



Third Creek Survey and Management Plan

Report to the Campbelltown City Council

Prepared by Catherine Miles

Miles Environmental Pty Ltd

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Miles Environmental Pty Ltd

E: cm@milesenvironmental.com.au

P: 0408 640 377

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Cover photos (clockwise from top left): Section 1; Section 2 Magill campus of the University of South Australia; Section 3 concrete-lined channel and Feather Grass along Shakespeare Avenue; Section 4 Flowering and fruiting Banksia in The Gums Reserve

All maps are produced by Miles Environmental Pty Ltd

1. SUMMARY

This report presents the results of an assessment of the biodiversity and habitat values of Third Creek within the Campbelltown City Council boundaries and proposes management recommendations for improving the terrestrial and watercourse habitat and condition and enhancing the amenity values. The creek was surveyed on foot in March 2017.

Within Campbelltown City Council, Third Creek has a very narrow riparian reserve along much of its length with occasional wider reserves. Remnant and regenerating River Red Gums occur along most of its length but there is very little other naturally occurring native vegetation. Revegetation with a small number of large shrubs and small tree species was undertaken in all the wider linear reserves between ten and twenty years ago, while recent revegetation has been undertaken in some areas that includes a more diverse range of local native species, particularly groundlayer species. A total of 43 local native species were recorded in this survey. Some sections of the watercourse are concrete-lined channels and underground pipes and there is little scope to improve these areas without significant investment.

For the purposes of this report, Third Creek is divided into five sections, described in detail and prioritised for management. Management priorities are given at the section scale and prioritised in Table 1, with more detail provided in Section 4.6.

Table 1 Management priorities for Third Creek

Section	Priority of Section	Management action priority			
		Very High	High	Medium	Low
1	Medium	Asset protection erosion management works	Removal of high threat woody weeds (including non-local native species)	Control of moderate threat weeds	Engage with local residents to encourage use of local native species in gardens and discourage planting weedy species
2	High		Removal of high threat non-woody weeds	Erosion management with revegetation and 'soft engineering'	
3	Low	Monitor and remove watercourse weeds		Revegetation of groundlayer species in areas of good weed control	
4	High		Spot weed around existing revegetation in good condition areas		
5	Low				

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2. INTRODUCTION

3.1 PROJECT OBJECTIVES

This project was undertaken to:

- Assess the biodiversity and habitat values of Third Creek
- Identify major weed issues and options for management, and
- Identify opportunities for strategic revegetation for both erosion control and habitat enhancement.

Ultimately, the aim of this work is to assist the Campbelltown City Council to take a coordinated approach to the management of Third Creek to ensure all aspects of management contribute to good environmental outcomes and community expectations. Creek surveys and management plans have been prepared for Fourth and Fifth Creeks within Campbelltown City Council (Miles 2016, 2017), giving the Council a consistent framework for watercourse management and investment across the Council area.

3.2 THIRD CREEK

Third Creek originates in the western Mount Lofty Ranges and traverses the Adelaide Plains for approximately five and a half kilometres until it joins the Torrens River. The upper catchment includes fruit orchards, grazing land, a quarry, conservation areas and lifestyle and residential blocks. A survey of Third Creek and its major tributaries upstream of the Campbelltown City Council area was undertaken in 2011 and found the creeks to be dominated by introduced species, with very little native vegetation (Bishop and Miles 2012) while the Third Creek Reserve was cleared of exotic trees and revegetated in the 1990s (P. Langman pers. com. March 2017). Following the preparation of the *Third Creek Catchment Management Plan* (Bishop and Miles 2012), landholders and community members in the upstream areas have removed weeds and planted local native vegetation in some sections.

Third Creek enters the area of Campbelltown City Council at the top of Magill Road in Magill and flows westwards to the River Torrens, crossing in to the neighbouring local government area of Norwood, Payneham and St Peters at Glynburn Road. Through the Campbelltown City Council area, the creek has been piped underground for some short sections, while a significant proportion of the channel has been concreted. There are, however, sections where the channel is largely 'natural' with wide riparian reserves (although it is likely that the creek has altered significantly from pre-European times). Downstream of the Campbelltown area, Third Creek is highly modified, with significant sections piped underground and the remainder of its length concreted, and minimal riparian corridor.

Because Third Creek has been effectively disconnected from the Torrens River through piping underground and channelisation, there is limited scope for the creek to function as a riparian corridor for the movement of aquatic and terrestrial fauna between the River Torrens and the Adelaide Hills Face Zone. However the reserves along the creek can still provide ecological value through supporting fauna that exist within and move across the urban matrix. The reserves also provide opportunities to conserve and promote the original native vegetation of the Adelaide Plains and are areas where the community can engage with nature as well as undertake recreation.

Pre-European vegetation of Third Creek would have been River Red Gum (*Eucalyptus camaldulensis* ssp. *camaldulensis*) woodland, with SA Blue Gum (*E. leucoxylon* ssp. *leucoxylon*) woodlands on the adjacent plains. The pre-European vegetation is described in more detail in Brewer (2009) and Kraehenbuel (1996).

Within the Campbelltown City Council area the native riparian vegetation has been largely cleared except for remnant River Red Gums lining the riparian corridor and occasional sedges and rushes that grow in the creek bed. A survey of the Gums Reserve was undertaken in 1999 /

2000 and found seven native species (Brewer 2000; see Appendix 1). Revegetation works have been undertaken in many reserves over the last twenty or so years and the diversity of native species has been increased. The Council is committed to continual improvement of the creek corridor for stormwater management, water quality, visual amenity and accessibility for the community while protecting and enhancing the remnant native vegetation to provide habitat and resources for the local wildlife.

Where the channel bed is exposed, it is lined with sand, gravel and cobblestones, and the adjacent banks are unconsolidated sediments with gravel and cobblestone. It is highly likely that, prior to vegetation clearance and urbanisation, the alignment of the watercourse would have been highly mobile, shifting during high flow events in response to sediment deposition and vegetation growth.

3.3 EXISTING PLANS AND STRATEGIES

The Council's Strategic Plan (Campbelltown City Council 2010) is framed around five key themes: quality living, leadership, city planning, environmental responsibility and local economy. Goal 4 is *"An enhanced local environment delivered in partnership with the community"* and relevant to this project is Objective 4.1: *"Valuable recreation and open spaces enhanced through effective planning and management."* Strategies to achieve this objective include

- Conserving and enhancing local biodiversity through formal and informal landscaping and
- Improving and developing local seed banks to maintain biodiversity.

The Council also has obligations to manage stormwater to meet current standards and environmental requirements. The Council's Environmental Management Plan (EMP) was updated in 2016 and, under the theme of connected and healthy landscapes, focusses on connecting open space, conserving biodiversity and protecting local waterways (City of Campbelltown 2016). This watercourse management plan will support the Council to undertake a number of the initiatives identified in the EMP, particularly:

- Identify high priority biodiversity areas and prepare management strategies for protection and enhancement of these areas.
- Undertake erosion, bank stabilisation and revegetation works along creeks within Council's care.
- Integrate creek improvement works with Chain of Trails Master Plan to provide opportunities for conservation options.
- Develop a strategic approach to creek management.
- Identify priority preventative works such as appropriate riparian revegetation.

The Council completed a Chain of Trails Master Plan (COTMP) (Swanbury Penglase 2014) for all creeks in the Campbelltown region, including Third Creek. The Master Plan includes a preliminary assessment of biodiversity values and erosion issues and recommendations to conserve and enhance biodiversity and mitigate erosion. The Master Plan sets a framework for developing and improving the trail network through the creek reserves and incorporates sustainable trail development principles (Government of South Australia). The Master Plan also promotes the use of local native species for plantings.

The Adelaide and Mt Lofty Ranges Natural Resources Management Plan (AMLR NRMB 2013) identifies the following targets relevant to the Third Creek Management Plan to be achieved by 2028:

- Target 2: Aquatic ecosystems and groundwater condition is maintained or improved by 2028
- Target 7: Condition and function of ecosystems (terrestrial, riparian) recovered from current levels
- Target 13: Increase participation in natural resources management activities by 20%.

3. WATERCOURSE MANAGEMENT PLAN

4.1 OVERVIEW

For the purposes of this report, Third Creek is divided into five sections (see Map 1) each exhibiting similar features and management issues. However there is considerable variation throughout the entire survey area and therefore each section has been further divided into zones of broad condition categories as follows:

- A – Good condition (e.g. remnant canopy, diverse revegetated understorey, few high threat weeds)
- B – Moderate condition (e.g. remnant canopy, low diversity revegetated understorey, high threat weeds present)
- C – Poor condition (e.g. remnant canopy may not be present, dominated by exotic species)
- D – Highly degraded (e.g. piped underground or concrete channel with no riparian zone).

4.2 MANAGEMENT OBJECTIVES

The objectives for managing Third Creek are to:

- *Prevent any further decline in condition of the watercourse and riparian habitats*
- *Restore the condition of the watercourse and riparian habitats*
- *Maintain and enhance the amenity and recreational values of the creek corridor*
- *Coordinate management across Council to achieve multiple objectives.*

4.3 STRATEGIC FRAMEWORK

In order to assist the Council to most effectively allocate funds to manage and restore creek-lines within the study area, each management section has been assigned an overall priority and the management requirements within each section are prioritised.

The overall priority of the sections for management is derived from a basic assessment of the ecological value of the sections based on:

- Naturalness (channel form, erosion, remnant native overstorey, revegetation, habitats, weed threat)
- Diversity and richness (number of native plant species, range of habitats).

More natural and more diverse sites are considered a higher priority on the basis that less resources are required to maintain these areas and they have more to lose than highly modified and low diversity sites.

Management actions within each section were prioritised based on the following ecological criteria:

Very high - short term action required in to mitigate immediate threats

High – action required to prevent the condition of the site deteriorating

Medium – action required to improve the condition of the site (relatively low level of resources required compared with the benefits)

Low – action required to improve the condition of the site (relatively high level of resources required compared with the benefit, or low cost and low level of benefit).

Some actions may be re-prioritised as circumstances change, such as where external funding becomes available for certain types of work or other related measures are being implemented (e.g. as part of the implementation of the Trails Master Plan or erosion control measures).

4.4 SURVEY METHOD

A survey of Third Creek was undertaken on the 8th of March 2017. Sections of creek were delineated in the field based on common features occurring throughout a section. For each section the following were recorded:

- Native and introduced vegetation species in the riparian zone and the watercourse
- Condition of riparian and watercourse vegetation (based on abundance and diversity of native species and exotic species)
- Riparian habitat features (hollows, fallen timber, leaf litter, groundcover, shrubs, overstorey and other)
- Watercourse habitat features (deeper pools, logs, rocks, other)
- High threat weeds
- Erosion and Channel modification
- Safety issues
- Other management issues

High threat weeds were mapped in the field using handheld GPS (Garmin GPSMap 62pc).

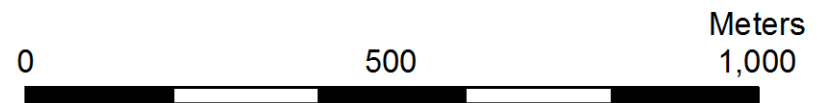
The following features were subjectively assessed to derive overall priority for each section:

- Remnant Native Vegetation: the proportion of native vegetation covering the site, and the range of native species.
- Weed Risk: the proportion of weed cover, and the risk of those weeds spreading through the site and the wider area (Croft et. al. 2005).
- Revegetation: areas already revegetated were considered to have a higher value for biodiversity and creek health.
- Habitats: areas with a greater range and number of habitats were given a higher value, habitats included large remnant trees with hollows, shrubs, reed beds, permanent pools, large woody debris in pools, open water and submerged aquatic vegetation.
- Channel form: unmodified channel form was given a higher priority than modified channels (e.g. widened).
- Erosion: presence or absence.

Plants are referred to by their common name throughout the report, with a list of scientific names in Appendix 1 where a full list of all plant species observed is given. It should be noted that, due to the timing of the survey, many annual native and exotic species would not have been observed (e.g. Chocolate Lilies, Sour-sobs, Climbing Asparagus and Three Corner Garlic).

The report was prepared in consultation with staff from Campbelltown City Council.

Third Creek Management Plan



Map produced by Miles Environmental Pty Ltd
March 2017

Map 1: Third Creek management sections

4.5 THIRD CREEK SURVEY RESULTS

4.5.1 Section 1. Magill Road to St Bernards Road

The most upstream part of Section 1 is in the most 'natural condition' (Figure 1) with respect to channel modifications and vegetation composition. Most parts of the creek have been channelised, including through Boord Reserve. Between Norton Summit Road and Vine Street the creek is eroded (Figure 2), presumably from the recent floods. Work has begun in this area to reinforce the banks with rock, however further work is required to address channel deepening.

Section 1 of Third Creek is primarily a narrow riparian strip where private gardens are planted to the edge of the creek banks and the vegetation is almost completely comprised of exotic species with the exception of the following reserves:

- A small section adjacent to the bus turn-around on Magill Road where there are native reeds and shrubs growing in the creek (Figure 1).
- The reserve between Norton Summit Road and Vine Street, where weeds have been largely cleared and a small area of diverse native understorey species have been established. These plantings could be extended but there are also some major erosion issues that will need to be addressed first.
- Boord Reserve where the south banks have been revegetated over a number of years and a diverse mix of species and vegetation layers has been established (Figure 3). The plantings are set back from the bank so that the watercourse still lacks riparian vegetation.
- Nightingale Reserve, where a small number of native species have been planted along the creek banks and the reserve contains River Red Gums over exotic lawns (Figure 4). This area could be enhanced by further scattered plantings of small tree species (e.g. Drooping Sheoaks and Blackwoods) and areas of groundlayer plantings around the base of large trees. The south banks are covered with Periwinkle. The reserve contains a children's playground therefore planting shrubby species that can block lines of sight should be avoided (see [section 5.2.2](#)).

Overall priority: Medium



Map 2: Section 1 weeds and watercourse condition

Third Creek Management Plan

Feature	Condition
Native vegetation condition	<p>Good condition (18%): Boord Reserve and the downstream end of the reserve adjacent to Vine Street. Boord Reserve appears to have been revegetated over a number of years, with newer plantings containing a diverse mix of understorey species. The Vine Street reserve has been recently planted.</p> <p>Moderate condition (15%): area of low weed threat but little native vegetation.</p> <p>Moderate/Poor (49%): sections where one bank is in moderate condition and the other bank is dominated by exotic species due to gardens extending to the creek banks.</p> <p>Poor (17%): exotic species dominate both banks.</p> <p>19 local native species recorded as being planted and remnant River Red Gums throughout.</p>
Watercourse condition	<p>Generally poor due to narrow riparian widths, channelisation and dominance of exotic species.</p> <p>Five native watercourse species recorded.</p>
High threat weeds	<p>Desert Ash seedlings present in low abundance throughout the watercourse and on the banks. Periwinkle is the dominant groundcover in many areas. Caster Oil Plant throughout in low abundance. Isolated Blackberry, Italian Buckthorn, Peppercorn Tree, Cape Ivy and English Ivy.</p> <p>Older plantings of non-local native species that are and have the potential to spread, these are: Flinders Ranges Wattle, Coastal Wattle, Bracelet Honey-myrtle and Pink Honey-myrtle.</p>
Habitat (terrestrial)	Overstorey, understorey and some groundlayer in revegetation areas, few large remnant trees with hollows.
Habitat (watercourse)	Water was present and flowing to the first weir (between Norton Summit Road and Braeside Avenue); otherwise the watercourse is predominantly rocky creek bed.
Watercourse erosion	<p>Major recent erosion (bed deepening and bank erosion) between Norton Summit Road and Vine Street; it appears that some work has begun to remediate this. There are two major issues that need to be addressed: firstly that there are two sharp bends in the creek, and secondly that the bed level is below the outfall of the Norton Summit Road bridge. Potential safety risks.</p> <p>Bank erosion and scouring below the first weir (upstream of Norton Summit Road).</p>
Channel modification	The channel has been concreted in some sections and two weirs have been installed, while rock embankments have been used to prevent erosion.
Other	Limited access to some sections.



Figure 1 The upstream end of Section 1 contains some native watercourse vegetation and the channel appears unmodified



Figure 2 Erosion downstream of the Norton Summit Road bridge

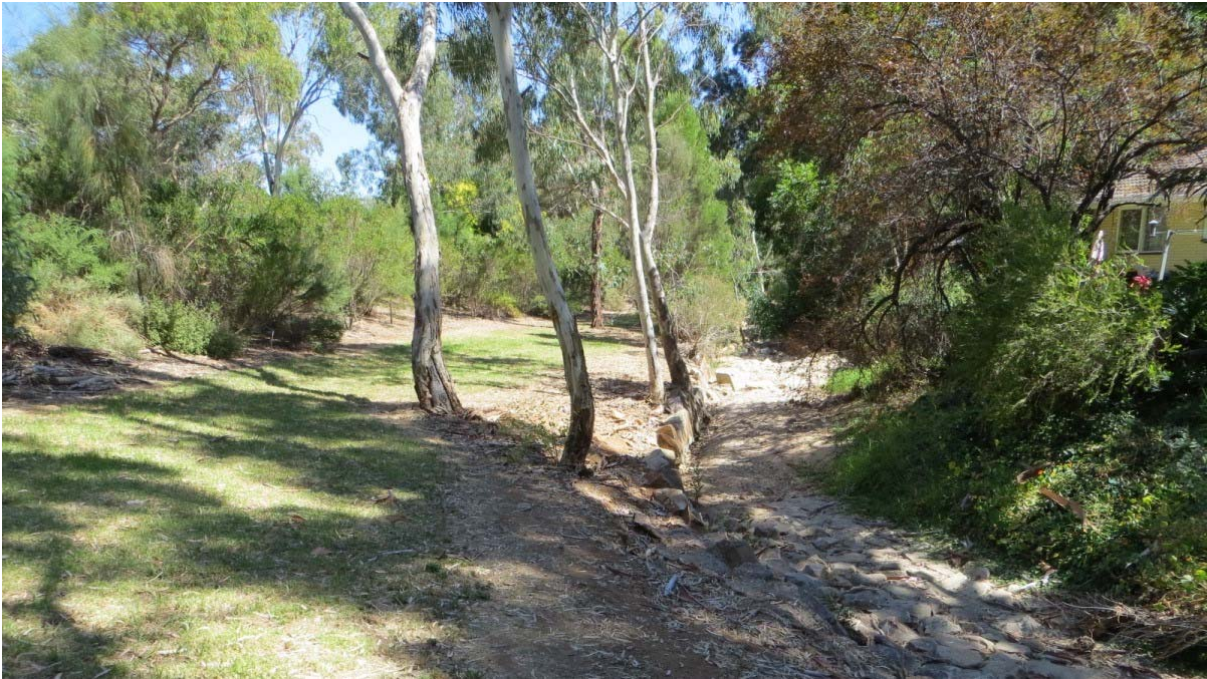


Figure 3 Boord Reserve showing revegetation areas set back from the creek banks on the south side but gardens extending to the north banks



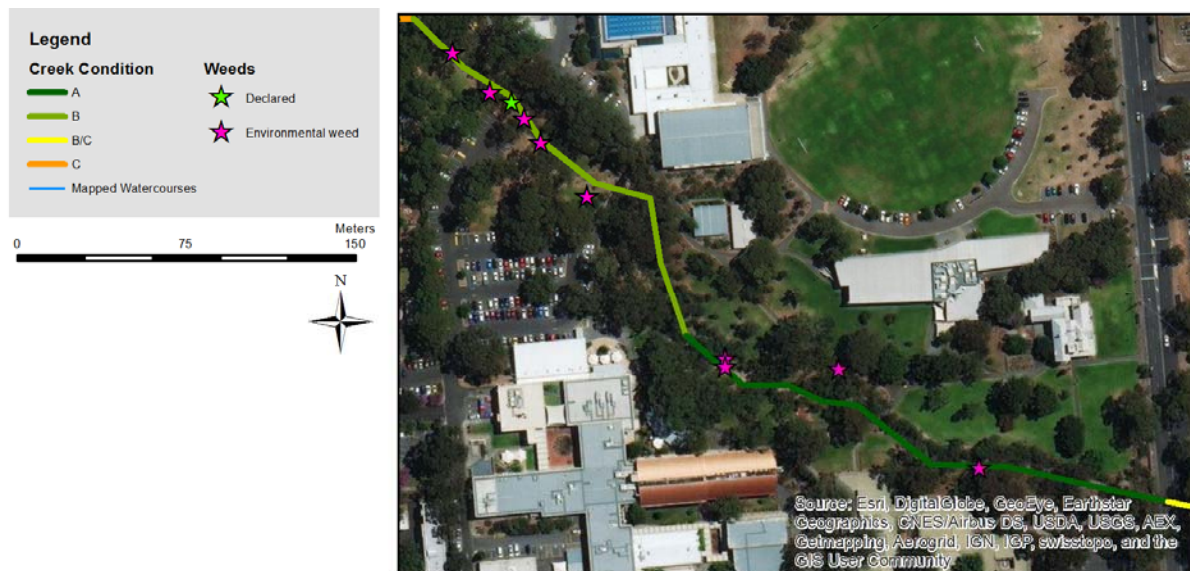
Figure 4 Nightingale Reserve

4.5.2 Section 2. University of SA Magill Campus

The highest diversity of native species of the entire Third Creek survey was recorded in the Magill Campus, with thirty four species planted in the upper portion (Figure 5) in addition to remnant and regenerated River Red Gums and relatively dense in-stream cover of Stiff Flat-sedge. There are few high threat weeds, although exotic grasses such as Couch, Water Couch and Rice Millet occur on the banks amongst the revegetation (Figure 6).

The downstream section of watercourse (below the second footbridge) is eroded, with banks between 1.5 and 2 metres high (Figure 7). Minimal bed deepening probably occurred in the recent floods, but the banks appear to have widened and several trees have had their roots exposed. The COTMP (Swanbury Penglase 2014)) notes that although the creek was deep the banks appeared to be stable. An assessment should be undertaken here to determine if there are any risks to safety or infrastructure that need to be addressed. Any works undertaken in this section should incorporate establishing riparian vegetation, particularly at the toe of eroding banks. The banks are currently sprayed in this area, leaving them bare and contributing to the erosion potential.

Overall priority: High



Map 3: Section 2 weeds and watercourse condition

Feature	Condition
Native vegetation condition	<p>Good condition (54%): the upstream part of the watercourse has been revegetated with a diverse range of local native species beneath an existing canopy of River Red Gums.</p> <p>Moderate condition (46%): the lower half of the watercourse comprises remnant and regenerated River Red Gums with occasional small trees over mown grasses with few high threat weeds.</p> <p>34 species planted and two naturally occurring.</p>
Watercourse condition	<p>Good to poor: there is a short section where the natural channel has been revegetated on the banks and there is a high density of native Stiff Flat-sedge (Figure 6), however upstream of this the channel is concrete lined and downstream it is deeply eroded.</p>

Third Creek Management Plan

Feature	Condition
High threat weeds	Low density of weeds: small Caster Oil Plants, one Olive, one White Cedar, one Peppercorn Tree in the gardens with potential to spread. Small patches of Periwinkle. Desert Ash seedlings in low abundance throughout.
Habitat (terrestrial)	Overstorey trees with hollows (although few very large trees), leaf litter, groundcovers and shrubs.
Habitat (watercourse)	Rocky creek bed, overhanging sedges.
Watercourse erosion	Bed deepening and widening downstream of the second footbridge, with instream trees undermined.
Channel modification	The top section has been concreted. There is a weir between the first and second footbridge. Some of the lower eroded part appears to have had rock and bank reinforcement in the past that has failed.

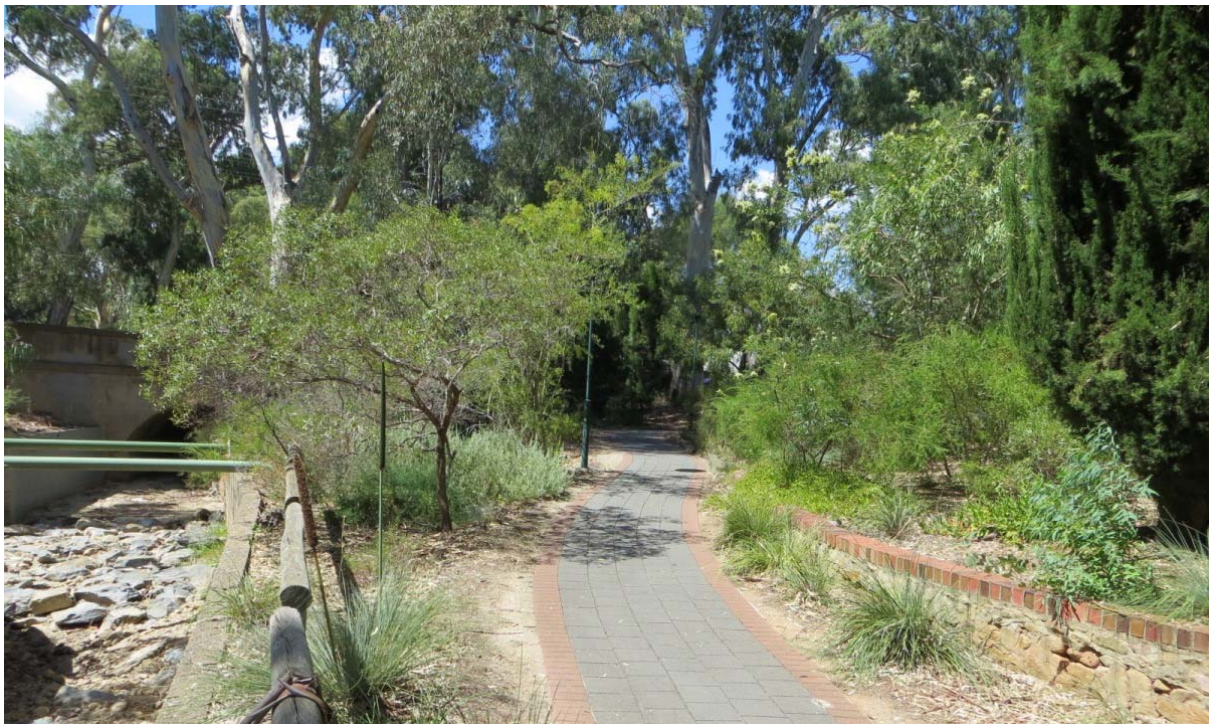


Figure 5 Area of local native plantings, with 32 local native species recorded, the highest of any section of Third Creek in this survey



Figure 6 Section of good riparian vegetation



Figure 7 Eroded lower half of the creek with trees undermined. Note the sprayed out, bare upper banks.

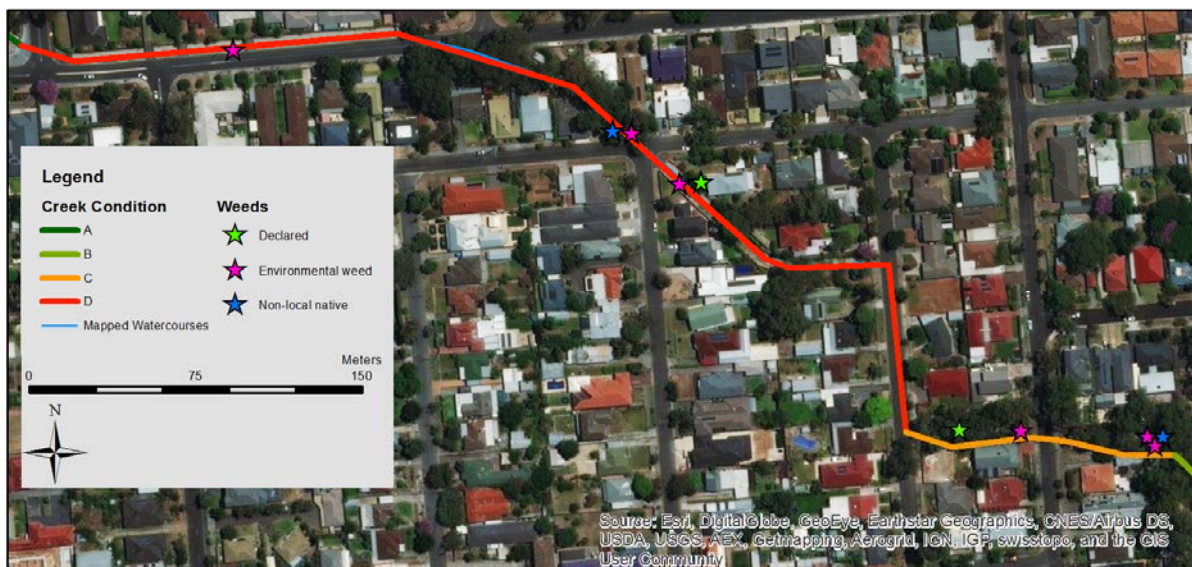
4.5.3 Section 3. Lorne Avenue to Fourth Street

This section of Third Creek is highly modified, with almost the entire length a combination of concrete lined channel and underground pipes. The only exception is between the Magill Campus and Lorne Avenue, where the channel is reinforced with rock gabions. Unlike most rock gabions, in this location the gabions are sloped, which may allow for the re-establishment of vegetation over time and also enable flows to recharge soil and groundwater.

The only remnant vegetation along this section is a small number of River Red Gums and there are two small areas of older revegetation at the upstream end, where six local native species were recorded. There is almost no riparian reserve along most of the creek and therefore limited scope for further revegetation. Local native groundcovers grasses, lilies and very low shrubs could potentially be planted at a small number of locations: either side of Lorne Avenue, immediately downstream of Balmoral Avenue and immediately downstream of Colton Avenue.

The COTMP proposes some major works in this area, namely to narrow some roads to create wider vegetated areas, and, subject to a flood study, a vegetated cap or boardwalk over the concreted sections of the watercourse. Should either option be implemented, local native low growing species could be incorporated. The creek reserve is too narrow to plant large trees, but smaller trees such as Drooping She-oak, Native Pine, Sticky Boobiala and Native Apricot could be incorporated.

Overall priority: Low



Map 4: Section 3 weeds and watercourse condition

Third Creek Management Plan

Feature	Condition
Native vegetation condition	Poor condition (20%): low diversity and weedy revegetation area at the upper end. Very degraded (80%): concrete open channel and underground pipes. Seven native species.
Watercourse condition	Poor to highly degraded due to channelisation and piping of the watercourse.
High threat weeds	Low due to concreting. Isolated Italian Buckthorn, White Cedar and Box Elm, a few occurrences of Caster Oil Plants. Feather Grass growing in the cracks of the channel along Shakespeare Avenue has the potential to spread downstream and is therefore a priority to control. Some plantings of weedy non-local natives.
Habitat (terrestrial)	Sparse canopy of River Red Gums.
Habitat (watercourse)	Nil.
Watercourse erosion	None, however a large section of the base of the concrete channel is absent (washed away?) just upstream of Windsor Avenue which may be a concern and should be assessed by an engineer.
Channel modification	Entire length is modified.



Figure 8 Section Three is predominantly a concrete lined channel. Below the tree the concrete is absent, although this is not easily visible in the photo.



Figure 9 Sloped rock gabions between Magill Campus and Lorne Road

4.5.4 Section 4. The Gums Reserve

Third Creek runs through the northern portion of The Gums Reserve which, as the name suggests, is characterised by numerous large remnant gum trees (River Red Gums and some SA Blue Gums). In 1999/2000 seven native species were recorded in the reserve; this survey recorded fourteen native species growing in the riparian zone. Revegetation in the reserve appears to have been undertaken in two stages, with older plantings of large shrubs and small trees along the creek, and newer plantings of smaller shrubs at the upstream end (Figure 10) and around the perimeter of the reserve. Of particular note is a large Silver Banksia in the older plantings that was flowering and carrying fruits with seeds (see cover photo bottom right).

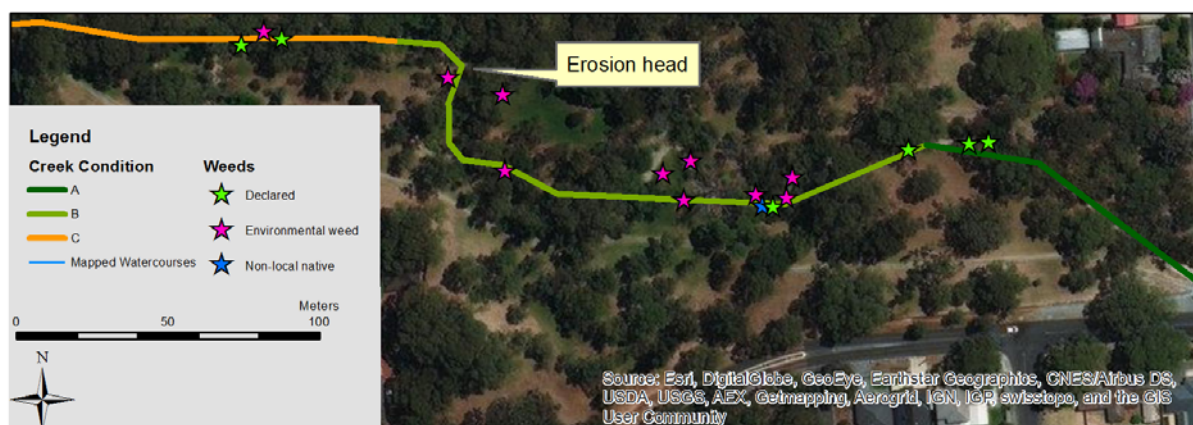
The Gums Landcare Group was recently formed and its focus includes improving the hydrology and biodiversity of Third Creek through The Gums Reserve. The group are working on controlling weeds and revegetation working from the upstream end to downstream, which is a sound approach. At the downstream extent of the newer revegetation area are large exotic trees and dense weedy groundcover which may be beyond the scope of volunteers to manage.

Future revegetation works in riparian zone of The Gums Reserve should focus on expanding the understorey planting area and continuing to add to the existing plantings to increase the cover and diversity of groundlayer species. However, revegetation will only be feasible where there has been good weed control.

An erosion head on an outer bend (see Map 5, Figure 11) may have been caused by overland flow in the recent floods, in which case it has the potential to continue into the grassed area of the reserve in the event of further floods. This site should be assessed by an engineer to determine the risk and if remediation is required.

The vegetation of the downstream end is large Olives, mature and seedling Desert Ash trees and large patches of Periwinkle (Figure 12). The soil is bare where the Periwinkle is not growing and there is some erosion of the banks. Some local native seedlings have been planted. Removal of the exotic trees in this area is a low priority in the context of other work required in The Gums Reserve, however, in the longer term their removal will reduce the weed seed load in the area as well as enabling expansion of the area of native vegetation in an urban area where there are few other areas to do so. The removal of the trees will need to be done in conjunction with Periwinkle control and re-establishment of native vegetation and potentially artificial soil cover such as jute matting to prevent erosion.

Priority: High



Map 5: Section 4 weeds and watercourse condition

Feature	Condition
Native vegetation condition	<p>Good (23%): young (<5 years old) revegetation mixed with older revegetation and few weeds. Wirilda appears to be regenerating from seed and suckering.</p> <p>Moderate (49%): older revegetation mixed with planted and self-seeded exotic trees and weedy understorey.</p> <p>Poor (28%): predominantly Olive trees and Desert Ash over exotic grasses and Periwinkle.</p> <p>Thirteen planted species and remnant River Red Gums in the riparian zone.</p>
Watercourse condition	Moderate: the first 60 metres is concreted, the mid-section is in good condition and the downstream section is weedy with some erosion.
High threat weeds	Desert Ash saplings and seedlings throughout with large trees in the downstream end; some small Olives in the upstream end and many large Olives in the downstream end. Periwinkle through all but the upstream end. There are various exotic trees planted in the reserve, some of which appear to have self-seeded and should therefore be removed. Flinders Ranges Wattle. Feather Grass at one location may have seeded from the plants growing in Section 3.
Habitat (terrestrial)	Large mature tree canopy, hollows, fallen timber, leaf litter and shrubs.
Habitat (watercourse)	Rocky creek bed.
Watercourse erosion	Outer bank erosion in the lower half of the section. Large rocks have been used to reinforce one area. There is one erosion head that has potential to cut back into the reserve during a flood.
Channel modification	The top end is concreted.



Figure 10 Concreted channel with new revegetation at the upstream end



Figure 11 Erosion head with potential to extend during flooding



Figure 12 Downstream end with Olives and Ash trees over Periwinkle. Note the planted seedlings.

4.5.5 Section 5. Freeman Avenue to Glynburn Road

Section 5 of Third Creek is comprised of a narrow riparian strip with gardens on the south bank along most of the length and the channel concreted. Between The Gums Reserve and Peckham Street the footpath is immediately adjacent to the creek channel on the north side so that there is effectively no riparian zone (Figure 13). The total native species count of twelve was due to revegetation at the downstream end (Figure 14) and remnant River Red Gums (of which there are few). There are a range of non-local native species planted in the reserve areas including some weedy species.

There is limited scope to improve the ecological values of Section 5 due to the narrow riparian widths, garden plantings and the concrete-lining of the channel. A small area adjacent to Glynburn Road could be improved by removing weedy native and non-native species and planting local native groundcovers. Local native species could also be incorporated in the reserve adjacent to Richardson Avenue, as suggested in the COTMP, however this is not considered a high priority site. The soil adjacent to the channel in this area has been eroded recently (Figure 15) and rehabilitation efforts could incorporate local native groundcovers and grasses.

Priority: Low



Map 6: Section 5 weeds and watercourse condition

Feature	Condition
Native vegetation condition	<p>Moderate (12%): Mixed plantings of local native and non-local native species.</p> <p>Poor (46%): Reserve adjacent to Richardson Avenue contains mostly non-local native species but few high threat weeds. Gardens extend to the channel on the south side.</p> <p>Very degraded (42%): both sides of the channel lack any native vegetation.</p> <p>Eleven planted local native species and remnant River Red Gums.</p>
Watercourse condition	Poor: entire channel is concrete-lined and there is no in-stream vegetation.
High threat weeds	Excluding the garden plantings, high threat weeds are Ash, Olives and Periwinkle in the top end, non-local natives: Flinders Ranges Wattle, Golden Wreath Wattle and Bracelet Honey-myrtle. Veldt Daisy and Giant Reed may have been planted but both have potential to spread.

Third Creek Management Plan

Feature	Condition
Habitat (terrestrial)	Very few remnant River Red Gums with hollows, some fallen timber and a patch of shrubs.
Habitat (watercourse)	Nil.
Watercourse erosion	On north side of channel in reserve.
Channel modification	Entire channel is concrete-lined.

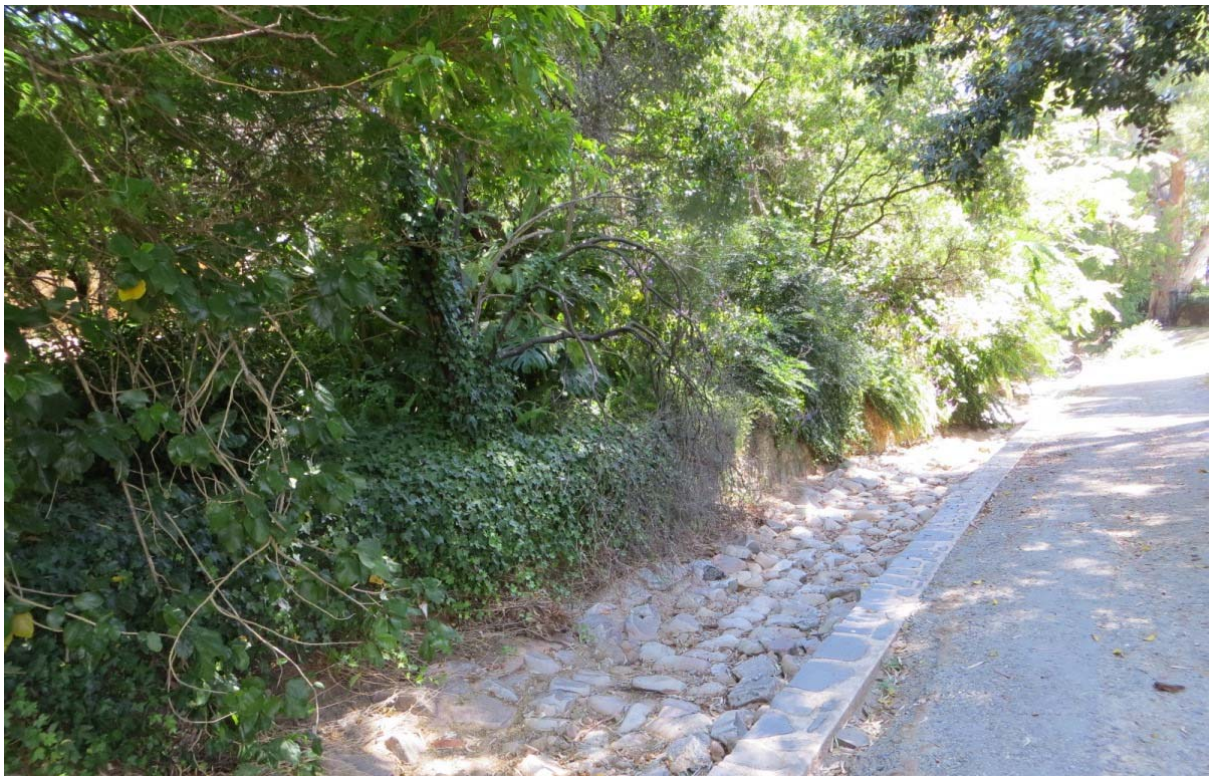


Figure 13 Between The Gums reserve and Peckham Street Third Creek exists only as a concrete-lined channel with gardens on the south (left) bank and a footpath on the north (right) bank



Figure 14 Mixed local and non-local native plantings adjacent to Glynburn Road



Figure 15 Erosion on the outside of the channel adjacent to Richardson Avenue

4.6 MANAGEMENT PRIORITIES

See Section 4 for methods.

Priority	Management Action	Section					
		1	2	3	4	5	
Section priority#:		M	H	L	H	L	
Very High	Asset protection erosion management works						
	Undertake engineering works to repair and reduce risk to assets and public safety, incorporating revegetation where feasible.	✓	✓			✓	
Very High	Monitor for and remove watercourse weeds						
	Remove watercourse weeds with a high potential to spread using minimal disturbance methods to prevent off-target damage to the aquatic environment; work from upstream to downstream; undertake monitoring for and removal of re-growth within twelve months:						
	• Blackberry	✓					
	• Desert Ash*	✓	✓	✓	✓	✓	
	• Feathergrass*			✓	✓		
High	Removal of high threat woody weeds (including non-local natives)						
	Control of exotic trees and woody weeds and follow-up every two to four years. Use minimal disturbance techniques such as “cut and swab” for saplings and shrubs, “drill and fill” for larger trees and small seedlings may be hand-pulled:						
	• Buckthorn	✓		✓			
	• Cactus	✓					
	• Caster Oil Plant*	✓	✓	✓	✓		
	• Coastal wattle	✓					
	• Flinders Ranges Wattle	✓		✓	✓	✓	
	• Golden Wreath Wattle			✓			
	• Olives.		✓		✓	✓	
	High	Removal of high threat non-woody weeds					
		Control of non-woody weeds using minimal disturbance methods including spot spray and grubbing out:					
		• Cape Ivy – monitor for re-growth in creek downstream	✓				
• Giant Reed						✓	
	• Periwinkle.	✓	✓		✓	✓	
High	Spot weed around existing revegetation in good condition areas						
	Use minimal disturbance techniques (spot spray, hand pull, brush-cutting) to remove grassy and herbaceous weeds around revegetation, particularly native groundcovers, to encourage natural regeneration.	✓	✓		✓		

Priority	Management Action	Section					
		1	2	3	4	5	
		Section priority:	M	H	L	H	L
Medium	Control of moderate threat weeds:						
	• Box Elm** - monitor for re-growth in sections downstream				✓		
	• Bracelet Honey-myrtle	✓					✓
	• English Ivy	✓			✓		
	• Peppercorn tree**	✓	✓			✓	
	• Pink Honey-myrtle	✓					
	• Rice Millet (in revegetation areas only)	✓	✓	✓	✓		
	• Rhodes grass - monitor for re-growth in sections downstream	✓					
	• Swamp Oak						✓
	• Umbrella sedge	✓		✓			
	• Veldt Daisy						✓
	• White Cedar.	✓	✓	✓	✓		
Medium	Erosion management with revegetation and ‘soft engineering’	✓				✓	
	Undertake erosion control works to address active erosion at lower risk sites, favouring ‘soft’ engineering options and improving bank protection with native sedges and rushes and focussing on addressing bed deepening.						
Medium	Revegetation						
	Plant groundlayer species where sufficient weed control has been achieved to improve diversity in good condition areas and expand revegetation into medium condition areas.	✓	✓			✓	✓
Low	Residential gardens						
	Engage with local landholders to encourage incorporation of local native species and removal of weedy species in gardens.	✓			✓		✓
Low	Landscaping works						
	Incorporate local native species in street re-vitalisation plantings, general landscaping and water sensitive urban design areas.	✓			✓		✓

Section priority: H (high), M (medium), L (low)

*Indicates weeds growing in the watercourse that require great care to avoid off target damage

**Indicates weeds growing in adjacent gardens/planted in reserves

4. MANAGEMENT METHODS

5.1 WEED MANAGEMENT

A previous survey of Third Creek upstream of study area found an abundance of weeds (Bishop and Miles 2012). Many weed species also exist in residential gardens adjacent to Third Creek. Weed control will therefore be an on-going task and it will be important to focus on maintaining areas that are currently low in weed abundance, focussing on species with potential to expand their distribution and supporting and encouraging community efforts on public and private land.

Isolated occurrences of high threat weeds were mapped as part of the field survey; these include Weeds of National Significance (WoNS), declared weeds under the Natural Resources Management Act (2004) as well as species considered to pose a threat to the watercourse values.

5.1.1 Woody weeds and exotic trees

Council staff currently undertake an annual to biannual program of woody weed control using cut and swab methods to remove instream and bank woody weeds, particularly Desert Ash and Olives. This program will need to be on-going as the urban setting of the creek means that weeds are constantly being replaced, however, with regular maintenance, the task is kept to a minimum.

Ash seedlings occurred throughout and were not mapped individually. The field survey component also identified a number of non-local native species considered a weed threat that have been planted and are either regenerating or have the potential to do so (Virtue and Melland 2003). These species should also be included in the regular woody weed control program and similar control methods can be used. Large exotic tree species (e.g. Buckthorn, Peppercorn Tree, large Olives) can be removed using drill and fill method and subsequently cut down if they are considered likely to pose a risk.

The control methods (Table 2) used must be consistent with current best practice (AMLR NRMB 2014, Shepherd 2013) to ensure no off-target damage, including undertaking control work when the watercourse is dry and no rain is expected and only using approved herbicides.

5.1.2 Non-woody weeds

A range of non-woody weeds were also identified in the field survey that should be controlled to reduce the threat of these becoming dominant. Control methods are outlined below based on Robertson (2005), Shepard (2013) and Romanowski (2011). Recommended herbicides and application rates for most species are given in Shepard (2013). As for woody weeds, control methods must be consistent with current best practice (AMLR NRMB 2014). It should be noted that, as the survey was carried out at the start of autumn, some annual weeds and weeds that shoot from bulbs and tubers and then die-back could be present during the winter months.

Exotic Sedges (*Cyperus* spp.)

One exotic sedge was observed during the field surveys, Umbrella Sedge (*C. involucreatus*). Another exotic sedge Dense Flat-sedge (*C. congestus*), has been found in neighbouring Fourth and Fifth Creeks (Miles 2016, 2017) and upstream in Third Creek catchment and there is potential for it to spread into the Campbelltown City Council portion of Third Creek. Native Flat-sedge (*C. vaginatus*) was found in the Third Creek survey while another native species (*C. gymnocaulos*) may also occur in Third Creek. The exotic sedges can be most easily be distinguished from the native species by the following features:

- Umbrella Sedge is almost twice the height of the other sedges and has much longer and more numerous bracts than the local native species
- Dense Flat-sedge has leaves of similar length to the stems and is bright green while the two native species have no obvious leaves (they are reduced to short bracts around the base of the stem) and the stems are a darker green colour.

Umbrella Sedge has been rated as a medium priority for control, however, should any occurrences of Dense Flat-sedge be found these should be controlled as a matter of high priority as this species has potential to become dominant in watercourses.

Herbaceous and grassy weeds

Herbaceous and grassy weed species were recorded throughout most of Third Creek, particularly Kikuyu, Nasturtiums and Couch and their occurrences were not mapped. Attempting to remove these weeds on a broad scale is not recommended as they are already so abundant that effective removal would be difficult to achieve, would leave large areas bare and may result in off-target damage. However, in existing and proposed revegetation areas, herbaceous and grassy weeds should be controlled as part of the revegetation preparation and management. Non-selective herbicides approved for use near a watercourse should be effective, however, non-herbicide methods that could also be effective are steam weeding and flame torch. Experienced contractors should be engaged to trial these non-herbicide methods.

Table 2 Weed control methods

Weed	Control methods	Timing	Other
Cactus	Inject herbicide into stems or spot spray	Spring to Summer	
Cape Ivy	Work inwards from the outer edges. Pull or dig up runners and grub out main root. Spot spray foliage.	Winter to Spring	
English Ivy	Work inwards from outer edges, grub out or spray	Spring	Herbicide may not be highly effective
Fountain Grass	Grub out plants where feasible. Spot spray when actively growing.	Spring to Summer	Remove and bag seed heads to prevent seeds spreading
Giant Reed	Slash and spot spray re-growth.	Spring to Summer	
Periwinkle	Spray from the outer edges, can be slashed and actively growing re-growth sprayed.	Winter – spring	Monitor and control regrowth annually
Rice Millet	Apply non-selective herbicide when actively growing.	Spring to early Summer	Slashing and spraying re-growth may be most effective
Umbrella Sedge	Grub out small plants, ensuring all roots are removed or wipe herbicide onto leaves.	Early summer (before seed set)	See below for identification tips. Work from upstream to downstream.

5.2 NATIVE VEGETATION MANAGEMENT

5.2.1 Management of existing revegetation

Third Creek has a very narrow riparian reserve along much of its length with occasional wider reserves. Revegetation with a small number of large shrubs and small tree species was undertaken in all the wider reserves between ten and twenty years ago, while in the larger reserves, recent revegetation has been undertaken that includes a more diverse range of local native species, particularly groundlayer species (e.g. Figure 3, Figure 5 and Figure 10). Areas that have been rated as being in good condition generally have remnant and regenerating River Red Gums and planted local native shrubs and small trees with groundlayer species (e.g. groundcovers, native grasses, tussocks and herbaceous species). Areas rated as being in medium condition generally have local native trees and large shrubs planted without groundlayer species. Areas without groundlayer will provide habitat and biodiversity benefits without further plantings, but could provide greater benefits with the establishment of native groundlayer species. Native groundlayer plants provide food and habitat for a greater range of fauna, particularly insects, lizards and ground foraging birds (Munro et al., 2007; Kazemi et al., 2009). Groundlayer species are, however, relatively difficult to establish in existing revegetation where there is competition for soil moisture and light and their establishment also requires more complex on-going weed management.

Managing weeds in existing revegetation areas is a priority to ensure that the resources and effort that has gone into these areas to date is not wasted, to encourage natural regeneration and to ensure community support for further revegetation work.

Encouraging natural regeneration

Spot spraying and hand-pulling weeds around existing plantings can assist to encourage natural regeneration but requires good plant identification and care to ensure no accidental damage to the revegetation. Brush-cutting annual weeds amongst revegetation can also be used to reduce the weed seed set.

Mulching is a useful method to control weed regeneration in new plantings but generally prevents natural regeneration. Therefore it is recommended that mulching should not continue to be applied once revegetation is well established (i.e. after three years) unless weed control is a priority (i.e. in 'demonstration revegetation' areas).

5.2.2 Future revegetation works

As noted above, all areas of Third Creek that can be revegetated have been, to varying degrees, and there are no areas where entirely new revegetation is required. However there is scope to expand the areas of understorey plantings into the older planting areas where good weed control has been achieved and increase the diversity of species in recent understorey planting areas. Revegetation in public places should also follow CPTED¹ principles, particularly ensuring good sightlines along pathways, with planting mostly lower than 0.6 metres and branches above two metres high.

Local seed sources should be used for propagation and a records system should be developed to document the source of seed used in projects. This will enable revegetation sites to become a source for propagation for future revegetation.

Any new areas of revegetation should have regard to the Trails Master Plan, including the proposed widths and location of trails.

¹ Crime Prevention Through Environmental Design

5.2.3 Revegetation species list and plant numbers

The following tables are recommended species for plantings (Table 3) and relative numbers of plant life forms per 10 x 10 metres (0.01 hectares) of revegetation area designed to achieve an 'open park' appearance (Table 4).

The groundlayer of any area of undisturbed remnant vegetation generally contains the greatest diversity of species but many of these species are difficult to propagate. Some groundlayer species are often accidentally mistaken for weeds by those not familiar in plant identification, which results in them being removed as part of site maintenance. The groundlayer revegetation species are therefore divided into two groups:

- Group A: species that are reasonably hardy and readily identifiable as being planted natives
- Group B: species that are less hardy and more likely to be confused with weeds.

Group B species should only be planted in areas where a high level of weed maintenance by experienced staff, contractors or volunteers can be undertaken. Council staff that are likely to undertake maintenance should be involved in the plantings so that they are aware of what has been planted, and plant identification resources and/or training will assist them to maintain the areas without causing accidental off-target damage. Bamboo stakes placed next to each plant may also assist to identify planted species.

Table 3 Revegetation species (see Table 4 for plant numbers)

Scientific Name	Common Name	Watercourse	Bank	Large tree	Small tree	Shrub	Groundlayer A	Groundlayer B
<i>Acacia acinacea</i>	Wreath Wattle		✓			✓		
<i>Acacia melanoxylon</i>	Blackwood		✓		✓			
<i>Acacia pycnantha</i>	Golden Wattle		✓		✓			
<i>Acacia retinodes</i>	Wirilda ('hill form')		✓		✓			
<i>Allocasuarina verticillata</i>	Drooping Sheoak		✓		✓			
<i>Arthropodium strictum</i> , <i>A. fimbriatum</i>	Chocolate lilies		✓					✓
<i>Atriplex semibaccata</i>	Berry Saltbush		✓				✓	
<i>Austrostipa elegantissima</i>	Elegant Spear-grass		✓					✓
<i>Austrostipa</i> spp.	Spear Grass		✓					✓
<i>Banksia marginata</i>	Silver Banksia		✓		✓			
<i>Bulbine bulbosa</i>	Bulbine Lily		✓					✓
<i>Bursaria spinosa</i> var. <i>spinosa</i>	Christmas Bush		✓			✓		
<i>Callistemon sieberi</i>	River Bottlebrush	✓				✓		
<i>Callitris gracilis</i>	Native Pine		✓		✓			
<i>Calocephalus citreus</i>	Lemon Beauty-heads		✓					✓
<i>Calostemma purpureum</i>	Pink Garland Lily		✓					✓
<i>Carex tereticaulis</i>	Rush Sedge	✓					✓	
<i>Chloris truncata</i>	Windmill Grass		✓					✓
<i>Chrysocephalum apiculatum</i>	Common Everlasting		✓					✓
<i>Clematis microphylla</i>	Old Man's Beard		✓					
<i>Correa glabra</i>	Rock Correa		✓			✓		
<i>Cullen parvifolium</i>	Native Scurf-pea		✓			✓		
<i>Cyperus gymnocaulos</i>	Spiny Flat-sedge	✓	✓				✓	
<i>Cyperus vaginatus</i>	Flat-sedge	✓					✓	
<i>Dianella longifolia</i> var. <i>grandis</i>	Pale Flax-lily		✓					✓
<i>Dianella revoluta</i>	Black-anther Flax-lily		✓				✓	

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Scientific Name	Common Name	Watercourse	Bank	Large tree	Small tree	Shrub	Groundlayer A	Groundlayer B
<i>Dodonaea viscosa ssp. spatulata</i>	Sticky Hop-bush		✓			✓		
<i>Einadia nutans</i>	Climbing Saltbush		✓				✓	
<i>Enchylaena tomentosa</i>	Ruby Saltbush		✓				✓	
<i>Enneopogon nigricans</i>	Blackhead		✓				✓	
<i>Eucalyptus camaldulensis ssp. camaldulensis</i>	River Red Gum		✓	✓				
<i>Eutaxia microphylla</i>	Common Eutaxia		✓				✓	
<i>Ficinia nodosa</i>	Knobby Club-rush	✓	✓				✓	
<i>Geranium retrorsum</i>	Grassland Geranium		✓					✓
<i>Goodenia amplexicans</i>	Clasping Goodenia		✓				✓	
<i>Grevillea lavandulacea var. lavandulacea</i>	Lavender Grevillea		✓				✓	
<i>Hakea rostrata</i>	Beaked Hakea		✓			✓		
<i>Hardenbergia violacea</i>	Native Lilac		✓			✓		
<i>Hibbertia exutiacies</i>	Prickly Guinea-flower		✓				✓	
<i>Juncus</i> spp. (e.g. <i>J. sarophorus</i> , <i>J. subsecundus</i> , <i>J. pallidus</i>)	Rushes	✓	✓				✓	
<i>Kennedia prostrata</i>	Running Post-man		✓				✓	
<i>Lavatera plebia</i>	Native Hollyhock		✓			✓		
<i>Leptospermum continentale</i>	Prickly tea-tree	✓	✓			✓		
<i>Lomandra multiflora ssp. dura</i>	Hard Mat-rush		✓				✓	
<i>Myoporum viscosum</i>	Sticky Boobialla		✓			✓		
<i>Olearia ramulosa</i>	Twiggy Daisy-bush		✓			✓		
<i>Pelargonium australe</i>	Australian Pelargonium		✓					✓
<i>Pittosporum angustifolium</i>	Native Apricot		✓		✓			
<i>Poa labillardieri</i>	Tussock Grass	✓	✓				✓	
<i>Rubus parvifolius</i>	Native Raspberry		✓					✓
<i>Rytidosperma</i> spp.	Wallaby Grass		✓					✓
<i>Scaevola albida</i>	White Fanflower		✓					✓
<i>Senecio phelleus</i>	Woodland Groundsel		✓					✓
<i>Senecio quadridentatus</i>	Cotton Groundsel		✓					✓
<i>Teucrium racemosum</i>	Grey Germander		✓				✓	
<i>Themeda triandra</i>	Kangaroo Grass		✓				✓	
<i>Vittadinia</i> spp.	New Holland Daisy		✓					✓
<i>Xanthorrhoea quadrangulata</i>	Rock Grass-tree		✓			✓		

Table 4 Number of plants per 10 x 10 metres of revegetation

Plant life form	Number
Large tree*	1
Small tree*	2
Shrub	5
Groundlayer A	25 to 100
Groundlayer B	50 to 200

*Note that there are very few areas where large and small tree species do not already exist and therefore these plant life forms should only be included where the mature tree species appear very old and there is no natural regeneration or the species listed is not already present. They could also be included in landscaping projects.

5.2.3 In-Stream Vegetation

River Red Gum Regeneration

River Red Gums seedlings and saplings were observed at some locations of growing in the watercourse. In a 'natural' system this would be considered a positive outcome, however, in the highly urbanised setting of Third Creek, where the creek provides an important stormwater transport system, such regeneration may contribute to flooding (by restricting and slowing flow) and erosion (by diverting flow into new flow paths). Therefore the current practice of removing River Red Gums growing in the watercourse can continue except:

- Those growing on the outer bends where they may provide protection of the banks from erosion and
- Potentially in areas where the reserve is wider and there is room for flows to spread out.

Where River Red Gums regenerate on the banks they should be clearly marked (so as not to be mown) and retained.

Revegetation of Sedges and Rushes

Little instream native vegetation was observed during the field survey, however these types of fast flowing, cobbled watercourses are commonly not densely vegetated. Stiff Flat-sedge was observed growing in the watercourse and Common Reed grew at the most upstream end of the project area. Additional sedges and rushes could be planted on the lower banks of the creek in areas with low weed cover.

5.3 EROSION MANAGEMENT

Major erosion issues were only recorded at a small number of sites in Third Creek, (although the concrete lining of much of the watercourse has effectively minimised the areas where erosion can occur). At a limited number of sites it is a very high priority to undertake bank and infrastructure protection and repair works, while there are lower priority issues to be addressed at other locations. The following are some issues to be considered in relation to these works:

- Where large trees are being removed the logs should be utilised in the adjacent riparian reserve, either for habitat (e.g. as natural fallen logs) or natural play areas (e.g. stumps and balance logs)
- Where new gabions are used to protect banks, incorporate methods or structures to prevent channel deepening and undermining of gabions in future flood events
- Rocks naturally deposited in channel will help prevent bed deepening in the future
- Where bank erosion has occurred but no assets are at risk, consider working with the new bank alignment
- Incorporate planting of native sedges, rushes and grasses around structures and infill to trap sediments.

In some instances large trees have had much of their roots exposed; these can have soil replaced around the roots covered with protective matting or rocks and planted with native grasses to stabilise the trees.

Soft engineering options that could be considered for future erosion management are:

- Not spraying the banks so that grass is retained to protect the soil,
- Establishing local native sedges and rushes (see Table 3) around existing and new instream rock structures to assist in binding the soil and trapping sediments,;

- Planting low growing woody shrubs and sedges and rushes (see Table 3) at the toe of outer bank erosion points to protect the banks and trap debris without obstructing the flow (it is important that only small species are used and this method is only used on outer bends so that flood risk is not exacerbated); this can be done in conjunction with the construction of alignment fences however these would need to be biodegradable and/or strongly constructed to minimise the impact if the fence is damaged in major floods.

Erosion control works may require a Water Affecting Activities permit under the Natural Resources Management Act (2004) and should utilise the AMLR NRMB Best Practice Operating Procedures (AMLR NRMB 2014).

Lined channels

Over time, the concrete lined-channels of Third Creek may become damaged and require repair or replacement (e.g. see Figure 8). Consideration should be given to the use of sloped rock gabions, such as have been used upstream of Lorne Road (Figure 9), as an alternative to concrete, subject to an engineering assessment. The gabions would allow infiltration of stream flows to recharge local soil water and groundwater stores. Smaller native species could be planted along the top of the gabions to spread across the gabions, e.g.

- Ruby Saltbush (*Enchylaena tomentosa*)
- Running Postman (*Kennedia prostrata*)
- Berry Saltbush (*Atriplex semibaccata*)
- Native grasses such as Windmill Grass (*Chloris truncata*), Blackhead Grass (*Einneapogon nigricans*), Elegant Spear- grass (*Austrostipa elegantissima*), Brush Wiregrass (*Aristida behriana*) and Wallaby Grasses (*Rytidosperma* spp.).

Care would need to be taken to prevent trees and large shrubs growing in the watercourse as these would reduce the channel capacity and increase the channel roughness.

5.4 MONITORING RECOMMENDATIONS

There are two types of monitoring that should be undertaken as part of the implementation of this plan. Firstly there is monitoring that informs day to day management activities, this can include monitoring the survival of revegetation, weeds that require control and the success of watercourse erosion control works. The second type of monitoring is evaluating if the objectives outlined in this plan are being achieved.

The first type of monitoring ('action monitoring') should be undertaken at least annually and is probably already undertaken to some extent at least informally by Council staff. This could be formalised to at least a biannual survey of medium and high threat weeds using GPS and plant counts.

The second type of monitoring ('objective monitoring') can be undertaken less frequently (e.g. every five years) and will require more careful planning to ensure progress towards the objectives is evaluated.

Table 5 presents some options for monitoring progress towards the objectives which could be developed into a more formalised monitoring program.

Table 5 Options for monitoring objectives

Objective	Method	Performance indicator
To prevent any further decline in condition of the watercourse and riparian habitats	Re-survey the creek using the method used for this project	No section declines in condition in overall or individual attributes
	Bushland Condition Monitoring (Croft et al. 2005) or Bushland Assessment (NVC 2017) methods	No decline in Bushland Condition Monitoring / Bushland Assessment score
	Fauna (e.g. birds, macroinvertebrates) monitoring	No decline in fauna diversity
To restore the condition of the watercourse and riparian habitats	Re-survey the creek using the method used for this project	Sections improve in watercourse attribute indicators (e.g. watercourse condition, weed threat, erosion)
	Establish BCM sites in each section	Improved BCM score
	Fauna (e.g. birds, macroinvertebrates) monitoring	Improved fauna diversity
Maintain and enhance the amenity and recreational values of the creek corridor	Survey adjacent residents	Resident satisfaction is maintained or improved
	Survey number of people using	Number of people using the creek corridor is maintained or improved
Coordinated management across Council to achieve multiple objectives.	Actions are implemented and maintained by staff	Qualitative evaluation

5. CONCLUSIONS

Third Creek in the Campbelltown City Council area is generally in a modified state, with much of its length either confined to concrete-lined channels or dissecting narrow linear reserves that are dominated by exotic and weedy vegetation. However, in The Gums Reserve and the University of Adelaide Magill campus, the creek has wide riparian reserves, with large remnant River Red Gums, revegetated native understorey and few exotic species. These two areas are the highest priority for management as a) there is potential for exotic species to re-establish without on-going management and b) to ensure the survival and encourage natural regeneration of the understorey plantings.

Erosion management works are a very high priority in parts of Third Creek to protect assets at risk as a result of the floods in late 2016. In lower risk areas, soft engineering options that focus on reducing bed deepening and incorporate native plant species should be implemented.

Weed management is also a high priority; given the extensive distribution of weeds in Third Creek, weed control should focus on high threat species, work from up to downstream for watercourse weeds, and work from the least weedy areas first for other weeds. Minimal disturbance techniques are required to prevent off-target damage to native vegetation and the aquatic environment. Careful spot weeding of grassy and herbaceous weeds around existing revegetation will encourage natural regeneration.

Further revegetation should focus on understorey (particularly groundlayer) species to increase the diversity in existing revegetation areas and expand revegetation extent where sufficient weed control has been achieved.

In the longer term, encouraging adjacent property owners to use local native species and not plant weedy species will improve the biodiversity values of the local area and reduce potential weed sources.

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7. APPENDIX: PLANT SPECIES OBSERVED

Table 6 Local native species

W = watercourse (naturally occurring), P = planted (banks), N = naturally occurring, T = throughout (naturally occurring), L = localised patch

Species Name	Common Name	The Gums 2000	Section 1	Section 2	Section 3	Section 4	Section 5
<i>Acacia acinacea</i>	Round-leaf Wattle		P	P			
<i>Acacia melanoxylon</i>	Blackwood					P	
<i>Acacia myrtifolia</i>	Myrtle Wattle		P				
<i>Acacia paradoxa</i>	Kangaroo Thorn				P	P	
<i>Acacia provincialis</i>	Wirilda				P		
<i>Acacia pycnantha</i>	Golden Wattle			P		P	
<i>Acacia retinodes</i>	Silver Wattle					P	P
<i>Acacia rupicola</i>	Rock Wattle		P			P	P
<i>Allocasuarina sp. (striata / muelleriana)</i>	Sheoak			P			P
<i>Allocasuarina verticillata</i>	Drooping Sheoak		P	P		P	
<i>Atriplex semibaccata</i>	Berry Saltbush			P			P
<i>Atriplex suberecta</i>	Lagoon Saltbush		L				
<i>Austrostipa elegantissima</i>	Elegant Spear-grass		P	p			
<i>Austrostipa sp.</i>	Spear-grass	N					
<i>Banksia marginata</i>	Silver Banksia					P	P
<i>Bursaria spinosa var. spinosa</i>	Christmas Bush			P		P	
<i>Callistemon sieberi</i>	River Bottlebrush			P			
<i>Callitris gracilis</i>	Southern Cypress-pine		P	P	P	P	
<i>Carex appressa</i>	Sedge		W				
<i>Clematis microphylla</i>	Old Man's Beard			P			
<i>Correa sp.</i>	Correa				P		
<i>Correa sp. (?reflexa?)</i>	Correa		P	P		P	
<i>Crassula decumbens var. decumbens</i>	Spreading Crassula	N					
<i>Cymbopogon ambiguus</i>	Lemon-grass			P			
<i>Cyperus vaginatus</i>	Stiff Flat-sedge		W	W			
<i>Dianella brevicaulis</i>	Short-stem Flax-lily			P			
<i>Dianella longifolia var. grandis</i>	Pale Flax-lily			P			
<i>Dianella revoluta var. revoluta</i>	Long-stem Flaxlily			P			
<i>Dianella sp. (revoluta/brevifolia)</i>	Flax-lily		P				
<i>Dodonaea viscosa ssp. spatulata</i>	Sticky Hopbush		P	P	P	P	P
<i>Einadia nutans</i>	Climbing Saltbush		P	P			
<i>Enchylaena tomentosa</i>	Ruby Saltbush		P	P			
<i>Eucalyptus camaldulensis ssp. camaldulensis</i>	River Red Gum	N	T	T	T	T	T
<i>Eucalyptus leucoxylon ssp.</i>				P			P
<i>Eucalyptus leucoxylon ssp. leucoxylon</i>	SA Blue Gum	N				P	P
<i>Eutaxia microphylla</i>	Common Eutaxia			P			
<i>Ficinia nodosa</i>	Knobby Club-rush			P			
<i>Gernaium retrorsum</i>	Grassland Geranium			P			
<i>Goodenia amplexans</i>	Clasping Goodenia			P			
<i>Goodenia varia</i>	Sticky Goodenia		P				
<i>Hakea carinata</i>	Erect Hakea						P
<i>Hakea rostrata</i>	Beaked Hakea			P		P	
<i>Hakea rugosa</i>	Dwarf hakea			P			
<i>Hardenbergia violacea</i>	Native Lilac		P	P			

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Species Name	Common Name	The Gums 2000	Section 1	Section 2	Section 3	Section 4	Section 5
<i>Hibbertia sp.</i>	Guinea-flower			P			
<i>Leptospermum lanigerum</i>	Wooly Tea-tree		W				
<i>Lomandra multiflora ssp. dura</i>	Irongrass		P				
<i>Lythrum hyssopifolia</i>	Lesser loosestrife		W				
<i>Melaleuca decussata</i>	Totem Poles		P	P			
<i>Melaleuca lanceolata</i>	Dryland Tea-tree		P				
<i>Myoporum insulare</i>	Native Juniper						P
<i>Myoporum viscosum</i>	Sticky Boobialla			P			
<i>Olearia ramulosa</i>	Twiggy Daisy-bush		P	P	P	P	P
<i>Phragmites australis</i>	Common Reed		W				
<i>Poa labillardieri</i>	Tussock Gras		P				
<i>Rytidosperma sp.</i>	Wattlaby Grass	N	P	P			
<i>Senecio phelleus</i>	Woodland Groundsel			P			
<i>Themeda triandra</i>	Kangaroo Grass	N		P			
<i>Xanthorrhoea quadrangulata</i>	Grass Tree			P			
	TOTAL	6	25	36	7	15	12

Table 7 Introduced species

O = Occasional, R = Rare, W = Widespread

High threat ²	WoNS ³	SA declared ⁴	Species Name	Common Name	Section 1	Section 2	Section 3	Section 4	Section 5
*			<i>Acacia iteaphylla</i>	Flinders Ranges Wattle	O		R	O	O
*			<i>Acacia longifolia</i>	Coastal Wattle	R				
*			<i>Acacia saligna</i>	Golden Wreath Wattle			R		O
*		C	<i>Acer negundo</i>	Box Elm			R		
*		Cn	<i>Arundo donax</i>	Giant Reed					R
*		C	<i>Casuarina sp. (? glauca)</i>	(?Swamp) Oak					R
			<i>Chloris guyana</i>	Rhodes Grass	R				
			<i>Cynodon dactylon</i>	Couch	O	W	O	O	O
*			<i>Cyperus involucratus</i>	Umbrella Sedge	R		R		
			<i>Delairea odorata</i>	Cape Ivy	O				
*		C	<i>Fraxinus angustifolia ssp. angustifolia</i>	Desert Ash	W	W	O	W	O
			<i>Graminae</i>	Exotic Grasses	W	W	W	W	W
*			<i>Hedera helix</i>	English Ivy	O		O		O
*			<i>Melaleuca armilaris</i>	Bracelet Honey-myrtle	P				R
*			<i>Melaleuca nesophila</i>	Pink Honey-myrtle	R				
*			<i>Melia azedarach</i>	White Cedar	O	R	R	R	
*		*	<i>Olea europaea ssp europaea</i>	Olive		R		O	O
			<i>Opuntia sp.</i>	Cactus	R				
			<i>Paspalum distichum</i>	Water Couch	O				
			<i>Pennisetum clandestinum</i>	Kikuyu	W	W	W	W	W
*			<i>Pennisetum setaceum</i>	Feather Grass			O	R	
*			<i>Piptatherum miliaceum</i>	Rice Millet	W	W	O	O	
*		C	<i>Rhamnus alaternus</i>	Italian Buckthorn	R		R		
*			<i>Ricinus communis</i>	Caster Oil Plant	O	O	O	O	
			<i>Rorippa nasturtium-aquaticum</i>	Watercress	O				
*	*	C	<i>Rubus fruticosus</i>	Blackberry	R				
*			<i>Schoenus molle</i>	Peppercorn	R	R		R	
			<i>Tropaeolum majus</i>	Nasturtium	O	O		O	O
*			<i>Vinca major</i>	Periwinkle	W	O		W	W

²Mapped weeds³WoNS = Weeds of national significance⁴SA Declared = Declared plants in South Australia, Natural Resources Management (NRM) Act 2004 , January 2017, C = Control required in part of the State only, Cn = Control not required (but sale prohibited)