2018 to December 2020)
- **Stage 3** – demolition of existing bridge and ancillary works (Nov 2020 to Feb 2021).

The site comprises highly developed and highly degraded landscapes along the banks of the Hawkesbury River, with remnants of Riparian Forest, Alluvial Woodland, and Shale Plains Woodland within the vicinity of the proposed project. These vegetation communities are considered threatened under the *Threatened Species Conservation Act 1995*.

1.2 Aim and Objectives of the Vegetation Management Plan

The general objective of the revegetation at the site will be to enhance the condition of vegetation in the riparian corridor through supplementary planting. Revegetation will be conducted in a manner that will maximise biodiversity values and minimise undesirable outcomes such as proliferation of weed species. Revegetation will aim to protect existing remnant bushland as per the MCoA.

In addition to enhancing the riparian corridor a key project objective is to retain and where possible improve, views to important landmarks in particular the Hawkesbury River, Thompson Square and the historic buildings around Thompson Square. These views have cultural significance to the existing landscape character of Windsor and its surrounds and are detailed in Chapter 7 of the EIS.

This plan aims to be consistent with the accepted best practice techniques and guidelines outlined in *Recovering Bushland on the Cumberland Plain: Best Practice guidelines for the Management and Restoration of Bushland* (Department of Environment and Conservation 2005) and *Guidelines for vegetation management plans on waterfront land* (NSW Office of Water, July 2012a).

1.3 Scope

This VMP includes methods for revegetation and maintenance of plantings, site preparation methods, and guidance on appropriate plant species selection and propagation for areas disturbed by the Project. Monitoring and success criteria are also provided. The roles and responsibilities for parties involved in the revegetation project are determined, an indicative cost analysis for the revegetation works is also provided.

Disturbed areas will be revegetated progressively during the construction period which will be followed by a 2 year monitoring and maintenance period after final planting. After this period, subject to meeting the performance criteria, revegetated areas will be handed over to Hawkesbury City Council (HCC) through a formal inspection process. The VMP will be handed over to council with information incorporated into council's existing and Land Management Plans.

2. Existing environmental conditions

The proposed development is located in the developed central portion of Windsor in the Hawkesbury Local Government Area (LGA) (refer Figure 2-1). The site to be re-vegetated consists of the riparian corridor, nearby remnant vegetation and cleared areas surrounding the site.

The construction footprint is wholly located within the Cumberland Plain Sub-region of the Sydney Basin Bioregion situated on the east coast of NSW. While the Bioregion is one of the most species-diverse in the state, the Cumberland Plain sub-region is considered to be the most highly developed and as a result, the most highly degraded.

The Hawkesbury River runs north-easterly through the site and is located in the South Creek sub-catchment of the Hawkesbury-Nepean catchment. The sub catchment is heavily degraded as a result of historical vegetation clearance and urbanisation, with riparian zones often infested with woody weeds. The area around the site is representative of the degraded environment of the broader sub-catchment.

2.1 Landscape context

The physical environmental features of the Sydney Basin Bioregion as identified in Mitchell (2003) are summarised in Table 3-1. The proportion of cleared estimates for each landscape is derived from the over cleared landscapes database (DECCW 2010).

The NSW Landscapes coverage is a state-wide map of landscapes, compiled using existing resources and describing land attributes considered to drive ecosystem processes (Mitchell, 2003). Definition of the landscapes emphasises geologic, geomorphic and pedologic factors. In the Eastern and Central Divisions of the state, geology and topography were emphasised. The study area traverses the floodplain of the Hawkesbury River and the low hills typical of the river terrace landscape (Mitchell, 2003).

Table 2-1 Mitchell Landscapes in the study area

Mitchell (2003) ecosystems	Landscape characteristics (geomorphic, pedologic and vegetation)	Percentage cleared*
Hawkesbury-Nepean Terrace Gravels	Three levels of river terrace dating to the Tertiary period. General elevation 20 to 45 m, local relief 10 m. Planar, poorly drained terraces with harsh texture-contrast soils and heavy clays in swamps and cut-off meanders. In places deep sands of crevasse splays support Scribbly Gum (*Eucalyptus sclerophylla*), Narrow-leaved Apple (*Angophora bakeri*) and Old Man Banksia (*Banksia serrata*) on podsols with adjacent sedgelands. Most clay-based soils (harsh texture-contrast profiles) are very gravelly and carry Broadleaved Ironbark (*Eucalyptus fibrosa* ssp. *fibrosa*) and Narrow-leaved Ironbark (*Eucalyptus crebra*), Grey Box (*Eucalyptus moluccana*), paperbarks (*Melaleuca* sp.) and Drooping Red Gum (*Eucalyptus parramattensis*). Several vegetation communities are now rare, especially on the Pliocene/Pleistocene sand body with podsol soil profiles at Agnes Banks.	67%
Hawkesbury-Nepean Channels and Floodplains	Meandering channel and moderately wide floodplain of the Hawkesbury and Nepean rivers on Quaternary sand and gravel. Sand is dominant upstream of the Warragamba River junction, general elevation 0 to 20 m, local relief <10 m. Undifferentiated alluvial sand to poorly structured gradation profiles of sandy loam or clay loam. Forests on the river flats include Blue Box (*Eucalyptus baueriana*), Broad-leaved Apple (*Angophora subvelutina*), Manna Gum (*Eucalyptus viminalis*), River Peppermint (*Eucalyptus elata*) in upstream sectors and dominated by River Oak (*Casuarina cunninghamiana*) possibly originally with rainforest species such as White Cedar (*Melia azedarach*) in the lower sectors. Common	79%

Mitchell (2003) ecosystems	Landscape characteristics (geomorphic, pedologic and vegetation)	Percentage cleared*
	Reed (*Phragmites australis*), Cumbungi (*Typha orientalis*) and other aquatic plants are found in the river. Deep organic loams and loamy sands on floodplain with river flat forest of Sydney Blue Gum (*Eucalyptus saligna*), Round-leaved Gum (*Eucalyptus deanei*), Forest Red Gum (*Eucalyptus tereticornis*), Cabbage Gum (*Eucalyptus amplifolia*), Broad-leaved Apple, Rough-barked Apple (*Angophora floribunda*) and River Oak. Water Gum occurs (*Tristaniopsis laurina*) in protected channel sections. Large swamps and lagoons on the floodplain and in tributary streams below Richmond dammed by levees on the main stream support Tall Spike Rush (*Eleocharis sphacelata*), *Juncus* sp., *Melaleuca* sp., and *Lepidosperma* sp. Below Pitt Town the river is tidal and Swamp Oak (*Casuarina glauca*), Common Reed, River Mangrove (*Aegiceras corniculatum*), Grey Mangrove (*Avicennia marina*) and limited salt marsh are found on the muddy sands of the inter-tidal zone.	

2.2 Vegetation communities

The NSW National Parks and Wildlife Service conducted a vegetation mapping project for the Cumberland Plain in western Sydney from 1997 – 2002 (NPWS, 2002) which covered the current study area. This vegetation mapping was ground-truthed and refined during ecological surveys undertaken for the EIS (SKM, 2012). Table 2-1 lists the vegetation communities present within the study area and their distribution is presented in Figure 2-1. Riparian vegetation in the study area is currently composed of one plant community type; River Oak open forest of major streams, Sydney Basin and South-East Corner (PCT ID 1105), which is present in two forms. A description of vegetation in the study area has been taken from the Flora and Fauna Working Paper (SKM 2010) and is provided below.

Table 2-2 Vegetation communities in the study area

Vegetation Community (NPWS 2002)	Plant community type	Condition	Area to be impacted (ha)
Riparian Casuarina open forest	River Oak open forest of major streams, Sydney Basin and South-East Corner (PCT ID 1105)	Low	0.1
Modified riparian open forest (highly modified)	River Oak open forest of major streams, Sydney Basin and South-East Corner (PCT ID 1105)	Low	0.65
Cleared grassland	N/A	Low	0.9
Parkland/landscaped areas	N/A	Low	0.3

Riparian Casuarina open forest

The community occurs in a narrow strip along the southern bank of the Hawkesbury River and bordered by the footpath of The Terrace which is landscaped with White Cedar (*Melia azedarach*), Jacaranda (*Jacaranda mimosifolia*), Liquid Amber (*Liquidambar styraciflua*) and Peppercorn (*Schinus* sp.). The riverbank is dominated by River Sheoak (*Casuarina cunninghamiana*) and Swamp Oak (*Casuarina glauca*) with White Cedar (*Melia azedarach*) along the mid-bank and higher. Occasional eucalypts occur along the mid bank and the community is generally of low condition with a moderately dense but weedy understory including Green Cestrum (*Cestrum parqui*) interspersed with paperbarks (*Melaleuca* sp.) and wattles (*Acacia* sp.). The ground layer is sparse but pockets of vegetation are dominated by exotic species including Trad (Tradescantia fluminensis). The width of this vegetation community that makes up the riparian corridor varies from approximately 15-30 metres within the project boundary.

This vegetation most closely aligns with the River Oak open forest of major streams, Sydney Basin and South East Corner plant community type (PCT ID 1105). However, the community is in low condition with commonly found understorey and ground layer species absent due to the highly modified and partially artificial nature of the community.

Modified riparian open forest

The community occurs in a narrow strip along the northern bank of the Hawkesbury River both east and west of the bridge. The riverbank is dominated by River Sheoak (*Casuarina cunninghamiana*) and Swamp Oak (*Casuarina glauca*) with occasional plantings of paperbarks (*Melaleuca* spp.) and White Cedar (*Melia azedarach*). One Swamp Mahogany (*Eucalyptus robusta*) was observed near the bridge on the midbank. The understorey is generally absent although exotic vines such as Balloon Vine (*Cardiospermum grandiflorum*) and Blackberry Nightshade (*Solanum nigrum*) persist. The ground layer is sparse but clumps of Lomandra (*Lomandra longifolia*) occur along the toe of the bank. The width of this vegetation community that makes up the riparian corridor varies from approximately 25-50 metres within the project boundary.

This vegetation most closely aligns with the River Oak open forest of major streams, Sydney Basin and South East Corner plant community type (PCT ID 1105). However, the understorey and ground layer species commonly found in that community are not present at the site due to the highly modified and partially artificial nature of the community. This vegetation community is considered to be in low condition within the study area.

Cleared grassland

Cleared grassland occurs along the riverbank and adjacent floodplain on the northern bank of the Hawkesbury River within the study area east of the bridge. This is an artificially constructed community most likely resulting from intensive land use since the banks were cleared of original vegetation in the first decade of the colonisation of Windsor. The floodplain is managed for turf farming and the creek bank is dominated almost entirely by exotic pasture and roadside weed species, largely herbs and grasses, with the occasional exotic tree such as the willow (*Salix babylonica*) present. One native Kurrajong (*Brachychiton populneus*) and one Swamp Oak (*Casuarina glauca*) were observed to persist in the landscape.

Shrub weeds in this community are clumped across the site and include Castor oil (*Ricinus communis*), Wild Tobacco (*Solanum mauritianum*), Lantana (*Lantana camara*), Fennel (*Foeniculum vulgare*) and Purpletop (*Verbena bonariensis*). Grass and groundcover weeds included Turkey Rhubarb (*Acetosa sagittata*), thistles and Johnson Grass (*Sorghum halepensis*). The exotic Madeira Vine (*Anredera cordifolia*) and Balloon Vine (*Cardiospermum grandiflorum*) were also prolific across the site.

Parkland/Landscaped areas

A number of parkland or landscape environments exist within the study area that is representative of early European colonisation in Australia. These include Thompson Square parkland and associated street scaping in the southern part of the study area (such as The Terrace), as well as the more recently landscaped Macquarie Park north of the Hawkesbury River. These areas are typically planted with either introduced horticultural species or Australian natives chosen for their aesthetic properties, but which would not occur in local native vegetation communities. These areas consist of mature trees, with no understorey and a completely maintained exotic grass cover. They are thus of low ecological condition and value in the context of this biodiversity assessment.

Mature trees of Thompson Square parkland include a number of Liquid Ambers (*Liquidambar styraciflua*), Silky Oaks (*Grevillea robusta*) and Kurrajongs and one Bunya Pine (*Araucaria bidwillii*). The stature of these trees suggests that some of them may be greater than 80 years in age. Streetscape plantings along The Terrace and other paths within the study area are landscaped with White Cedar (*Melia azedarach*), Jacaranda (*Jacaranda mimosifolia*), Liquid Amber (*Liquidambar styraciflua*) and Peppercorn (*Schinus* sp.).

Figure 2-1 Existing vegetation communities and key sightlines [1]

[1] Scour protection design is detailed in drawing set NB98005-ECC-DG-0901-0955

3. Layout of the proposed riparian corridor

Developing the layout of the site involves first identifying and delineating the extent of the riparian corridor within the study area. Riparian land is any land that adjoins or directly influences a body of water and includes:

- the land immediately alongside small creeks and rivers, including the river bank itself
- gullies and dips which sometimes run with water
- areas surrounding lakes
- wetlands and river floodplains which interact with the river in times of flood.

In accordance with CoA C34, a riparian corridor consisting of vegetation from the relevant local native vegetation communities shall be established along the Hawkesbury River bank areas disturbed by the project with the exception of those areas required for scour protection for the safety of the bridge. Using the document *Guidelines for riparian corridors on waterfront land* (NSW Office of Water 2012b), the distribution of the existing riparian corridor within the study area has been identified and described (see Figure 3-2).

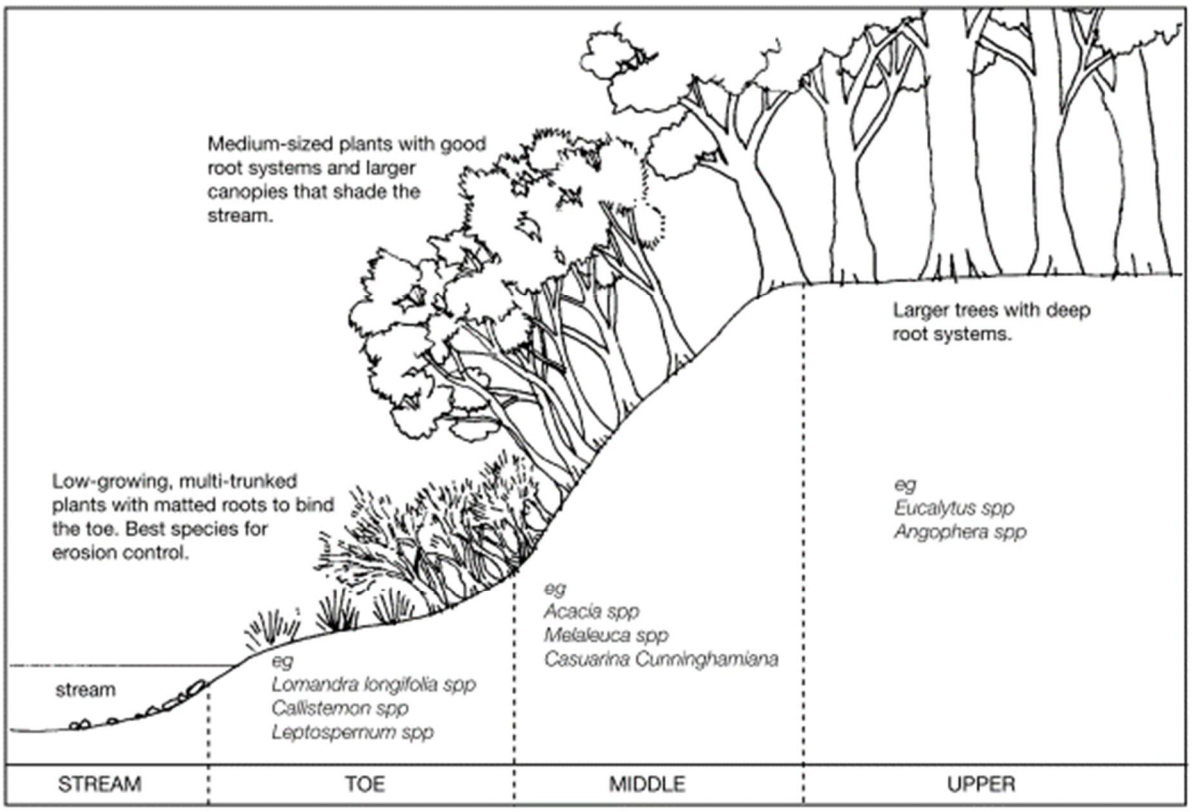
3.1 Riparian corridor width

Identifying the extent of the riparian corridor on the site is key to ensuring its protection during the construction and future operation of the distribution centre. The riparian corridor consists of:

- the channel which comprises the bed and banks of the watercourse (to the highest bank)
- the vegetated riparian zone (VRZ) adjoining the channel.

Figure 3-1 illustrates a cross section of a typical riparian corridor, showing the boundaries of the different zones and the typical plant species that are required to make up these zones. In reality however, the channel will not always be this well-defined and some zones may be absent. The Office of Water recommends a VRZ width based on watercourse order as classified under the Strahler System of ordering watercourses. The *Guidelines for riparian corridors on waterfront land* (NSW Office of Water 2012b) stipulate that, as this section of the Hawkesbury River is 4th order stream (Strahler, 1952), a 40 metre VRZ is required.

Due to a history of disturbance and the development of infrastructure close to the Hawkesbury River, the riparian corridor in the study area is highly modified, fragmented and varies from approximately 15 to 50 metres. Although there is no obvious delineation of the different riparian zones based on vegetation type, Figure 3-2 displays the current extent of the riparian corridor in the study area, separating the zones based on area and slope. The 40 metre VRZ width guideline (NSW Office of Water 2012b) has been applied to the corridor, however this is not achievable across much of the site due to restrictions imposed by existing and planned infrastructure. This will continue to be a limiting constraint to the design and construction of the new VRZ. The bridge design, bike paths, scour protection and existing infrastructure to be retained will all limit the physical extent of the riparian corridor. Figure 3-3 displays the proposed new VRZ extent and zones of revegetation. Although the proposed VRZ will not satisfy the NSW Office of Water (2012b) guidelines on width, it does only involve work within “areas disturbed by the project” (CoA C34) and will significantly improve the current riparian corridor, which in many zones is largely absent.



Adapted from *Rivercare: Guidelines for Ecological Sustainable Management of Rivers and Riparian Vegetation:* Raine, A.W & Gardiner, J.N, (1995), LWRRDC, Canberra.

Figure 3-1 Typical riparian cross section

Vegetation in the riparian corridor is currently highly modified and dominated by exotic groundcover species across much of the study area. Areas lacking an intact canopy will require weed removal and planting to re-establish a functioning VRZ. Vegetation to be retained and areas of proposed revegetation as part of the project are shown in Figure 3-3. Table 3-1 provides a summary of planting constraints applicable to different zones within the riparian corridor adjacent to the project area.

Table 3-1 Planting constraints in the different riparian zones

River bank	Riparian corridor zones and riparian planting constraints			
	Stream	Toe	Middle Bank	Upper Bank
Northern	As the Hawkesbury River is classified as a 4th order stream, prone to frequent flooding events and not ephemeral in nature no instream planting is proposed	Scour protection will be installed along the toe. Pockets of riparian planting will be interspersed within the scour protection to assist in reducing the visual impact of the scour protection material	Scour protection will be predominantly installed in the middle bank zone. Pockets of riparian planting will be interspersed within the scour protection.	The upper bank consists of cleared grassland and parkland. It is proposed to maintain a parkland area with a selection of planted representative native riparian species.
Southern	As above	Scour protection will be installed along the toe	Riparian planting will be provided within the middle bank	There is no defined upper bank zone with modified parkland and car park present.

3.2 Management zones

Planning for the rehabilitation and re-establishment of the riparian corridor following the completion of the majority of construction works involves identifying a number of management zones. Establishment of management zones early on in the process assists in planning and monitoring the success of management activities.

In line with the current bridge design, five (5) management zones have been delineated within the study area (Figure 3-3). Each of these management zones will require management activities that are sensitive to the desired riparian zone, bridge infrastructure and the existing condition of the area. These zones are described below and details of relevant management activities required or each zone are listed in Table 3-2.

Table 3-2 Management activities for each management zone

Zone	Management activities						
	Site management	Temporary fencing of sensitive features	Weed control	Soil preparation	Riparian zone	Revegetation	Infill planting*
1	Land within this zone consists of high density weed cover across the toe and middle bank.	No	Yes, high abundance: Balloon vine, Delairea odorata, Green Cestrum, Japanese honeysuckle, Lantana, Panic grass	Soil scalping and top soil	Toe and Mid bank	Tubestock	Within 7 days of site seeding
2	Land within this zone is currently occupied partly by toe and mid bank modified riparian Casuarina open forest.	Yes - Para web material and star pickets as per RMS Biodiversity Guideline Type 3	Yes, low abundance	Soil scalping and top soil	Mid and upper bank	Conservation of existing vegetation	Within 7 days of site seeding
3	This area currently contains non-native grasses.	No	Yes, low abundance	Soil scalping and top soil	Upper bank	Parkland planting	Within 7 days of site seeding
4	Land within this zone is currently occupied partly by toe and middle bank modified riparian vegetation and exotic weed species.	No	Yes, high abundance: Balloon vine, Delairea odorata, Green Cestrum,	Soil scalping and top soil	Toe and Mid bank	Tubestock	Within 7 days of site seeding
5	Land within this zone is currently occupied partly by toe and mid bank riparian Casuarina open forest.	Yes - Para web material and star pickets as per RMS Biodiversity Guideline Type 3	Yes, low abundance	Not required	Mid and upper bank	Conservation of existing vegetation	Not required

*Infill planting is required in accordance with RMS specification R179 where planted trees, shrubs, herbs, sedges and rushes do not successfully establish.

Zone 1 - This zone is located in the north east of the project site, on the eastern side of the existing Windsor Bridge and adjacent to the river channel. Land within this zone consists of high density weed cover across the toe and middle bank. Due to the presence of exotic vegetation is recommended that the soil surface is prepared by scalping the existing topsoil to remove the weed seedbank prior to revegetation.

This zone is earmarked for scour protection at the toe and middle bank and two distinctive pockets of riparian revegetation planting within the middle bank area as detailed below. A constructed bike pathway will delineate this riparian revegetation area with planted parkland and native species representative of the plant community type River Oak open forest (PCT ID 1105) as detailed in **Appendix A**.

- **Riparian Revegetation Area 1A** - This area will be planted with riparian species as listed in **Appendix A**. Species planted in this zone should include those of the middle and upper bank types.

- **Riparian Revegetation Area 1B -** This area will be planted with riparian species as listed in **Appendix A**. Species planted in this zone should include those of the middle and upper bank types.

Zone 2 - This zone is located in the north west of the project site, on the western side of the existing Windsor Bridge adjacent to the river channel. Land within this zone is currently occupied partly by toe and mid bank modified riparian Casuarina open forest. Vegetation within this zone should be retained as much as possible and weeds managed throughout the life of this VMP (i.e. a minimum of two years after the completion of works or until such time as a minimum 80 per cent survival rate of each species planted and a maximum 5 percent weed cover for the treated riparian corridor controlled activity is achieved).

Zone 3 - This zone is located on the north east of the project site, on the eastern side of the existing Windsor Bridge in the upper bank area. This area currently contains non-native grasses. Due to the presence of exotic weeds within this area it is recommended that the soil surface is prepared by scalping the existing topsoil to remove the weed seedbank prior to revegetation.

This area will be planted with a mix of parkland and native species as represented in the Windsor Bridge Landscape Design (Volume 12, Accepted for Construction, 04/05/2018) .

Zone 4 - This zone is located on the south of the project site, on the eastern side of the existing Windsor Bridge adjacent to the river channel. Land within this zone is currently occupied partly by toe and middle bank modified riparian vegetation and exotic weed species.

- **Riparian Revegetation Area 4** - This area will be planted with riparian species as listed in **Appendix A**. Species planted in this zone should include those of the toe and middle bank types.

Zone 5 - This zone is located in the south west of the project site, on the western side of the existing Windsor Bridge and adjacent to the river channel. Land within this zone is currently occupied partly by toe and mid bank riparian Casuarina open forest. Vegetation within this zone should be retained as much as possible and weeds managed for a two-year period which commences after final planting.

The recommended layout for the riparian revegetation works are in 3 areas (Reveg1A, Reveg1B and Reveg4 – refer to Figure 3-2 and Figure 3-3). These areas are designed based on the required area for revegetation of each vegetation community, current distribution of vegetation community types, underlying geology, and site constraints. Appendix B outlines planting schedules for each revegetation area.

Each of the five management zones will be monitored throughout the life of this VMP to ascertain the success of management activities. This will be undertaken by way photo-point monitoring. Details of this methodology and monitoring locations are described in Section 11.1 and shown in Figure 3-3.

3.3 Delineation of revegetation areas

Each revegetation area at the site will be precisely measured and pegged out with clearly marked wooden stakes prior to the commencement of any revegetation works to clearly establish their location and extent. Areas of vegetation to be retained should also be clearly demarcated prior to the commencement of any clearing works.

The recommended layout for the revegetation works are in three areas (R1A, R1B and R4 - refer to Figure 3-3). These areas are designed based on the required area for revegetation of each vegetation community, current distribution of vegetation community types, underlying geology, and site constraints. **Appendix B** outlines planting schedules for each revegetation area.

Any vegetation areas outside the project area but disturbed by the works will be regenerated into pre-works condition.

Figure 3-2 Layout of the existing riparian zones

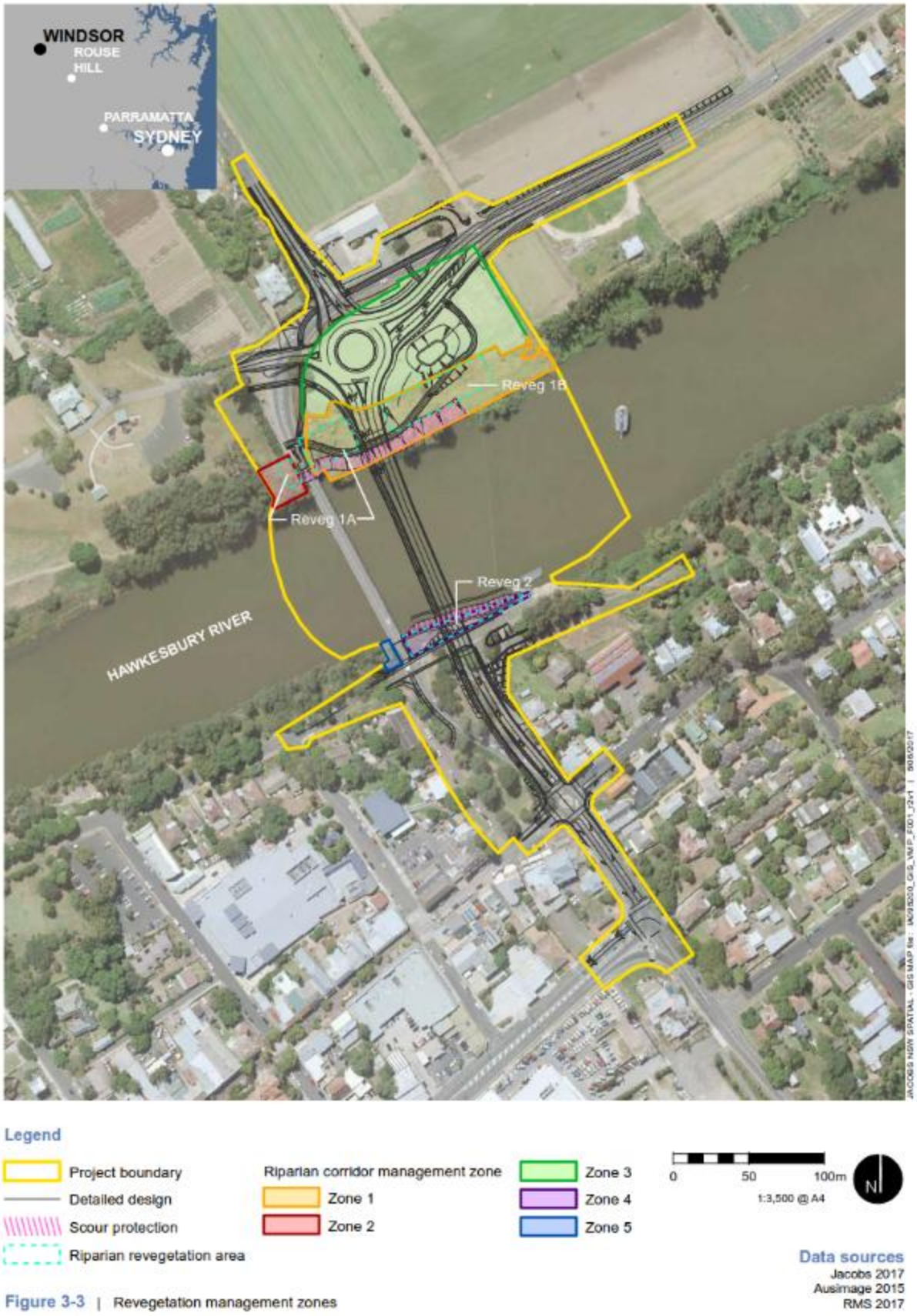


Figure 3-3 Proposed revegetation management zones

4. Site preparation

Appropriate site preparation is essential for a successful revegetation program. The biggest threats to the revegetation at the site would be inadequate weed control prior to seeding and planting and during the maintenance phase. Weed control is one of the most important features of any revegetation program and is often a major factor in the success or failure of a revegetation project. Weed control and other necessary site preparation measures are outlined below.

The site must also be clearly delineated to identify where revegetation works are to occur, and where vegetation is to be retained. It is important that vegetation to be retained is fenced off prior to the commencement of works as per the RMS *Biodiversity Guidelines: Protecting and managing biodiversity in RTA projects* (RTA, 2011a), and that all personnel involved in the project area are inducted to understand the ecological sensitivity of these areas.

Revegetation areas will be established and signposted once the majority of the infrastructure works have been completed. Further requirements regarding the protection of vegetation to be retained during construction will be detailed in the project Construction Flora and Fauna Management Plan (CFFMP).

Additional RMS QA roadworks specifications should also be adhered to during site preparation, specifically R178 Vegetation and R179 Landscape Planting.

4.1 Controlling access

The vegetation to be retained, including the management zones, will be fenced off prior to the commencement of works as per the RMS *Biodiversity Guidelines: Protecting and managing biodiversity in RTA projects* (RTA, 2011a).

4.2 Weed control

Successful weed control is important to ensure successful establishment and rapid early growth and establishment of plantings. Failure to achieve appropriate weed control prior to planting will result in competition by weed species which will severely affect the survival and growth rate of plantings.

Weed free conditions should be provided adjacent to the plantings and this is best achieved before planting begins. The revegetation areas should be treated for weeds at least one year before planting begins to decrease the weed soil seedbank and provide conditions suitable for planting native species. A combination of the techniques outlined above in Section 4-1 should be utilised during weed control activities. Management measures for weed control are listed in more detail in the project EIS and must follow Guide 6: Weed Management of the RMS *Biodiversity Guidelines: Protecting and managing biodiversity in RTA projects* (RTA, 2011a). All weed material must be removed from site onto trucks immediately without stockpiling and disposed of at a licensed waste facility.

4.3 Stabilisation and weed suppression

Currently, the banks of the Hawkesbury River within the site have evidence of erosion, and the presence of modified riparian vegetation along the toe of the river provides some level of protection. The finished design includes the addition of scour protection, consisting of large rock, on both the northern and southern bank. However, where construction is occurring next to the river banks, the contractor will be required to ensure adequate soil stabilisation controls are implemented to ensure the risk of bank erosion is avoided. Where required, appropriate erosion control and weed suppression measures will be implemented (for example, installation of thick jute mesh). Removal of the weedy groundcover will result in the rapid recolonisation of native groundcovers to aid in bank stabilisation. Where invasive bank stabilisation works are required along the creek, this will occur after primary weed control.

Where soft soil stabilisation methods are required to be implemented along the river banks to support infrastructure construction the following soil stabilisation guidelines will be followed:

- In areas where there is a risk of erosion soil stabilisers are to be used such as geotextile material or thick jute mesh
- Temporary soil stabilisation using vegetation will avoid the introduction of exotic plants unless there is no suitable native alternative. Where exotic species are used these will be sterile, non-invasive and easily eradicated when permanent native vegetation is established (Office of Water, 2010).

4.4 In-stream Debris and Snags

The Hawkesbury River along the site contains limited large woody debris (LWD) but does contain habitat structure in the form of debris dams and smaller woody debris, and these will be retained wherever possible. Snag removal will be minimised where possible (RTA, 2011a).. Management of snags or debris within the development footprint will follow the DPI Policy and guidelines for fish habitat conservation and management, (NSW DPI 2013).

4.5 Soil preparation

To provide optimal conditions for seed germination and seedling establishment, the soils at the site will require preparation. The requirements for optimal seed germination and seedling establishment are soft, uncompacted soils and soil that is bare and free of weeds. As the areas to be revegetated are highly disturbed and dominated by exotic species, soil preparation would be best achieved through a combination of scalping of topsoil and ripping and ploughing.

Any new topsoil intending on being imported onto the site should have samples sent off to a National Association of Testing Authorities (NATA) approved soil laboratory to ensure it contains no weed seeds or propagules (RTA 2011a).

4.5.1 Soil scalping

In areas dominated by exotic grass species it may be necessary to remove the topsoil layer in order to achieve the bare soil required for successful revegetation and to remove the weed soil seed bank to reduce competition and make planting area maintenance easier (Schirmer & Field 2000).

There is no effective method of treating soil on-site that is highly contaminated with weed seeds or propagules. The top 2 to 10 cm of grass and topsoil should be removed with a machine that has a large blade (e.g. a grader), removed from site, and disposed of at an appropriate waste disposal facility.

4.5.2 Ripping and scarification

While not recommended for use in areas displaying the potential for natural regeneration, ripping is suitable for use at the site in the revegetation areas as they have been subject to disturbance in the past which has compacted the soil. Ripping will assist with the absorption and availability of soil moisture, soil aeration, and will create an environment where plant roots have easier access to resources.

Ripping and scarification can impact potential heritage items, and therefore, as per the MCoA, a Construction Heritage Management Sub-plan will be required prior to any construction. Details of management, strategies and procedures for dealing with previously unidentified objects will be specified in this assessment and should be read in conjunction with this plan.

Soil should be ripped to a depth of 20 to 50 cm with a multi tined ripper towed by a bulldozer or tractor then scarified by a plough to a depth of 20 cm so that no large sods remain (Schirmer & Field 2000). Where the ground is sloping, the rip lines should follow the bank contour to prevent erosion. Location details of where ripping and scarification is required prior to planting activities is included in the projects Urban Design and Landscape detail drawings (NB98005-ESD-DG-0101-0405).

Ripping and scarification of the soil is likely to stimulate weed growth and this should be monitored and treated as part of the maintenance program.

In areas where construction works have caused compacted soil, the soil should be decompacted when works have been completed.

4.6 Educational signage

Educational signage should be erected around the edges of the revegetation areas to inform the public of the importance of the remnant vegetation communities on the site and the revegetation program.

Information on maintenance and conservation measures should also be included along with the fauna habitat values of the vegetation. Prior to and during revegetation works, signs should be erected to notify site users of the locations of works and the methods being used (e.g. warning signs for herbicide spraying and locations of revegetation areas).

Example of nearby educational signage at nearby Howe Park

Example of nearby revegatation works in progress signage

4.7 Phytophthora prevention

Phytophthora cinnamomi is a microscopic soil-borne water mould which causes root rot of susceptible plant species. *Phytophthora cinnamomi* has been recorded in Sydney and dieback associated with the water mould is evident in many areas.

Due to the relatively isolated nature of the bushland remnants and the high ecological importance of the vegetation communities present, *P. cinnamomi* prevention measures should be implemented (Botanic Gardens Trust 2008). Measures for prevention of *P. cinnamomi* are listed in more detail in the project EIS and must follow Guide 7: Pathogen Management of the RMS *Biodiversity Guidelines: Protecting and managing biodiversity in RTA projects* (RTA, 2011a).

- *Phytophthora cinnamomi* prevention measures include: Ensuring that all tools, shoes, vehicles (including tyres) and machinery are clean and made free of attached soil or mud prior to arrival at the site.

5. Revegetation methods

The best approach to revegetation is to use a combination of available methods. This often means utilising methods such as assisted natural regeneration (bushland regeneration) and active revegetation such as direct seeding and the planting of tubestock. This technique allows for the most appropriate technique to be used in each area within the site, and compensates for seasonal fluctuations to ensure that plants will survive past the initial establishment period.

5.1 Weed removal

Weed control should be undertaken using a staged approach incorporating three levels of treatment: Primary weed clearance; followed by Secondary treatment or follow-up; and finally Maintenance weeding (National Trust of Australia 1999).

Primary weed clearance refers to the initial treatment of a weed infestation. Secondary treatment or follow-up works refer to the intensive weeding of areas that have already received primary weeding, removing the largest flush of second generation weeds that have germinated from soil stored seed and those that were not successfully killed during primary weeding. Native regeneration is also encouraged during this stage. Once an area has been restored and preventive measures to stop weed recruitment on site have been implemented, the maintenance weeding phase can begin. It is inevitable that weeds will re-establish on site due to dispersal and the soil seed bank will also be a continual source of new weed infestations so regular maintenance works will be required.

The techniques to be used to control weeds should include a combination of the following techniques as necessary:

- Hand removal and cultivation
- Mulching
- Cut and paint with herbicide
- Scrape and paint with herbicide
- Stem injection, frilling or chipping with herbicide
- Foliar spot spraying with herbicide.

5.1.1 Hand removal and cultivation

Hand removal or cultivation with small tools aims to remove and destroy the existing plants and prevent the plants from setting seed. Therefore, the timing of hand removal and cultivation is important as well as the technique. Hand removal and cultivation is best carried out before the plant seeds, or if the plant is seeding, the fruits must be bagged and removed from site. Different cultivation methods may kill the existing plant depending on whether or not the plant can sucker and reproduce vegetatively, in which case the roots, tubers, and corms must be controlled as well as the stems (Ensbey & Johnson 2007). Hand removal and cultivation techniques may:

- Remove plants and expose roots to dry them out
- Bury shoots to stop them growing
- Separate shoots from roots
- Bag seed heads and flowers and then remove the whole plant (roots, crown and stems).

Correct disposal of vegetative matter after cultivation is imperative for species that reproduce vegetatively or those that produce many seeds. Appropriate disposal methods include burning piles in accordance with Rural Fires Service (RFS) guidelines for pile burns or storing on site wrapped in plastic until the plant decomposes (composting). For non-vegetative reproducing species or those without seeds present, bagging and disposal in domestic green waste bins or at a waste disposal centre equipped to handle green waste is sufficient.

5.1.2 Mulching

Mulching uses barriers to exclude light and prevent the establishment of weeds. A bobcat or other vehicle can lay barriers (i.e. geotextile cloth) according to RMS specification R63, but due to the material's expense this is only viable for smaller areas. Traditional mulching with wood chips or using a Hydroseeder machine is more cost effective (Ensbey & Johnson 2007).

5.1.3 Cut and paint with herbicide

Cut and paint is a method of weed control for woody weeds where by the stem or trunk of the weed is cut horizontally near the ground then herbicide applied to the living plant tissue across the cut surface. The best technique for the cut and paint method is as follows:

- Cut the stem as near towards the ground as possible, leaving a horizontal surface so the herbicide does not run off.
- Paint the living tissue of the open wound with herbicide evenly (within 10 seconds of cutting the stem for water based herbicides and 1 minute for diesel based herbicides).

The cut and paint method is advantageous as it removes the weed straight away. This technique is best used on woody shrubs and trees. Some species will sucker after being treated with this technique (e.g. *Senna pendula* var. *glabrata*, *Ochna serrulata*, and *Cinnamomum camphora*); therefore, cut and paint is not appropriate for these species unless follow up treatment will be employed (Ensbey & Johnson 2007).

5.1.4 Scrape and paint with herbicide

The scrape and paint method is similar to the cut and paint method but is used for smaller shrubs that will sucker if the cut and paint method is applied (e.g. *S. pendula* var. *glabrata*, *O. serrulata*, and *C. camphora*) and for vines with aerial tubers (e.g. *Anredera cordifolia*). The scrape and paint technique should be used on plants with stems or trunks less than 5 centimetres (cm) in diameter (Ensbey & Johnson 2007). The correct technique for the scrape and paint technique is as follows:

- Scrape a vertical section of the bark off both sides of the stem down to the cambium layer (with a sharp knife or chisel) approximately 5 cm in length to where the stem meets the ground, without ringbarking the plant.
- Apply herbicide on the open wound (as per the cut and paint method).

5.1.5 Stem injection, frilling or chipping with herbicide

If required on site, stem injection, frilling or chipping is a method that can be employed successfully in a number of situations to treat large mature woody weeds with a trunk diameter of more than 5 cm. At inaccessible sites where rubbish and debris prevent removal, where the tree should be left in situ to provide fauna habitat, or where removal would increase soil erosion, stem injection, frilling or chipping are appropriate methods of weed control (National Trust of Australia 1999). The following outlines the appropriate method for stem injection, chipping and frilling:

- Using a drill, chisel, saw, or axe, make holes or a deep cut at a downward angle (45 degrees) into the sapwood at regular intervals of 5 cm apart around the tree in a circle
- Do not ringbark the plant
- For multi stemmed plants drill or chip below the lowest stem or treat each stem individually
- Apply herbicide into the hole or cuts at the recommended rate by the manufacturer
- Reapply herbicide when the first application is absorbed into the plant.

5.1.6 Foliar spot spraying with herbicide

Foliar spraying of herbicide is an option for the control of shrubs, herbs, grasses, and vines. Spraying can be conducted with a small volume hand operated backpack sprayer or a large volume motorised spray unit

mounted on a vehicle. The type of environment, presence of native species, site access, and desired control outcome will determine the techniques used in herbicide spraying (Ensbey & Johnson 2007). When applying the foliar spray technique the following must be adhered to:

- Only spray designated areas to avoid off target damage
- Ensure that when spraying the whole plant is treated (100% foliar cover)
- Only spray healthy and actively growing plants to ensure effective uptake of herbicide
- Do not spray in windy conditions, excessively hot conditions, if plants are heavy with dew, or if rain is expected within four hours.

5.1.7 Revegetation

Revegetation is preferred in areas that are considered to have a low ability to recover naturally, even with the assistance of weed control. This may be due to a long history of disturbance in these areas resulting in loss of native species, soil compaction, and an altered soil seed bank composition. Active revegetation areas form the bulk of revegetation required for this vegetation management plan.

Active revegetation essentially involves planting by mechanical or hand methods and will usually involve the installation and maintenance of an irrigation system, and a weed management program. Active revegetation is most appropriate when:

- The natural regeneration potential of a site has been wholly or severely depleted
- Key missing species cannot be naturally recruited to an area
- Soil profiles have been altered resulting in loss of the natural seed bank.

Revegetation will aim to protect existing remnant bushland as per the MCoA and plant species in similar composition to that which occurs in vegetation adjacent to the revegetation sites (e.g. River Oak open forest). Given the relatively small area of riparian planting areas and to maximise the chance of successful revegetation the preferred method of planting is via tubestock planting detailed below.

5.1.8 Tubestock planting

Planting of tubestock (seedlings in small plastic forestry tubes) provides guaranteed plant material to a revegetation site and is the most common method used to reintroduce vegetation to an area. Although tubestock planting is more expensive and labour intensive than direct seeding, the results are more reliable and an immediate impact is made on the environment. The positioning and placement of plants is also able to be controlled. Other advantages of using tubestock are that less transplant shock is suffered and they rapidly establish healthy root systems (Florabank, 2008). An immediate visual impact is also evident which signifies that revegetation is taking place.

6. Plant species selection

This section outlines the plant species selection and planting density. Plant species are chosen based on those that would have occurred naturally on site. The species mix is chosen to emulate the revegetated community. Density will be high enough to quickly establish vegetative cover and root mass to stabilise the riparian zone. A sterile exotic cover crop (like sterile rye grass or Japanese millet) may be initially used in some cases to stabilise soil.

The general principle behind the selection of plant species to be used in revegetation at the site is to establish plants in areas that:

- Suit the site characteristics
- Are native to the area and vegetation community that is being enhanced
- Belong together naturally
- Have been grown from local seed.

Selection criteria for plant species to be used in the revegetation are provided below.

6.1 Selection criteria

6.1.1 Provenance

As per the MCoA C36, seeds used for rehabilitation in the riparian corridor are to be acquired from local native provenance where possible. Local native provenance refers to seeds found in local or adjacent areas in the same type of vegetation community so as to simulate the original species that would be found at the site for revegetation. These species are adapted to the environmental conditions, pollinators, predators, symbionts and dependent on wildlife present on site (Florabank 2008). This will also avoid introducing exotic species and will retain vegetation community integrity (refer **Appendix A** for list of suitable species for use in revegetation).

Where possible plants used in revegetation will be sourced from seed collected on site or from Cumberland River Flat Forest or Swamp Oak open forest (PCT ID 1105) in the surrounding area to ensure local provenance, avoiding dilution of the plant gene pool on site. Using plants of local provenance in revegetation will ensure that the genetics, and morphological and physical traits of the species selected for revegetation will be similar to those that currently exist in the vegetation communities on site (Florabank 2008).

Florabank (2008) recommends that provenance be considered in the following manner when collecting seed:

- Ensure correct plant identification during collection to make sure you are dealing with the same species/subsp/variety or cultivar
- Collecting from 20–100 plants that are at least 3 plant-heights apart
- Only collect from large populations or pool multiple collections from smaller populations
- Store seed under appropriate conditions from collection through to use
- Match the site conditions of collection, including soil, altitude, aspect, slope, and latitude, to the revegetation area.

6.1.2 Species diversity

The revegetation program will seek to maximise species diversity. By introducing all structural vegetation layers at once (e.g. trees, shrubs, grasses, sedges, groundcovers, and climbers) multiple planting events are avoided and disturbance to the revegetation areas is minimised. Using a balanced mix of species from the majority of plant families that are found in naturally occurring examples of the vegetation community that is being planted will avoid the overuse of readily obtainable species (e.g. *Lomandra longifolia*). As such, a natural vegetation community will be created that contains higher biodiversity value (Department of Environment and Conservation 2005).

6.1.3 Succession and nitrogen fixation

It is important to include a mix of coloniser species, such as *Acacia* spp. and *Dodonaea* spp. that will establish and grow quickly in the revegetation areas. These species help to create the optimal environment for species that are slower to colonise areas to establish. *Acacia* spp. and *Casuarina* spp. form symbiotic relationships with nitrogen fixing bacteria and fungi that make nitrogen available in the soil for plants. As *Acacia* spp. and *Casuarina* spp. are naturally occurring in the vegetation communities that are to be revegetated, they will be included in the species mix.

The presence of these early successional and nitrogen fixing species will increase soil carbon, reduce surface temperature variation, reduce erosion, and create surface conditions conducive to the establishment of other longer lived native plant species such as *Eucalyptus* spp. and *Angophora* spp. (Department of Environment and Conservation 2005).

6.2 Recommended species mix and planting density

Ideally, the proportion of seed for each species used in direct seeding should replicate the proportions in which they naturally occur in the River Oak open forest (PCT ID 1105) that is to be revegetated. The following formula should be used by contractors as a guide to calculate the weight of seed required for each species (Department of Environment and Conservation 2005):

$$\text{Weight of seed required} = \frac{\text{No. of plants required per ha}}{\text{No. of seeds per kg X \% establishment rate}}$$

Appendix A specifies the appropriate species to be used for revegetation of each vegetation community. Planting densities for each plant growth form are provided, along with the revegetation method, and vegetation community type for each species. Appendix B provides specific plant numbers for each revegetation area.

The dimensions of the mature plants and the natural densities of each species in natural vegetation communities will guide the planting densities of tubestock in this revegetation project. For example, large trees such as *Eucalyptus* sp. and *Anghophora* sp. will be planted at a low density of plants per hectare, with a moderately sparse understory of shrubs planted at a higher density, and finally the groundcover of grasses and herbaceous species planted at even higher densities (refer **Appendix A**). Plants will not be planted at densities beyond the long term site capabilities apart from an additional 10 per cent in each stratum (i.e. tree, shrub, groundcover, and climber) to account for mortality. This will avoid the loss of plants through density dependent mortality, encourage faster establishment and growth of plants, and reduce the need for replacement planting.

The planting densities provided in **Appendix A** and plant numbers provided in Appendix B should be used as a guide only as it should be noted that mature native canopy and shrub species currently exist in the revegetation areas. Planting of canopy species should not be undertaken beneath existing mature canopy trees. Similarly, shrubs should not be planted underneath existing mature shrubs.

6.3 Seed collection methods

The following guidelines, based on that of Florabank (2008), should be followed when collecting seed for revegetation:

- Only collect from species on site or from the local area to ensure provenance
- Obtain the best quality genetic material as possible (from healthy disease free plants in a viable population)
- Collect seed form at least 20 – 100 plants that are spaced widely apart
- Do not over collect seed to ensure ecologically sustainable collection by only collecting 20 per cent of the seed or fruit crop

- Do not damage the donor plant or the surrounding environment during collection.

6.3.1 Seed collection permits and licences

In order to undertake seed collection in endangered ecological communities near to the site if required (i.e. from River Flat Eucalypt Forest), a state licence under the TSC Act would be required as follows:

- Section 91 Licence to harm or pick a threatened species, population or ecological community or damage habitat listed under the TSC Act (e.g. River-flat Eucalypt Forest in the NSW North Coast, Sydney Basin and South East Corner Bioregions (endangered)).

7. Plant propagation

A number of species that are to be used in the revegetation are best established by propagation in a nursery. All tubestock and species for which seed is hard to obtain will be propagated in a nursery to ensure that use of the limited seed is optimised.

Propagation can be achieved from seed or from cuttings. Most plants to be used in the revegetation can be successfully grown from seed (e.g. *Eucalyptus* spp. and *Acacia* spp.) however; some species are more successfully grown from cuttings. The nursery contracted for propagation and plant supply will be able to provide advice on the most appropriate techniques for propagation of each species.

8. Plant installation guidelines

8.1 Direct seeding

Instead of spreading seed by hand, a Hydroseeder or similar machine can be used to quickly and economically seed large areas as the seed, fertilizer, mulch, tackifier and water are all applied at once. The seed, water and mulch are mixed in the tank of the Hydroseeder to form a slurry, which is then sprayed over the site through a high pressure water cannon.

8.2 Tubestock planting

Tubestock, grown in small square plastic nursery tubes, is the preferred method of revegetation for tree and shrub species. Planting of tubestock will be carried out using hand tree planting tools and should be conducted in the following method:

- Rake away an area of mulch (min 300mm x 300mm) to expose the soil
- Dig a hole at least twice the size of the tube / pot (min 300 x 300 x 200mm deep)
- Disturb the surrounding substrate up to 100mm to avoid leaving 'clean' sides and base of the hole, particularly when an auger has been used to dig the hole
- Add a slow release fertiliser and soil-wetting agent to the base of the well and cover with a small amount of existing soil, or mix in with the soil to be placed back around the plant. Avoid any contact of the fertiliser and soil-wetting agent with the plant roots
- Plant the seedling slightly below the soil level and back-fill the hole with existing soil, covering the top of the potting mix. Create a small well to the catch water
- Replace mulch around the plant. Ensure no mulch touches the base of the trunk, maintaining a space of 50-100mm between mulch and trunk
- Erect a 'Growtube' around each plant. Remove Growtubes when plants are at 1.5 times the height of the Growtube
- Water each plant thoroughly within 1 hour of planting.

8.3 Plant spacing

Appropriate spacing between plants will assist in higher survival rates and lower maintenance costs. High density planting with fast growing species not only creates an early canopy cover, providing shade cover for weed suppression and habitat for native fauna, but also begins the process of protecting and stabilising the banks. Plant spacing within the riparian corridor should be as follows:

- Lower Bank (for areas where scour protection is not being installed) – Lomandra and sedges to be planted in clumps or rows along the Lower Bank or at 1m centres. Plant trees and shrubs at a wider spacing of 2m – 3m in stable conditions.
- Mid and Upper Bank – Tree, shrub, native grasses and ground cover species should be planted at 1.5m – 2m centres. Extend *Lomandra* plantings from the Lower Bank into the Mid Bank zone. For good structural diversity, plant an even ratio of tree, shrub and ground cover species.

8.4 Timing

Choosing the best time to undertake riparian revegetation plantings is difficult due to the potential impacts of frost, drought, flood and erosion on seedlings and young plants. Spring is the preferred time for planting to allow for strong establishment of the root structure and good plant growth, before floods or frosts.

Pre-winter planting is not advisable, however, this is not always possible to avoid. Choose hardy species with high frost tolerance, and wherever possible, extend plantings over to spring to ensure better revegetation success of the site. On some sites where there is a risk of soil loss, provide protection to the banks with covers

such as jute mat, Geofabric or Coconut Coir. Refer to manufactures specifications and understand site conditions before using these products.

8.5 Plant protection

To aid in identification of plantings, a large wooden stake should be placed next to all plants to prevent incidental damage to the plantings during maintenance activities. Tree guards should be installed over the newly planted seedlings to provide protection from grazing animals during the plant establishment period.

8.6 Weed control and mulching

A weed suppression mat is to be installed around the base of each seedling to reduce competition from weeds in the immediate area of each planting. Mulching also provides protection to bare soil, retention of soil moisture and suppression of weed re-growth. Due to the difference in size and complexity of the management areas, it is recommended that both 'mulching' and 'hydromulching' techniques are adopted:

- Mulching – Organic mulch such as hoop pine fines or similar (to meet AS4454-2003). Ensure that mulch is free of weed seed or foreign objects. Spread to a depth of 100mm–150mm and allow to settle for four (4) weeks before planting seedlings. Spot spraying of any emerging weeds maybe needed at this stage. The use of mulch is only recommended on the Mid and Upper Banks, with a slope less than 1:1.5
- Hydromulching – An alternative technique that can be used for covering steep banks with a sprayed-on mixture of fertilisers, seeds, water and mulch. It is often used where there is a large area of bare earth or the site is too steep for safe access with machinery or people. This technique is relatively expensive, but is useful in instances where planting of seedlings is not practical. The seed mix is to consist of native trees, shrubs and grasses, in accordance with supplier's standard specifications and subject to Hawkesbury City Council approvals.

8.7 Watering

Watering would be required in accordance with RMS specification R179, which includes the following watering schedule:

(i) 20 litres of water per plant at weekly intervals for the first 12 weeks;

(ii) 10 litres of water per plant at 14 day intervals thereafter.

Watering may be undertaken by regular visits using a truck or by installation of an irrigation system. A drip irrigation system should be installed with the main system laterals in place before planting begins to allow for the installation of emitters and required tubing as the plants are installed

9. Planting area maintenance

Maintenance requirements should extend for a minimum of 2 years or until plants become self-sustaining (no watering required), weed growth is low (maximum 5 per cent weed cover) and a minimum 80 per cent survival rate of each species planted and for the treated riparian corridor controlled activity is achieved (CoA C37; NSW Office of Water 2012a).

9.1 Short-term maintenance

This period is from the date that construction commences until the completion of works.

9.1.1 Weed control

Weed control is the most important feature of any maintenance program and is often a major factor in the success or failure of a revegetation project. A weed free area of at least 1 metre in diameter should be maintained around the planting at all times to reduce competition for resources and encourage establishment (Florabank 2008). Spot spraying with a contact herbicide such as Glyphosate or non-chemical methods such as hand removal and mulching can be used.

9.1.2 Irrigation

Watering of seedlings will be necessary in the initial weeks after planting and the level of watering required will be determined by rainfall and temperature. More watering will be required in hot dry conditions. Irrigation will be required for the first year after planting and should be used as a supplement to seasonal precipitation to establish plants. After the first year, depending on plant condition, the irrigation system should be removed to allow plants to adapt to the site. Maintenance of plant stakes and bags will also be necessary.

9.2 Long-term maintenance

This period is a minimum of two years after the completion of works or until such time as a minimum 80 per cent survival rate of each species planted and a maximum 5 per cent weed cover.

9.2.1 Weed control

The weed control program should be the focus of maintenance activities over the long-term to remove weeds from site and allow the plantings to establish successfully. Weeding should be conducted around the plantings for at least five years until a canopy can be formed that will potentially shade out weed species (Florabank 2008). The aim of revegetation will be to create a self-sustaining area of bushland and this can only be achieved by a long-term weed control program.

Revegetation maintenance

- Removal of Growtube bags and bamboo stakes at specified plant height
- Removal, and where necessary replacement, of any bank protection material (e.g. Jute Mat) that has been displaced through flooding, poor installation or vandalism.

9.2.2 Fertilisers

Native plants are generally adapted to survive in low nutrient locations. Application of a broad fertiliser to the site is likely to encourage weed growth. Fertiliser tablets are effective and can be used at the bottom of each planting hole to encourage growth where species require.

9.2.3 Pests and diseases

New plants are extremely susceptible to pests and diseases and these must be identified and managed quickly in order to avoid significant plant losses. New plantings (whether initial or replacement plantings) will be

monitored for pests and diseases every week for the first month and then quarterly. Plants decimated by pest or disease will be removed immediately and disposed of offsite. The type of species affected the type of pest or disease affecting the plant and the location for replanting will be recorded. Replacement planting in this instance will occur as part of a bulk plant replacement program every six months, unless local provenance replacement plants are readily available to be planted in a suitable season – preferably autumn.

Plant pests and diseases frequently strike as plagues or under certain climatic conditions. Opportunities to co-ordinate site pest and disease control programs will be investigated through contact with Hawkesbury City Council and NSW Agriculture.

9.2.4 Plant protection

Plant markings and plant protection must be maintained during the initial stages of plant establishment. As rabbits have been previously identified on the site during preliminary environmental investigations (LEC 2002), grazing prevention is important for the successful establishment of plants in the revegetation areas. Tree guards are the preferred method to avoid seedling death due to grazing and can be either the cardboard milk carton or plastic bag type (Florabank 2008). After the first year, the revegetation site should be walked and the plants assessed to determine which are sufficiently established and no longer need protection.

9.2.5 Pruning

Pruning of plants may be required to ensure views to important landmarks in particular the Hawkesbury River, Thompson Square and the historic buildings around Thompson Square are maintained. Pruning requirements will be identified in the maintenance inspections.

9.2.6 Replacement planting

Replacement planting may be required where seedlings do not successfully establish in the revegetation area. This will most likely occur within the first year of planting. Additional planting should be undertaken to replace dead plants and fill gaps (Florabank 2008). A survival rate of at least 80% should be obtained in the revegetation area.

9.2.7 Thinning

Problems may arise with overcrowding of plantings and where natural regeneration occurs amongst the planted species. Thinning of plants may be required to enhance the survival of plantings or natural regeneration; however, this is unlikely to be necessary due to the recommended planting densities and the process of natural density dependent mortality.

9.2.8 Deep Watering

Deep watering will occur quarterly, dependent on local climatic conditions, and will continue until all plants are established. During extended dry periods plant health and soil moisture will be checked weekly. Watering will be undertaken early in the morning to avoid evaporation during the middle of the day.

9.2.9 Rubbish Removal

The riparian corridor will continue to receive rubbish in high flow events from upstream. Rubbish will be collected quarterly (or following a flooding event) and disposed of appropriately. If debris is considered to be providing fauna habitat, then it will remain in-situ until alternative suitable habitat has been provided. This may include dead timber/logs, rocks or vegetation.

9.2.10 Maintenance Inspections

Maintenance inspections are required to gain an overall assessment of how each of the management zones are responding to the suite of rehabilitation works implemented across the site. The intention is to draw together all of the maintenance information recorded by the bush regeneration contractor over a period of three months and

compare this to the objectives of the project. Maintenance inspections also involve site inspections and act as a quasi-audit to satisfy both the proponent and regulatory authorities that CoA and SOC requirements are being met. Maintenance inspections can be reduced to six monthly post-construction. This will not occur until the site has been operating for six months. Maintenance inspections will be undertaken for all management zones.

Quarterly maintenance inspections will comprise the following:

- Weeds - Assessment of average densities of each weed species within each management zone, observations and treatment recommendations
- Pests and disease – Number and types of species affected, type of pest or disease, percentage of species affected, observations and treatment recommendations. This includes grazing by feral and native animals and the success or otherwise of any programs to protect regenerating areas from such impact
- Planting – Estimate of initial planting success, trends in unsuccessful establishment of particular species, plant size and spread and evidence of natural regeneration
- Erosion – Inspection of rehabilitation and erosion control in riparian areas next to the bridge construction, photo monitoring points will be established at this site to track change over time
- Deep watering – Assessment of general soil moisture in each management zone and information on observed watering requirements by species
- Mulch – Depth of mulch should be measured and maintained.

9.3 Revegetation timeline

Figure 9-1 provides a timeline summary of revegetation activities

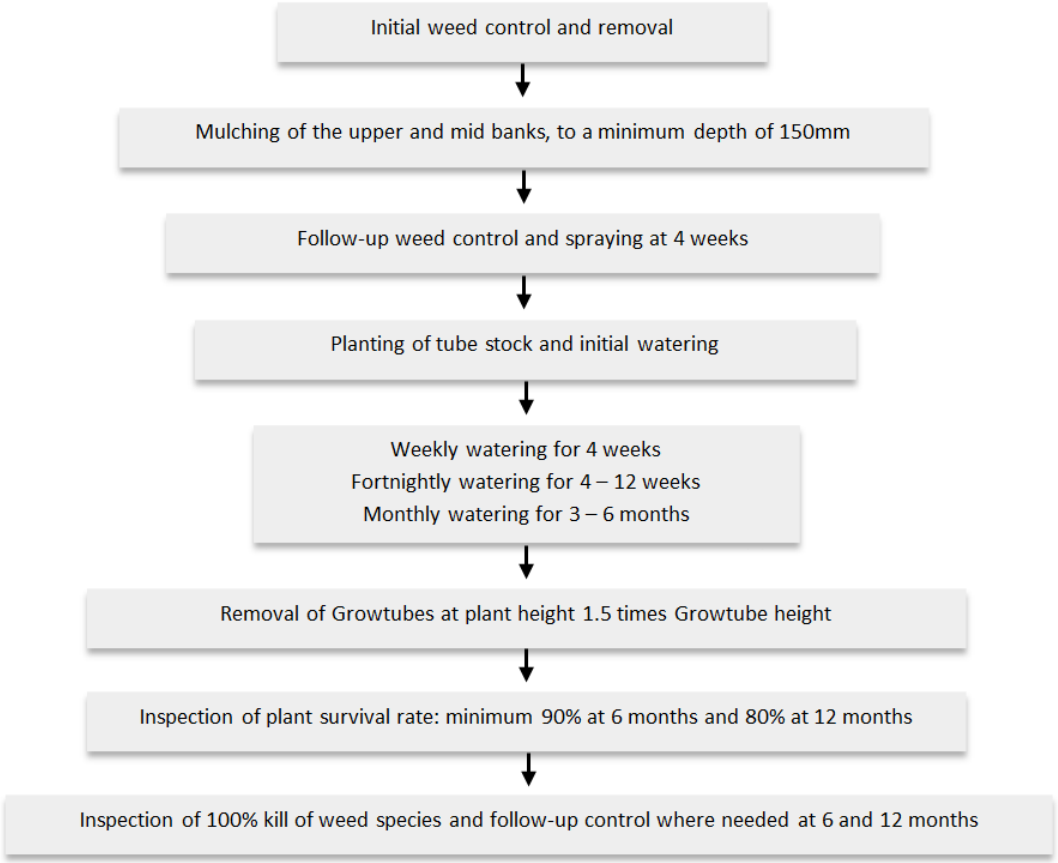


Figure 9-1 Revegetation timeline

10. Implementation schedule and indicative cost analysis

10.1 Implementation schedule

The entire area is to be revegetated over a period of 3 years, subject to budget and staffing constraints. This would include an initial year of weed control, site assessment and planning, soil preparation, plant species selection, seed collection, and propagation. Plant installation will begin in the second year. Planting area maintenance would begin directly after the first plantings and continue for a two year period post construction.

A timeline for completion of each management action outlined in this plan is provided below in Table 10-1. Each action has been assigned a priority, a recommended time-frame for implementation and a checkbox for completion.

Table 10-1 Implementation schedule for each management action

Management action	Construction	Post Construction*		Priority	Complete
		Year 1	Year 2		
· Revegetation areas delineated by pegging	P			High	··
· Site preparation:					
- Initial weed control	P			High	··
- Soil preparation	P			High	··
- Educational signage	P			Medium	··
- Phytophthora prevention	P	P	P	High	··
· Plant species selection	P			High	··
· Plant propagation	P			High	··
· Plant installation	P			High	··
· Planting area maintenance		P	P	High	··
· Monitoring		P	P	High	··
· Reporting	P	P	P	High	··

*Maintenance and monitoring must extend for a minimum of two years after the completion of works or until such time as a minimum 80 per cent survival rate of each species planted and a maximum 5 per cent weed cover.

10.2 Roles and responsibilities

There are a number of key roles in the VMP which, by the technical nature of the regenerative works, should be undertaken by contractors or consultants external to both the proponent (Roads and Maritime Services) and the construction contractor for the site. Key roles and responsibilities associated with the implementation of the VMP, including statutory reporting, are outlined in Table 10-2.

Roads and Maritime is responsible for the revegetation program and its implementation. It is envisaged that a maintenance contractor(s) will be engaged by Roads and Maritime to undertake and complete the revegetation works.

The chosen contractor(s) will be responsible for all facets of the maintenance program including the site preparation, plant species selection, plant propagation, plant installation, planting area maintenance, monitoring, and reporting.

Table 10-2 Roles and responsibilities

Role	Responsibilities
Roads and Maritime Services project manager	Co-ordination of VMP associated conditions with clearing and construction works ensure native vegetation to be retained will be protected, as practical / where applicable and enhanced through the life of the project. Completion of site management to ensure ongoing protection of regenerated sites post-maintenance period.
Construction contractor	Compliance with the requirements of the VMP.
Ecologist	Management and implementation of the VMP, including performance indicator monitoring, provision of technical advice and statutory reporting to the construction contractor. Certification of completion of maintenance project by achievement of performance indicators.
Bush regeneration sub-contractor	On-ground works associated with the VMP, maintenance inspections and meeting of performance criteria, including the management of pest species contractor, if required. Certification of supply and installation of local provenance native seed.
Consent authority	Certification of commencement of maintenance period. Inspection of restoration and revegetation works during maintenance period. Certification that restoration and revegetation works have met the assessment criteria at completion of the maintenance project.

10.3 Indicative cost analysis

The cost of works may be used as a bond by the NSW Department of Planning and Environment (DPE) to ensure that the proponent actions the VMP. The proponent receives the bond back upon completion of the maintenance period if they have implemented the VMP as stated.

Revegetation costs may be very variable depending on the needs of the site, the intensity of planting, size of the area planted, and the labour source (Schirmer & Field 2000). Based on current market rates, it is estimated that the two year riparian revegetation program would cost approximately **$110,457** (refer Table 10-3). This cost analysis covers the revegetation program from initial site preparation to final monitoring. As such, it should be used as a guide when judging tenders for the engagement of a contractor to implement the revegetation plan.

Table 10-3 Indicative cost analysis for the revegetation project

Item	Unit	Quantity	Cost
Site preparation	$180/ha machine hire	36 hrs	$4,320
	Plant operator labour costs @ $100/hr	36 hrs	$3,600
Mulching	$220/tonne	20	$4,400
	Application via blower operation	1 day	$3,000
Jute matting / erosion control blanket	1.22m x 68m @ $99.00	40	$4,000
Trees	Approximately $350 for a 75L species	33	$11,550

Item	Unit	Quantity	Cost
Shrubs	Approximately $20 for a 150mm species	143	$2,860
Virotube	Approximately $1 per tube	10,756	$10,756
Tree planting	1hr per 5 plants @ $40/hr	8 hr	$960
Tree plant protection	Staking and mesh @ $50 per plant	33	$1,650
Shrubs / viro tube planting	1hr per 50 plants @ $40/hr	215 hr	$8,600
Shrubs / viro tube plant protection	1 bag per plant @ $0.97 each	10,756	$10,756
Irrigation and watering	1ha @ $1,000/ha	12	$12,000
Maintenance & weed control	800hrs @ $40/hr	-	$32,000
Monitoring	Visits to be undertaken quarterly	8	$5,000
	Indicative total cost (GST exclusive)		**$110,457**

Note: All costs are approximate and have been provided to give a broad overview of the likely costs involved in implementing the revegetation plan. It is likely that other costs may be involved.

Refer to the UDL drawings for quantity schedules and corresponding locations.

11. Monitoring, reporting and success criteria

Processes for monitoring and review including a method of performance evaluation need to be identified in this section.

11.1 Monitoring procedure

The success of revegetation measures should be monitored as part of this revegetation plan to assess its effectiveness and to determine the need for amendments or otherwise to the revegetation strategy. The data gathered can be compared to reference sites established in adjacent vegetation communities in good condition to determine the success of revegetation. A monitoring option is to establish a set of monitoring quadrats throughout the revegetation area that can be compared to reference sites. A monitoring program such as this can determine the effectiveness of revegetation measures in all areas proposed for revegetation.

The monitoring program is as follows:

- The monitoring quadrats should be 10 x 10 m in size set up in each revegetation area
- Assessment could include recording cover abundance ratings (Braun-Blanquet cover codes) and stem density for weeds and native species as well as an inventory of all species present in each quadrat. In addition, in consultation with RMS biodiversity specialists, an alternative method (Tongway & Hindley 2003) for Landscape Function Analysis (LVA) can be considered when there is disagreement over the results of the primary assessment criteria.
- Photographic monitoring should occur at a fixed location at each monitoring point to provide a visual indication of the success or otherwise of the revegetation works. Appendix C provides a basis for this form of monitoring.
- Quadrats may be pegged at each corner with a star picket and their location recorded using a GPS
- Quadrats should be monitored every three months during the first year of the revegetation program then every six months for the remaining life of the program.
- Reporting is required after each monitoring event in the form of a concise monitoring report including key observations and supporting photographic evidnece

Photo points are permanent or semi-permanent sites set up from where you can take a series of photographs over time which can be compared to show short- or long-term physical change at each location. The pictures for comparison are taken at the same location, with the same direction (south), angle, focus points and preferably camera settings. Photo monitoring points will be used within each management zone to demonstrate compliance with performance criteria or otherwise. Draft photo point locations have been established in each management zone and preliminary photos are supplied in **Appendix C**. Table 11-1 lists the coordinates and bearing of each proposed photo point monitoring locations and shown graphically on **Figure 11**. However, the final locations of the photo monitoring points will be determined once the limits of clearing associated with the proposal are clearly demarcated by fence lines. Establishment and use of photo monitoring points have/will follow the Land Managers Monitoring Guide – Photopoint Monitoring (Environment and Resource Sciences, 2010).

General site inspections may also be conducted in addition to the formal monitoring quadrats to enable opportunistic detection of weed outbreaks and plant death. Identification of inappropriate planting maintenance actions and suggestions for improvement can also be detected and made through a general site inspection. General site inspections should be conducted every three months for the life of the weed control program.

Table 11-1 Photo point monitoring locations

Management zone	Point ID	Coordinates		Bearing
		Easting	Northing	
1	1a	297904.2036	6279790.698	130

Management zone	Point ID	Coordinates		Bearing
		Easting	Northing	
	1b	297995.0817	6279819.369	60
	1c	298061.2994	6279852.974	220
2	2a	297897.1802	6279774.444	240
	2b	297888.0748	6279762.27	40
3	3	297974.172	6279836.496	200
4	4a	297976.6379	6279652.387	240
	4b	298025.5818	6279678.825	10
	4c	298039.6639	6279695.69	250
5	5	297956.9085	6279658.296	210

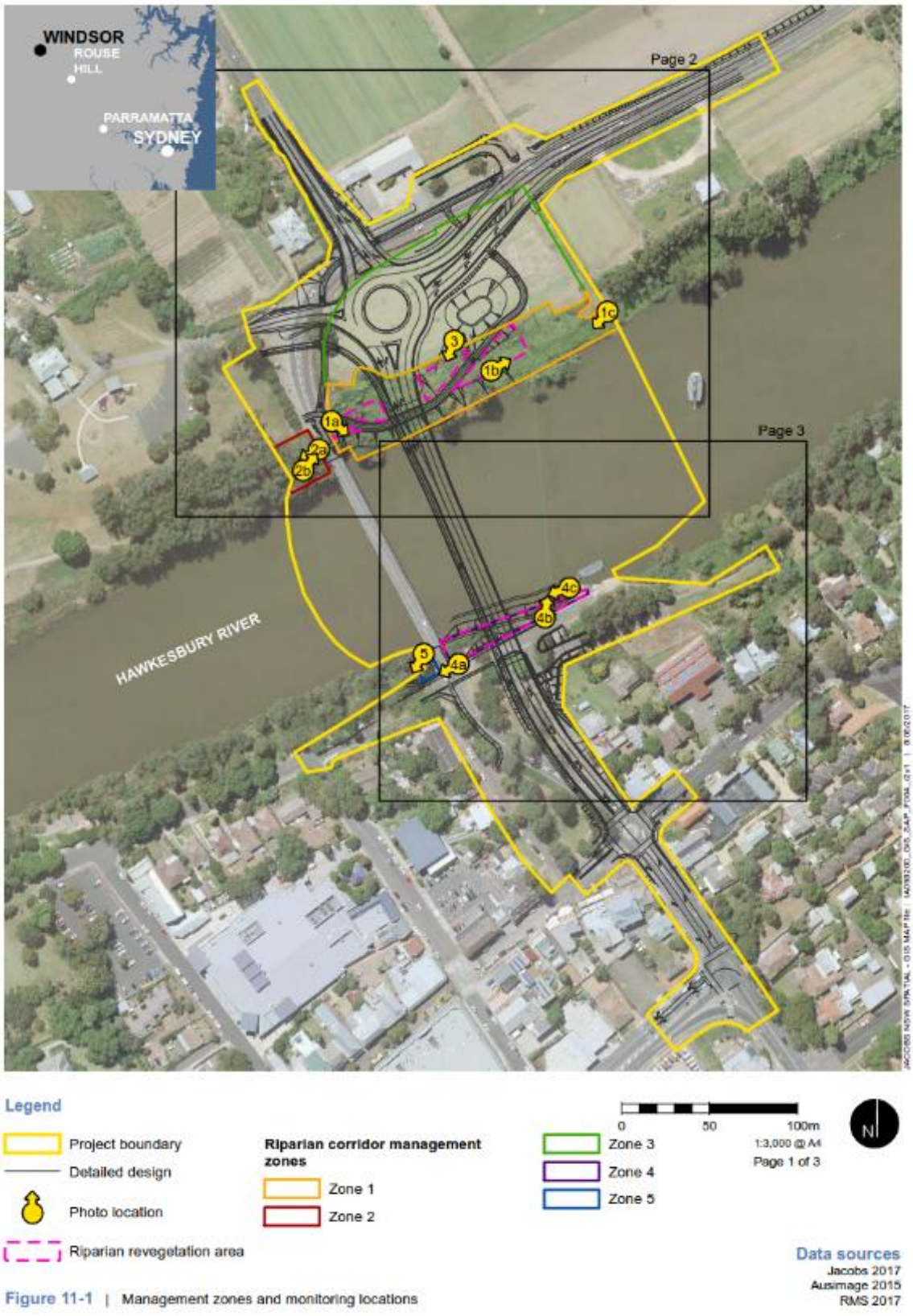


Figure 11-1 Revegetation management zone and monitoring locations

11.2 Reporting

Reporting of the outcomes of management actions is important in ensuring their effectiveness. Details of management actions undertaken during the revegetation project should be recorded along with any subsequent outcomes.

All contractors should report on all management actions completed during the revegetation project. This information should be provided monthly to Roads and Maritime and should include details of the area worked, the type of work carried out and any problems encountered. This information should be provided to the Project Manager, who will regularly brief the relevant staff and management.

Items to be included in the monthly reporting may include, but is not necessarily limited to:

- The revegetation area in which works were conducted
- The number of hours spent in each revegetation area conducting works
- The number of plants installed (during initial planting works)
- The number of staff working on site
- Any comments on the success of revegetation works and any other observations.

The organisation or people responsible for implementation of the revegetation program shall prepare an annual report on its implementation. Annual reporting shall include but not necessarily limited to a detailed description of all works conducted that year in every revegetation area, suggestions and recommendations for future works, and before and after photographs.

11.3 Success criteria

The *Guidelines for vegetation management plans on waterfront land* (NSW Office of Water, July 2012a) stipulate that maintenance requirements should extend for a minimum of two years after the completion of works or until such time as a **minimum 80 per cent survival rate of each species planted** and a **maximum 5 per cent weed cover is present** in the treated riparian corridor.

Alternative performance based assessment criteria can indicate the health of the revegetated zone using the Landscape Functional Analysis methodology (Tongway & Hindley 2005).

The Landscape Functional Analysis includes Soil Surface Assessment Indicators such as; perennial vegetation cover; percentage of litter cover and evidence of any erosion which would indicate if the vegetation is sufficiently stabilising the riparian zone.

Erosion increases sediment and alluvium deposits into the waterway and should be a key consideration in the measure of success to the VPM. Low percentage weed cover is also critical to the establishment of the native species in the revegetated riparian corridor.

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Appendix A. Recommended species mix for revegetation

This appendix details the appropriate species of plant to be used for revegetation. The species chosen for revegetation are those that are naturally occurring along the Hawkesbury River and are not restricted to one vegetation type. Planting densities for each plant growth form are provided, along with the vegetation community type for each species.

The recommended planting density for each growth form is as follows:

- Trees – 1 plant / 4m2
- Shrubs – 1 plant / 2m2
- Grasses, sedges, groundcovers, and climbing species will be included in the seed mix that is to be broadcast over the revegetation areas.

Table 12-1 specifies the most appropriate endemic species to be used for revegetation. A mix of species from the **River Oak open forest species of major streams, Sydney Basin and South-East Corner (PCT ID 1105)** (shaded in blue) and Cumberland River-flat Eucalypt Forest (shaded in grey) have been specified.

Plants used in revegetation will be sourced from seed collected on site or from identical vegetation communities in the surrounding area to ensure local provenance, avoiding dilution of the plant gene pool on site.

As the native vegetation communities present in the local area are for the most part identical to that found within the Hawkesbury LGA, using plants grown from seed collected from nearby vegetation communities will be sufficient to ensure local provenance. Using plants of local provenance in revegetation will ensure that the genetics, and morphological and physical traits of the species selected for revegetation will be similar to those that currently exist in the vegetation communities on site (Florabank 2008).

Table 12-1 Recommended species for revegetation

Scientific name	Common name	Growth form	Community type
Casuarina cunninghamiana	**River Oak**	**Tree**	*River Oak open forest*
Eucalyptus tereticornis	Forest Red Gum	Tree	*Cumberland River-flat Eucalypt Forest*
Eucalyptus eugenioides	Thin-leaved Stringybark	Tree	
Eucalyptus amplifolia subsp. amplifolia	Cabbage Gum	Tree	
Angophora floribunda	Smooth-barked Apple	Tree	
Angophora subvelutina	Broad-leaved Apple	Tree	
Acacia floribunda	**White Sally Wattle**	**Tree**	*River Oak open forest*
Acacia parramattensis	Parramatta Wattle	Tree	*Cumberland River-flat Eucalypt Forest*
Acacia decurrens	Black Wattle	Tree	
Melaleuca styphelioides	Prickly-leaved Tea Tree	Tree	
Melaleuca linariifolia	Flax-leaved Paperbark	Tree	
Casuarina glauca	Swamp Oak	Tree	
Acacia mearnsii	**Black Wattle**	**Shrub**	*River Oak open forest*
Breynia oblongifolia	Coffee Bush	Shrub	*Cumberland River-flat Eucalypt Forest*
Bursaria spinosa	Blackthorn	Shrub	
Leucopogon juniperinus	Prickly Beard-heath	Shrub	

Scientific name	Common name	Growth form	Community type
Melicytus dentatus	**Tree Violet**	**Shrub**	*River Oak open forest*
Ozothamnus diosmifolius	Rice Flower	Shrub	*Cumberland River-flat Eucalypt Forest*
Trema tomentosa	Native Peach	Shrub	
Urtica incisa	**Stinging Nettle**	**Groundcover**	*River Oak open forest*
Lomandra longifolia	Spiny-headed Mat-rush	Groundcover	*Cumberland River-flat Eucalypt Forest*
Dichondra repens	Kidney Weed	Groundcover	
Pratia purpurascens	Whiteroot	Groundcover	
Solanum prinophyllum	Forest Nightshade	Groundcover	
Brunoniella australis	Blue Trumpet	Groundcover	
Commelina cyanea	-	Groundcover	
Centella asiatica	Indian Pennywort	Groundcover	
Dianella longifolia	Blueberry Lily	Groundcover	
Einadia hastata	Berry Saltbush	Groundcover	
Veronica plebeia	Trailing Speedwell	Groundcover	
Wahlenbergia gracilis	Sprawling Bluebell	Groundcover	
Alternanthera denticulata	Lesser Joyweed	Groundcover	
Plectranthus parviflorus	Cockspur Flower	Groundcover	
Senecio hispidulus	Hill Fireweed	Groundcover	
Sigesbeckia orientalis	-	Groundcover	
Pandorea pandorana	**Wonga Wonga Vine**	**Climber**	*River Oak open forest*
Stephania japonica	**Snake Vine**	**Climber**	*River Oak open forest*
Austrostipa ramosissima	Stout Bamboo Grass	Grass	*Cumberland River-flat Eucalypt Forest*
Paspalidium distans	-	Grass	
Digitaria parviflora	Small-flowered Finger Grass	Grass	
Microlaena stipoides	Weeping Grass	Grass	
Entolasia marginata	Bordered Panic	Grass	
Echinopogon caespitosus	Bushy Hedgehog-grass	Grass	
Eragrostis leptostachya	Paddock Lovegrass	Grass	
Lachnagrostis filiformis	-	Grass	
Oplismenus aemulus	Australian Basket Grass	Grass	
Poa affinis	-	Grass	

Appendix B. Recommended planting schedule

Tables B-1 to B-3 detail the recommended species mix and plant numbers to be used in each revegetation area. As the aim of this revegetation plan is to recreate a natural ecosystem, species are not to be planted in homogeneous monospecific blocks.

Table 12-2 Recommended tree species numbers for each revegetation area

		Number of plants		
Species	**Common Name**	**Reveg 1A**	**Reveg 1B**	**Reveg 2**
		450m2	**390m2**	**350m2**
Casuarina cunninghamiana	**River Oak**	Mix of adjacent plant species at 1 plant / 4m2	Mix of adjacent plant species at 1 plant / 4m2	Not applicable as area is within toe riparian zone
Eucalyptus tereticornis	Forest Red Gum			
Eucalyptus eugenioides	Thin-leaved Stringybark			
Eucalyptus amplifolia subsp. amplifolia	Cabbage Gum			
Angophora floribunda	Smooth-barked Apple			
Angophora subvelutina	Broad-leaved Apple			
Acacia floribunda	**White Sally Wattle**			
Acacia parramattensis	Parramatta Wattle			
Acacia decurrens	Black Wattle			
Melaleuca styphelioides	Prickly-leaved Tea Tree			
Melaleuca linariifolia	Flax-leaved Paperbark			
Casuarina glauca	Swamp Oak			
Recommended total number of trees		**113**	**98**	**N/A**

Table 12-3 Recommended shrub species numbers for each revegetation area

Species	Common Name	Number of plants		
		Reveg 1A	Reveg 1B	Reveg 2
		450m2	390m2	350m2
Acacia mearnsii	**Black Wattle**	Mix of adjacent plant species at 1 plant / 2m2	Mix of adjacent plant species at 1 plant / 2m2	Mix of adjacent species at 1 plant / 2m2
Breynia oblongifolia	Coffee Bush			
Bursaria spinosa	Blackthorn			
Leucopogon juniperinus	Prickly Beard-heath			
Melicytus dentatus	**Tree Violet**			
Ozothamnus diosmifolius	Rice Flower			
Trema tomentosa	Native Peach			
Recommended total number of shrubs		**225**	**195**	**178**

Table 12-4 Recommended seed mix of grass, sedge, groundcover, and climbing species for each revegetation area

Species	Common Name	Number of plants		
		Reveg 1A	Reveg 1B	Reveg 4
		450m2	390m2	350m2
Urtica incisa	**Stinging Nettle**	Mix of adjacent plant species (seed mix / tube stock) at 6 plants / m2	Mix of adjacent plant species (seed mix / tube stock) at 6 plants / m2	Mix of adjacent plant species (seed mix / tube stock) at 6 plants / m2
Lomandra longifolia	Spiny-headed Mat-rush			
Dichondra repens	Kidney Weed			
Pratia purpurascens	Whiteroot			
Solanum prinophyllum	Forest Nightshade			
Brunoniella australis	Blue Trumpet			
Commelina cyanea	-			
Centella asiatica	Indian Pennywort			
Dianella longifolia	Blueberry Lily			
Einadia hastata	Berry Saltbush			
Veronica plebeia	Trailing Speedwell			
Wahlenbergia gracilis	Sprawling Bluebell			
Alternanthera denticulata	Lesser Joyweed			

Species	Common Name	Number of plants		
		Reveg 1A	Reveg 1B	Reveg 4
		450m2	390m2	350m2
Plectranthus parviflorus	Cockspur Flower			
Senecio hispidulus	Hill Fireweed			
Sigesbeckia orientalis	-			
Pandorea pandorana	**Wonga Wonga Vine**			
Stephania japonica	**Snake Vine**			
Austrostipa ramosissima	Stout Bamboo Grass			
Paspalidium distans	-			
Digitaria parviflora	Small-flowered Finger Grass			
Microlaena stipoides	Weeping Grass			
Entolasia marginata	Bordered Panic			
Echinopogon caespitosus	Bushy Hedgehog-grass			
Eragrostis leptostachya	Paddock Lovegrass			
Lachnagrostis filiformis	-			
Oplismenus aemulus	Australian Basket Grass			
Poa affinis	-			
Total number of grasses / sedges / groundcover		**2700**	**2340**	**2100**

Appendix C. Photographic monitoring points

Refer to Figure 11 for coordinates and bearing of each photo monitoring location.

Monitoring location 1A

Monitoring location 1B

Monitoring location 1C

Monitoring location 2A

Monitoring location 2B

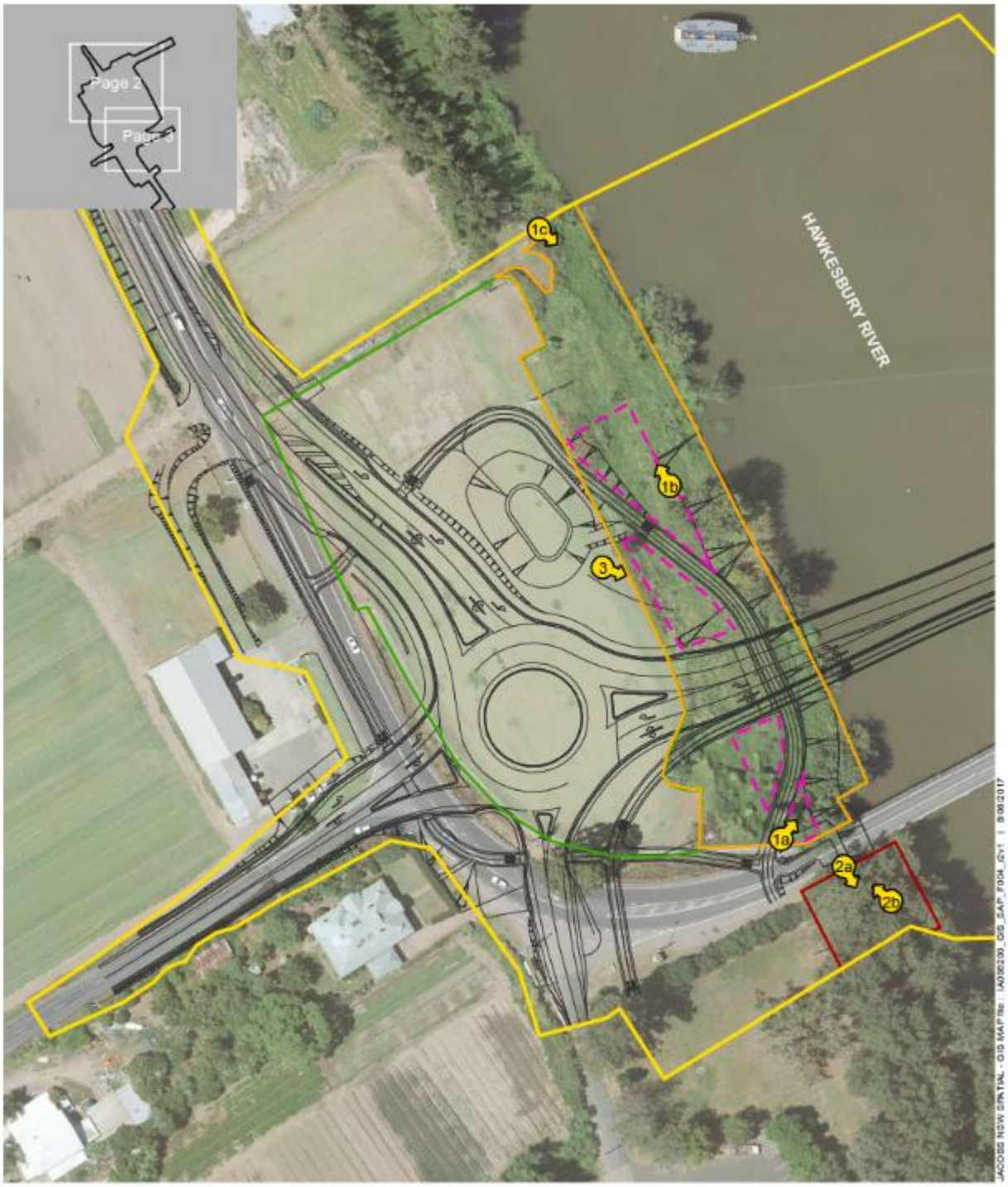
Monitoring location 3

Monitoring location 4A

Monitoring location 4B

Monitoring location 4C

Monitoring location 5



Legend

- Project boundary
- Detailed design
- Photo location
- Riparian revegetation area

Riparian corridor management zones

- Zone 1
- Zone 2
- Zone 3

0 25 50m

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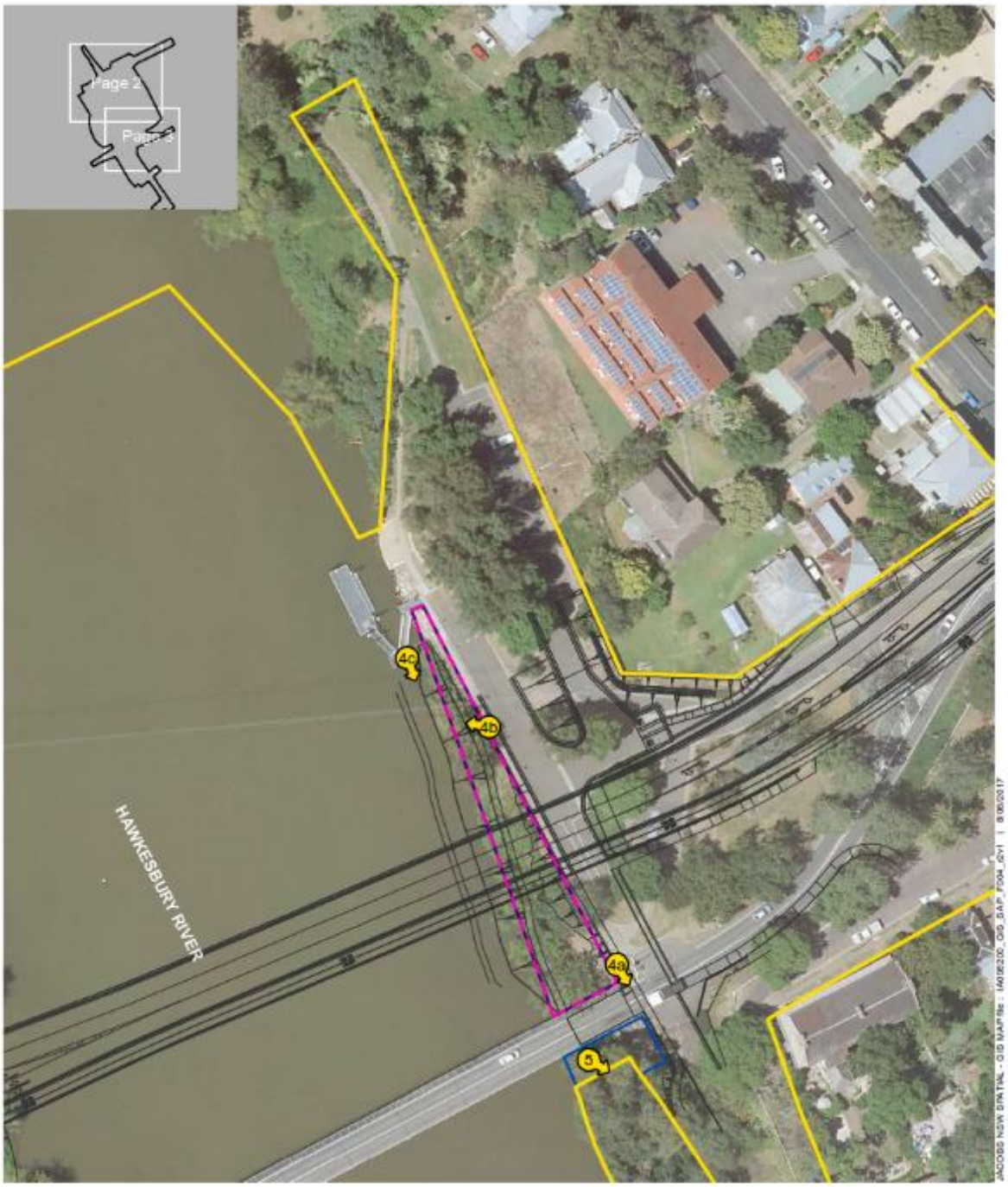
Data sources

Jacobs 2017
Ausimage 2015
RMS 2017

Figure 11-1 | Management zones and monitoring locations



Legend

- Project boundary
- Detailed design
- Photo location
- Riparian revegetation area

Riparian corridor management zones

- Zone 4
- Zone 5

0 25 50m

1:1,200 @ A4

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N

Data sources

Jacobs 2017
Ausimage 2015
RMS 2017

Figure 11-1 | Management zones and monitoring locations