River Action Plan for the Brunswick River

2006

Leschenault Catchment Council

SOUTH WEST CATCHMENTS COUNCIL

GOVERNMENT OF WESTERN AUSTRALIA

Australian Government

How to use this river action plan

This River Action Plan (RAP) was prepared for the Leschenault Catchment Council and landholders within the Brunswick River catchment. It contains a detailed description of the current health of the waterway, provides information on current management issues, and recommends strategies to address these issues.

Landholders may find this a useful tool to manage their waterways, while community groups may find it helpful in prioritising actions to make the best use of limited resources. For others, it will provide background information to aid decision making.

For landholders

Landholders should turn to their relevant map in Chapter 5 and read the associated management issues and recommendations. They should then read Chapter 4 to determine why these issues are considered to be a priority for remediation, and Chapter 6 to determine the most appropriate actions to address the issues. Information on the general study area and methodology used to develop this action plan can be found in Chapters 1, 2 and 3.

For the Leschenault Catchment Council

Turn to Chapter 5 as it contains detailed information on management issues for each stretch of the waterway. Chapter 6 provides technical advice on how to best address and manage these management issues, and relevant pages should be read carefully prior to implementing any actions.

Seven appendices provide further information that may be useful to landholders and community groups.

- Native vegetation of the Brunswick River Catchment
- Common weeds found in the study area
- Planning advice from the Vasse River Action Plan
- Permits Required Prior to Commencing Works In Rivers
- Landcare Project Time Line
- Best Management Practice (BMP)
- Useful contacts and phone numbers

Acronyms

RAP	River Action Plan
LCC	Leschenault Catchment Council
NHT	Natural Heritage Trust
CALM	Department of Conservation and Land Management
WRC	Water and Rivers Commission
DoW	Department of Water
DEC	Department of Environment and Conservation

Cover photo: The Brunswick River near Mornington Rd, Mornington WA taken by Leigh Taylor

Acknowledgments

This River Action Plan was developed in consultation with Leschenault Catchment Council, and thanks are extended to this community group for their assistance. Special thanks to Renelle Thorpe, Genevieve Hanran-Smith, Cassandra Jury, Mike McKenna, Debbie Blake and Rae Mcpherson for their technical support.

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The Shire of Harvey for providing information on land tenure, vesting and property owners. Aidan Power and Chris Roach from the Regional Support Branch of the Department of Water for preparing the maps.

This River Action Plan has drawn extensively from the work of Genevieve Hanran-Smith in the Margaret River and the Sabina, Abba and Ludlow Action Plans and John McKinney's work in the River Action Plan for Ellen Brook.

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Reference details

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"The care of river is not a question of rivers, but of the human heart"

Tanako Shozo

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Summary

The Brunswick River is located in the Leschenault Catchment area. The Brunswick River has a catchment of 228 square kilometres it extends approximately 55km inland from the coast

The aim of this River Action Plan is to provide information to landholders, interested community members, and organisations on the health and current state of the Brunswick River and recommendations on how to improve its management for the future.

Assessments were carried out in October, November and December 2005 using the Foreshore Condition Assessment method developed by Dr Luke Pen and Margaret Scott for rivers in the south west of Western Australia (Pen & Scott, 1995). Many landholders assisted with the foreshore surveys.

A summary of the foreshore condition ratings and length of fencing of the river is presented in Tables 1 and 2.

Key issues identified

The key issues of concern identified during the foreshore assessments and community consultations were:

- Loss of native fringing vegetation and degradation of remaining vegetation;
- Weed invasion;
- Erosion and sedimentation of the waterway;
- Water quality issues, including nutrient enrichment, pollution and salinity
- Impact of urban development on the water quality
- Need for assistance if landholders are to protect and enhance the foreshore by fencing or revegetating.
- Impact of feral animals
- Impact of water extraction on water quality and quantity.

Table 1: Summary of foreshore condition rating of Brunswick River

Condition	Total Length	Percentage of Total
A (pristine)	34.35 km	34.23%
B (weedy)	22.2 km	22.12%
C (erosion prone/eroding)	50.71 km	50.54%
D (ditch)	8.66 km	8.63%

Table 2: Length of adequately fenced areas on Brunswick River.
(Adequately fenced means that stock can not access the Riverbank).

	Length Fenced	Percentage of Length
North/Right Bank (facing downstream)	8.3 km	16%
South/Left Bank (facing downstream)	8.8 km	17.5%
Total Fenced	17.1 km	17%

General recommendations to improve the health of the Brunswick River

It is recommended that landholders consider the following:

- Retain and protect the remaining riparian vegetation of Brunswick River
- Fence the River to better control stock access.
- Use available funding to contribute towards the costs of fencing and rehabilitation projects.
- Control weeds, particularly invasive species in the riparian zone.
- Implement best management practices that minimise soil erosion and nutrient loss to waterways such as soil testing and maximising vegetation cover on the soil.
- Revegetate waterways with local native species to provide habitat and enhance ecological function.
- Use available funding and resources to control feral animals.

It is recommended that the Leschenault Catchment Council consider the following:

- Encourage and support community efforts to fence the River to restrict stock access.
- Apply for further funding to continue to subsidise the cost of revegetation projects and fencing.
- Encourage, as a priority, the protection of areas of the river still retaining native fringing vegetation. It is more cost effective to protect these areas now than to restore them later after further degradation has occurred.
- Provide encouragement and support to landholders to undertake revegetation using a diverse suite of local native species (including trees, shrubs, sedges, rushes, herbs and native grasses).
- Expand and continue to support weed and feral animal control projects in the catchment.
- Promote best management practice techniques that minimise soil erosion and nutrient loss to waterways such as buffer strips, soil testing and fertiliser management plans, and maximising vegetation cover on the soil.
- Work with landholders, and engineers from the Department of Water to address serious erosion and sedimentation problems.
- Work with Department of Water to expand their water monitoring program of the Brunswick River to address community concerns in regards to nutrient levels, sedimentation contamination and salinity.
- Work with other community organisations and utilise the Ribbons of Blue program to increase community awareness and knowledge of the Brunswick River catchment, focussing on natural assets, values, and threats.
- Promote the use of "clean site" building techniques to reduce the impact of urban development on the water quality of the Brunswick River.
- Encourage land managers, such as the Shire of Harvey, to implement Foreshore Management Plans on unmanaged reserves and ensure new developments are subject to Foreshore Management Plan implementation and compliance.

1. Introduction

Background

The Leschenault Catchment Council is an incorporated community-based body that works in partnership with government agencies, local government, industry and community groups to share awareness and responsibilities in determining natural resource management issues and their solutions within the catchment.

The Council was formed in 2000, through the amalgamation of two community-lead NRM groups - the Leschenault Inlet Management Authority and the Leschenault Catchment Coordinating Group. It has a membership comprised of community, local government, industry and State government representatives with links to many other community focus groups.

The Leschenault subregional boundaries encompass the drainage catchment of the Leschenault Estuary and associated lands and includes the Wellesley, Brunswick, Preston, Ferguson and Collie River systems and the upper Collie River upstream of the Wellington Dam.

Its charter is:

'To develop ways to achieve a sustainable, healthy and productive catchment in partnership with the community.'

In recognition of the need to address the poor state of the rivers in the South West region including the Leschenault Catchment, the Geographe Catchment Council submitted an application to the South West Catchment Council Investment Plan (funded by Natural Heritage Trust (NHT) and National Action Plan for Salinity and Water Quality NAP). The project was funded through the Improving Waterways Health Program of the SW Investment Plan, the basis of this program is:

"To bring about the improvement of the health of the Regions waterways"

Study aims

The primary aims of this River Action Plan are:

- To produce a detailed description of the current state of the Brunswick River and identify priority actions which guide works and help improve the health of these waterways;
- To help increase the community's awareness of the importance of healthy waterways and riparian vegetation;
- To provide a benchmark against which the local community's future catchment work, to protect and rehabilitate the waterways, can be gauged;
- To provide guidance on the possibility of funding and assistance available for fencing, weed and erosion control, and the planting and rehabilitation of native vegetation; and
- To provide a sound technical basis for future funding or project submissions.

"A river is more than an amenity... It is a treasure. It offers a necessity that must be rationed among those who have power over it"

Oliver Wendell Holmes Jr, 1931

2. Study area

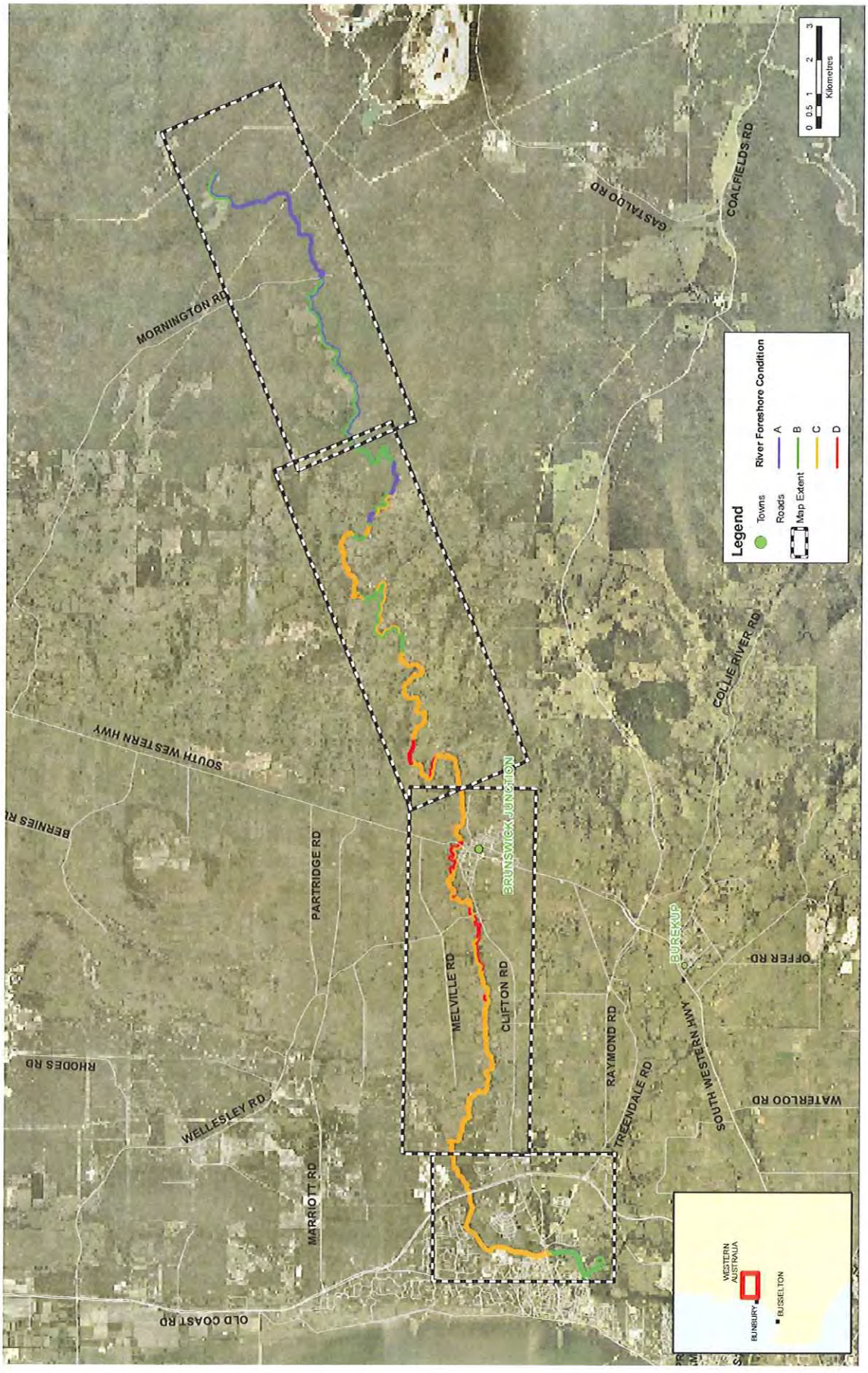

Figure 1: Study area.

Catchment description

The Brunswick River originates in the State Forest approximately 20km east-north-east of the Brunswick Junction townsite. The Augustus River and the Lunenburgh River flow into the Brunswick River in its upper reaches. The Catchment west of Brunswick Junction can be described in general as undulating hills with low to medium clearing. The catchment characteristics change considerably downstream of the townsite (McLaughlin, 1994).

As the Brunswick River flows west from Brunswick Junction, the surrounding catchment quickly becomes flat with a high percentage (85-95%) of clearing. The Wellesley River flows south into the Brunswick 10 km downstream of Brunswick Junction. The catchment of the Wellesley River forms part of the Harvey Irrigation District and as such is very flat and highly cleared. The Brunswick then turns south and flows into the Collie River at Point Latour (McLaughlin, 1994).

The river system

For this study, the Brunswick River was considered to include the main channel but does not include its tributaries. The Brunswick River has a catchment of 228 square kilometres it extends approximately 55km inland from the coast. The rainfall range is regarded as high, between 1000-1300mm per annum producing 67 million cubic metres per annum of flow.

The Brunswick River is classified as a "T3" river type which means it's a "shorter river originating in the higher rainfall Jarrah/Marri forest before descending the Darling Scarp to the coastal plain to the sea" (WRC 2/92).

Approximately 100 km of foreshore was assessed (including right and left banks).

The location of the study area is shown in Figure 1.

Landuse description

The Brunswick River Catchment is approximately 25% cleared in the Upper Catchment and about 75% cleared on the coastal plain, downstream of Brunswick Junction. Urban development fringes the Brunswick River west of the Australind Bypass, the river foreshore in this area being vested with the Shire of Harvey or State Government. In cases where recent or new subdivisions have occurred along the river the developers are required to prepare and implement a foreshore management plan, which identifies a suite of management actions the developer commits to undertaking in the foreshore reserve. After managing the foreshore for a minimum two years, the foreshore management reverts to a nominated authority, generally local or state government (pers. Comm. Mike McKenna, 2006).

The major landuse east of the Australind Bypass is beef and dairy farming with the majority of the river foreshore privately owned. In this area farmers usually water their stock from the River. The Brunswick River and its tributaries were proclaimed under the *Rights in Water and Irrigation Act 1914* in 1954, thus all surface water abstraction from the river and tributaries require a licence from the Department of Water with the exception of non-intensive stock watering and domestic use which are excluded from licensing as a Riparian right.

Upstream of the Beela Dam, State Forest 15 covers the majority of this area. The State Forest is vested in the Conservation Commission and managed by the Department of Environment and Conservation (DEC) on their behalf. The Brunswick Plantation forms part of the State Forest. The Forest Products Commission (FPC), under supervision of (DEC), conducts silviculture operations in the plantation (Water and River Commission, 2001).

The Worsley Alumina Pty Ltd (Worsley) refinery Crown lease area is located in State Forest 15. A Special Mining Lease 1SA covers all of the Crown land in the upper catchment, with the exclusion of the Worsley Crown leases. This State Agreement tenement was granted to Alcoa World Alumina Australia (Alcoa) in 1961. Under the State Agreement Act, Alcoa has rights to extract bauxite from Crown land, with associated responsibilities to protect environmental values and rehabilitate mine-sites. Alcoa has not conducted bauxite mining in the catchment to date (Water and Rivers Commission, 2001).

Climate

The area has a Mediterranean-type climate, characterised by warm, dry summers and cool, wet winters. The average yearly rainfall is 1200 mm and the Class A pan evaporation is 1430 mm (Water Authority

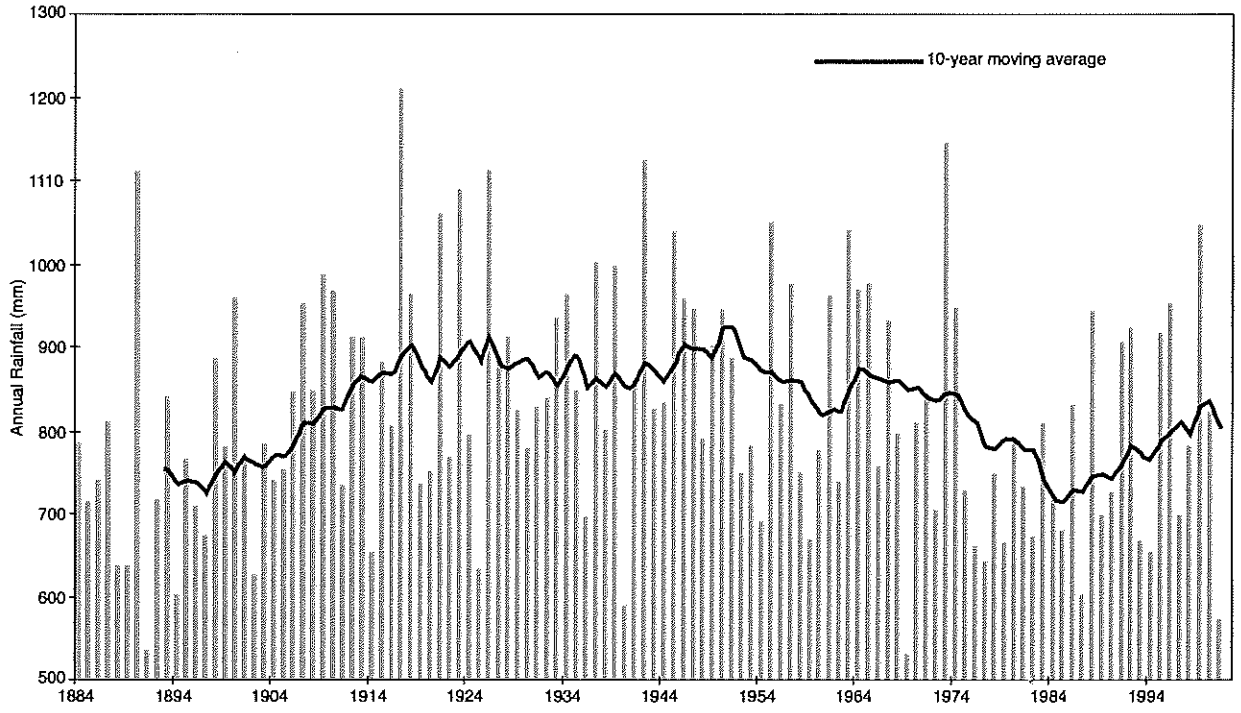

Figure 2: Annual total rainfall for south west Western Australia. Source Hennessy (2002).

of Western Australia, 1988). Rainfall and flow are highly seasonal with over 90% of rain falling between April and November (Rose, 2004).

There is data that supports the anecdotal evidence from landholders of decreased rainfall. It shows a 10-25 % decline in annual rainfall in the south west of Western Australia from the long-term climate mean (Hennessy, 2002). Figure 2 shows that since circa 1970 there has been a clear reduction in total annual rainfall. This is due to a reduction in the mean number of raindays, and the mean number of heavy raindays in winter. According to the State Water Strategy – 'Climate change has contributed to a 10-20 percent reduction in rainfall in the south-west of the State over the last 28 years, a subsequent 40-50 percent reduction in run-off into our dams and reduced recharge of groundwater' (Government of Western Australia, 2003).

Landforms and Soils

The upper catchment soils of the Brunswick River are dominated by Lowden landforms with steep slopes and lateritic soils with rocky outcrops. The lower catchment area on the coastal plain is more dominated by the Pinjarra landforms. The following description of these two landforms was taken from AgMaps Land Manager 2005, for the shires of Serpentine-Jarrahdale, Kwinana, Rockingham, Mandurah, Murray, Boddington, Waroona and Harvey, can be seen below.

The Pinjarra System extends along the Swan Coastal Plain from Perth to Capel. The landform is poorly drained coastal plain. The geology is alluvium over sedimentary rock. The soils are semi-wet soils, grey deep sandy duplexes, brown loamy earths, pale sands and clays.

The Lowden Valleys System on the Western Darling Range, extends from Harvey to Bridgetown. The landform is deeply incised valleys. The Geology is colluvium over metasediments and granitic rocks. The soils are friable red/brown loam earths, brown loamy earths, loamy gravels, brown deep loamy duplexes, duplex sandy gravels and stony soils.

Vegetation communities

Known Vegetation Complexes taken from Regional Forest Agreement Vegetation Complexes, (Mattiske and Havel 1998) are as follows:

Upper Catchment

Darling Scarp - Mosaic of open forest of *Eucalyptus marginata* subsp. *Marginata* (jarrah) - *Corymbia calophylla* (marri), with some admixtures with

Eucalyptus laeliae (Darling range ghost gum) in the north (subhumid zone), with occasional *Eucalyptus marginata* subsp. *Elegantella* (jarrah) (mainly in subhumid zone) and *Corymbia haematoxylon* (mountain marri) in the south (humid zone) on deeper soils adjacent to outcrops, woodland of Eucalyptus wandoo (wandoo) (subhumid and semiarid zones), low woodland of *Allocasuarina huegeliana* (rock sheoak) on shallow soils over granite outcrops, closed heath of *Myrtaceae-Proteaceae* species and lithic complex on or near granite outcrops in all climate zones.

Lowdon - Open forest of *Corymbia calophylla* (marri) - *Eucalyptus marginata* subsp. Marginata (jarrah) - *Agonis flexuosa* (peppermint) with some *Eucalyptus wandoo* (wandoo) and occasional *Corymbia haematoxylon* (mountain marri) on slopes, and woodland of *Eucalyptus rudis* (flooded gum) - *Melaleuca rhaphiophylla* (swamp paperbark) on valley floors in the humid zone.

Mid Catchment

Murray 1 - Open forest of *Eucalyptus marginata* subsp. *marginata* - *Corymbia calophylla* - *Eucalyptus patens* (blackbutt) on valley slopes to woodland of *Eucalyptus rudis* - *Melaleuca rhaphiophylla* on the valley floors in humid and sub-humid zones.

Lower Catchment

Swan Coastal Plain Vegetation includes salt-marsh *Sarcocornia quinqueflora* (bearded samphire), *Halosarcia indica* (shrubby glasswort), *Juncus Kraussii* (shore-rush), *Melaleuca rhaphiophylla* (swamp paperbark), *Casuarina obesa* (saltwater sheoak), *Bolboschoenus caldwellii* (club rush) and *Eucalyptus rudis* (flooded gum).

Fauna

The following information was provided by the Conservation and Land Management Office, Bunbury.

These following threatened species are found in the study area.

Threatened Fauna

Mammals

- Chuditch (Schedule 1)
- Brush-tailed Phascogale (Priority 3)
- Quenda (Priority 5)
- Western Ringtail Possum (Schedule 1)
- Western Brush Wallaby (Priority 4)

Birds

- Forest Red-tailed Black Cockatoo (Schedule 1)
- Baudins Black Cockatoo (Schedule 1)

The above are known records from CALM fauna database. Also pers. comm. from Jen Harrison (CALM Collie) suggests Brushtail Possums are likely to occur along the river. Outside the 100m buffer additional species may include Quokka (Eastern end of the Brunswick River) and Woylie (have previously been translocated to a forested area at the Eastern end of the Brunswick River).

Fish and freshwater crayfish

During February 2006, seven sites were sampled on the Brunswick River for fish, freshwater fish and crayfish (Morgan and Beatty, 2006). Four freshwater species were found in the Brunswick River, all of which are endemic to south western Australia. They are the Freshwater Cobbler (*Tandanus bostocki*), Western Minnow (*Galaxias occidentalis*), Western Pygmy Perch (*Edelia vittata*) and Nightfish (*Bostockia porosa*) (Morgan and Beatty, 2006).

A number of estuarine fish were found in the Brunswick River due to the Leschenault Estuary acting as a nursery ground for numerous fish of marine origin (Potter *et al* 2000). Within the Brunswick River the marine/estuarine Yellow-eye Mullet (*Alderichetta fosteria*), Whitebait (*Hyperlophus vittatus*), Western Hardyhead (*Leptatherina wallaccei*), Swan River Goby (*Pseudogobius olorun*), South Western Goby (*Afurcagobius suppositus*) and the marine straggler Blue Sprat (*Spratelloides robustus*) were captured, but were limited to the area of tidal influence. None of these species were found to penetrate to the freshwater environment of the Brunswick River (Morgan and Beatty, 2006).

Two species of freshwater crayfish were captured during this study, the Gilgie (*Cherax quinquecarinatus*) and the Marron (*Cherax cainii*). While the Gilgie was extremely widespread, the Marron was found to be less abundant (Morgan and Beatty, 2006). The Gilgie is a species able to occupy a range of habitats and is able to burrow to escape habitats that dry out. The Marron, in contrast,

only occupies permanent water bodies that have adequate water quality particularly in terms of dissolved oxygen and salinity levels (Morgan and Beatty, 2006).

Two introduced species were captured in this study, a number of Rainbow Trout (*Oncorhynchus mykiss*) from the upper the Brunswick River and the Eastern Mosquitofish (*Gambusia holbrooki*) from numberous sites along the Brunswick (Morgan and Beatty, 2006). The introduced mosquito fish is of serious concern in the Brunswick River. This feral species is extremely tolerant of poor water quality, efforts should be made to reduce or eradicate the population if possible.

In general, the perennial flows in the Brunswick River support good populations of a number of native fish. There is a distinct correlation between in-stream habitat and fish and crayfish populations. Therefore, any rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges will increase the habitat values of the Brunswick River. Indeed, fish habitat creation should be considered when planning any rehabilitation or restoration projects.

Heritage

The Brunswick River catchment has significant Indigenous and non-Indigenous cultural heritage values.

Indigenous heritage

The Aborigines of the South West Region, prior to European contact, formed a distinctive socio-cultural group collectively known as Nyungar (O'Connor *et al.*, 1995). A painting by John Sara tells the story of how the Ngarngungudditj Wargal or Hairy Faced snake came down from the north of Collie a long time ago, to form the Rivers within the Leschenault Catchment.

"The snake came down through Collie creating the hills and rivers down to Turkey Point (Australind- Pelican Point area) and Eelaap (Bunbury). He pushed his big body and turned to form the estuary and Koombana Bay. He then came back up the Collie River to a place called Minninup pool. When the moon is high in the sky you can see his spirit resting there.

Koombana Bay (before the Breakwater Rocks had begun) was a beautiful sea bay front from the ocean and Turkey Point was an Aboriginal ceremony camping hunting and corroboree ground. The Wargal is the great mythical snake that controls the lives, actions, totems and beliefs of the Nyungar people"

This story told by John Sara with special thanks to George E Webb (dec), elder Wardandi Tribe Busselton and Joseph Northover, Collie Nyungar.

European heritage

The Brunswick River was documented by John Septimus Roe in 1830 and first appeared on a map published in London in 1839. It was named in honour of the Duke of Brunswick (Fred William) who was the Commanding Officer for Captain James Stirling (B. Stanley, 1999).

The first bridge built in this area was over the lower the Brunswick River in 1843, on the road which is now known as Paris Road in Australind. The bridge was built by William Forrest, the father of John Forrest. At the time it was the only bridge between Fremantle and Busselton. The bridge opened in 1945, the opening ceremony was performed by Marshall Clifton. The bridge marked a significant point in history as it enabled the first settlers to move their livestock from the sandy soils of Australind to the more fertile soils along the Brunswick River (B. Stanley, 1999).

The first real farming near the Brunswick River was done at 'Alverstoke' in 1842 were milking of cows and growing crops such as wheat, barley and potatoes had commenced. By the 1880's the number of stock on 'Alverstoke' had increased to 200 cattle and a dairy herd of 50 cows (B. Stanley, 1999).

In the early years two large water tanks in the town of Brunswick served as the towns' water supply. These tanks were filled from the Brunswick River by a small steam engine. However, at a Progress Meeting in 1936 it was documented that for several years the Brunswick River ceased to flow in February. Thus, in 1938 the Government gave the go ahead for a dam near Beela Siding with a capacity of 5 million gallons with a 6 inch fibrolite pipeline coming down to Brunswick to supply the town, this dam is today known as Beela Dam (B. Stanley, 1999).

3. Study methodology

River foreshore condition assessment

The Pen-Scott method of riparian zone assessment was used. This system provides a graded description of the river foreshore from pristine (A grade) through to ditch (D grade). A summary of the grades of the Pen-Scott system follows (Pen & Scott, 1995; Water and Rivers Commission, 1999a). These are illustrated in Figure 3 and photos on the following pages. This method allows comparisons of waterway health across the south west of Western Australia, and can be used to prioritise actions.

A grade foreshore:

Pristine – near pristine

A1: Pristine

Embankments and floodway are entirely vegetated with native species and there is no evidence of human presence or livestock damage.

A2: Near pristine

Native vegetation dominates but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species.

A3: Slightly disturbed

Areas of localised human disturbance where the soil may be exposed and weed density is relatively heavy, such as along walking or vehicle tracks. Otherwise, native plants dominate and would quickly regenerate in disturbed areas should human activity decline.

B grade foreshore:

Weed infested but tree cover still largely present

B1: Degraded

Understorey mainly natives - weeds have become a significant component of the understorey vegetation. Although native species remain dominant, a few have probably been replaced or are being replaced by weeds.

B2: Degraded

Understorey 50% weeds – understorey weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3: Degraded

Understorey weed dominated - weeds dominate the understorey, but many native species remain. Some tree and large shrub species may have declined or have disappeared.

C grade foreshore:

Erosion prone to eroded

C1: Erosion prone

Trees remain, possibly with some large shrubs or grass trees, but the understorey consists entirely of weeds, mainly annual grasses. Most of the trees will be of only a few resilient or long-lived species and their regeneration will be almost negligible. In this state, where short-lived weeds support the soil, a small increase in physical disturbance will expose the soil and render the river valley vulnerable to serious erosion.

C2: Soil exposed

Annual grasses and weeds have been removed through heavy livestock damage and grazing, or other impacts such as a result of recreational activities. Low level soil erosion has begun, by the action of either wind or water.

C3: Eroded

Soil is being washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley.

D grade foreshore:
Ditch to drain

D1: Ditch, eroding

Fringing vegetation no longer acts to control erosion. Some trees and shrubs remain and act to retard erosion in certain spots, but all are doomed to be undermined eventually.

D2: Ditch

Freely eroding - no significant fringing vegetation remains, and erosion is completely out of control. Undermined and subsided embankments are common, as are large sediment plumes along the river channel.

D3 Drain

Weed dominated - the highly eroded river valley may have been fenced off enabling colonisation by perennial weeds. The river has become a simple drain, similar if not identical to the typical major urban drain.

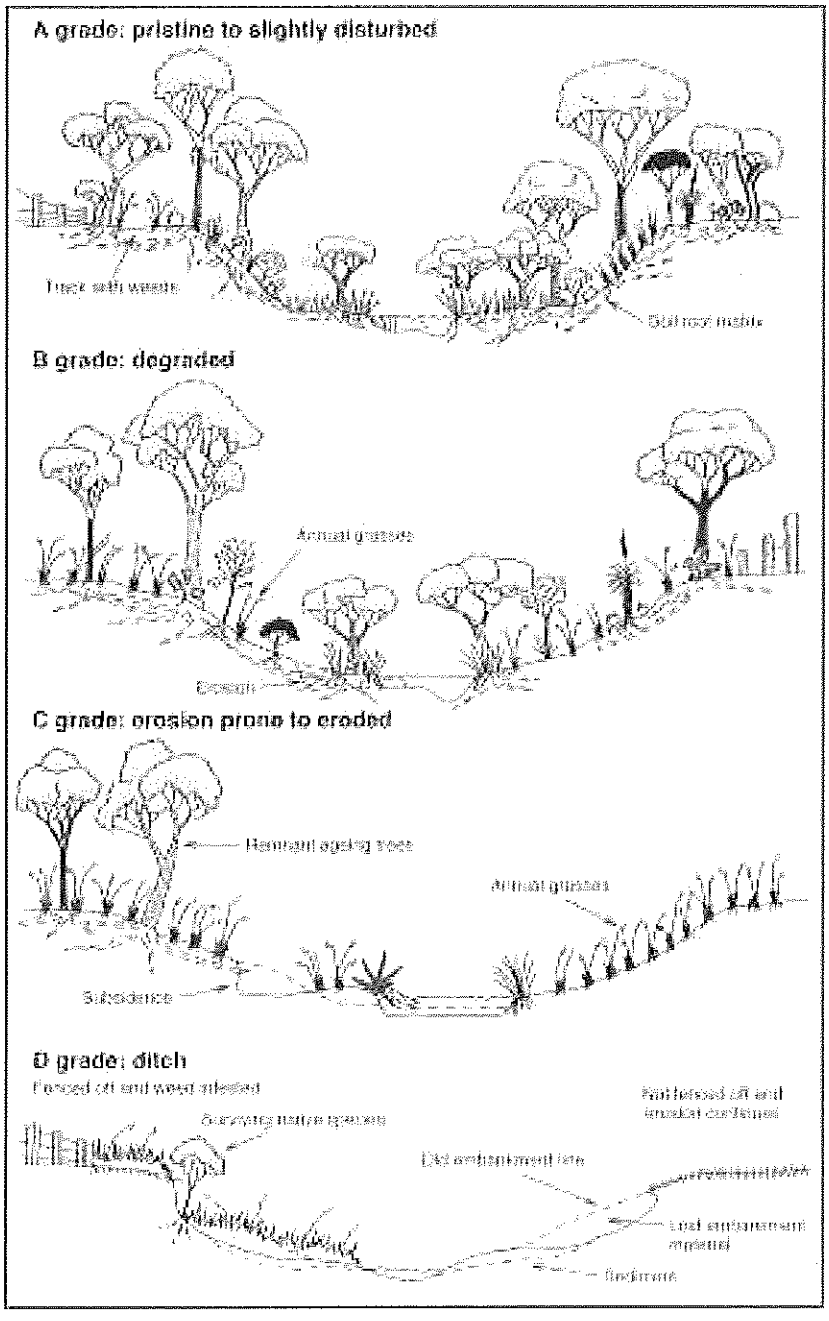

Figure 3: The four grades of river foreshore condition - (A) pristine to ditch (D).

A Grade foreshore: Note complete vegetation cover which is essential to the health of the waterway.

B3 Grade Foreshore: The understory is entirely dominated by weeds (mainly watsonia), but many native trees still remain.

C3 Foreshore. Note the extensive bank erosion and the understorey consists entirely of annual weeds.

D2 Grade Foreshore: The channel has eroded away over time, leaving a weed (mainly annual grasses) infested drain. No native vegetation occurs at all on these banks.

Community involvement

Community involvement is an integral component of River Action Plans. Every effort was made to involve the community at each stage of the process from initial assessments to developing management recommendations.

Most of the assessments were conducted with the landholders, and they were able to provide invaluable historical and anecdotal information about the catchment. Importantly they expressed their views, explained what their concerns were, and why and how they felt the waterway should be managed.

Other consultation processes included individual phone calls and articles in local newspapers. Once the foreshore assessments were completed, a community workshop (on the 21st of May 2006) was held to present initial findings and to seek feedback about the project and management recommendations and from the community. The community representatives at the workshop were asked to provide information about what they felt were the major management issues on the Brunswick River. The following points were raised by the community. *(Please note that the views expressed are those from the consulted community and do not necessarily reflect those of the author or the Leschenault Catchment Council)*;

- Loss of native vegetation and native animals
- Weeds –including blackberry, watsonia, cotton bush and bridle creeper
- Erosion – erosion of river banks, loss of fencing and land
- Water Quality –the impact of Worsley Alumina Pty Ltd, urban development and nutrients on the water quality of the river
- Lack of Water –the Worsley Aluminia Pty Ltd dam having an impact on water flows
- Salinity –irrigation water is coming from Wellington dam through the Harvey Water Irrigation network and is increasing salinity levels in the river
- Feral Animals –fox and pig numbers increasing
- Decline in fish species –marron and cobbler numbers have reduced
- Sedimentation –sediment in the river being infested by couch grass is blocking the natural flow of the river. Trees falling over in the river is also trapping sediment and causing changes in river flow.

These community concerns and management issues have been addressed in more detail in Chapter 4.

4. Management issues

What are the environmental impacts on the Brunswick River?

The Brunswick River, for the most part, is a highly degraded system. Downstream of the Beela Dam the Brunswick is highly eroding, has very little native understorey and a declining native overstorey. Downstream of Brunswick Junction, much of the river was straightened and desnagged in the early 70's by the Public Works Department. Although, carried out in good faith, this work has contributed to a faster flowing and far more erosive river than it was naturally.

Minimal foreshore areas have been fenced as a consequence of current and historical grazing practices, and associated stock watering, which has lead to a decline in native understorey vegetation and an increase in erosion.

The most obvious issue with the Brunswick River, especially for those living near Paris road in Australind is sedimentation. Many local residents have commented on how shallow and wide the Brunswick River has become in those areas.

Water quality is also an increasing issue, with recent studies showing high levels of nutrients in the lower Brunswick River. The Leschenault Catchment covers the drainage area of the Brunswick, Wellesley, Collie, Ferguson and Preston River systems. Nutrient enrichment, or eutrophication, in the lower reaches of the Brunswick and discharging into the lower Collie River, has triggered algal blooms in both these systems which in turn can result in fish kill events. Studies have shown that the Brunswick and Wellesley catchments contributes approximately 35% each of the total external nutrient load to the Leschenault Estuary (Donohue *et al*, 1994).

There are a number of management issues in the Brunswick River Catchment. They vary according to landform and soils, and past and current land use and management practices. These interrelated issues are summarised below.

Water extraction and allocation

A number of landholders extract water directly from the Brunswick River, the volume of which is not quantified due to the number of landholders with riparian rights and non-metered or unlicenced extractive drawpoints. Under the *Rights in Water and Irrigation Act 1914* 'riparian rights' allow landholders to take water for specific non-commercial purposes such as domestic use, or non-intensive stock watering (Water and Rivers Commission, 2001). Riparian rights only occur where there is a stream flowing through a property or the property abuts the watercourse, and there is no publicly reserved land between the watercourse and the private property. Extracting water for commercial purposes or in excess of riparian rights may require a licence from the Department of Water (previously the Department of Environment). Riparian rights only give access to what water is available, and are not a guarantee of supply (Cape to Cape Catchments Group, 2005).

Stream and environmental flows

There is community concern regarding decreased stream flows in the Brunswick River. In particular their

> *"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principle measure of how we live on land"*
>
> Luna Leopold

concern lies with the impact of the dam at the top of the catchment owned by Worsley Alumina Refinery is having on water flows.

Worsley has a surface water licence entitlement to take 2.1 Gigalitres per annum from the Augustus River catchment. Under a Ministerial Commitment, Worsley has historically maintained a basal summer flow of 35 m 3 per hour from the Freshwater Lake from which the entitlement is drawn into the Augustus River (which in thurn flows into the Brunswick River). An Ecological Water Requirements (EWR) study for Augustus River catchment has recently been completed and will be utilised in reviewing the surface water licence as part of Worsley's proposed expansion. The EWR identifies the water level required to maintain current ecological values.

The Department of Water has been surveying water users in the Brunswick River catchment, collecting information on domestic, stock and commercial water use as part of a long term plan for Environmental Water Provisions (EWP). The objective of EWP is to provide protection of water dependent ecosystems while allowing for management of water resources for sustainable use and development to meet the needs of current and future water users.

Water Quality Issues

There is community concern about the water quality in the Brunswick River. Issues such as nutrient levels, eutrophication, fish kills and heavy metal levels in the waterway were raised during the foreshore surveys. Much of the concern was about the fish kills that have occurred in the past, and what caused the fish kills. There is some speculation from the community, that the mining company at the top of the catchment may be having an impact on the water quality of the Brunswick River.

However, Department of Water who monitor the Worsley refinery state that there is no evidence that the refinery is having an impact on water quality. The following excerpt was taken from the Environmental Assessment Report (EAR).

"The two pipehead dams (Northern and Southern) contain any runoff from the Bauxite Residue Disposal Area's and return water back to the Refinary Catchment Lake. Any additional water for the process is sourced from the Fresh Water Lake. The quality of the Fresh Water Lake is protected by extensive grout curtains below the earthen embankment of the pipehead dams and tied into the bedrock. There is an extensive groundwater monitoring network on the site to ensure prompt detection of leakage or contamination. The report containing the results of the monitoring, and analysis of trends is required as part of the Alumina Refinery (Worsley) Agreement Act 1973 (as amended) and administered by the EMLG (Environmental Management Liaison Group). Regular hydrological review is undertaken by hydrogeologists of the Department of Water.

Drainage outside the refinery process area is directed to the Fresh Water Lake and is only uncontaminated rainfall. This water can be directly discharged though the Augustus River Gauging Station." (Department of Environment, 2005).

Tables 3 and 4 show the general water quality within the Brunswick River at two monitoring sites. The data collected by the Department of Water between 1998-2003, indicates that in the upper catchment the water is oxygenated with less turbidity and fewer suspended solids. Whilst downstream the water quality data indicates that this river is under extreme pressure, with low oxygen levels, high levels of nutrients, high levels of turbity and suspended solids.

Past studies in 1990 and 1992 by the Waterways Commission showed that only 30% of the flow into the Leschenault Estuary comes from the catchment of the Brunswick River. However, a large 70% of the external phosphorus load and 46% of the external nitrogen load within the Estuary was contributed by the Brunswick River (in conjunction with the Wellesley River) (Donohue, Parsons & Deeley, 1994). Further monitoring of nutrient levels in the Brunswick River is required in order to get a better understanding of their source and how to best manage these nutrient levels.

Algal blooms and episodic fish kill events in particularly, the lower Brunswick reflect nutrient enrichment. Algal blooms predominate in summer and autumn, including non-toxic and potentially fish-killing species of phytoplankton have been recorded. Blooms of different species reflect different conditions for growth, but all present as symptoms of a catchment under stress. The most recent, and largest fish kill occurred in late May 2004 in the Brunswick Rivers

lower reaches where thousands of black bream and other estuarine fish were killed. Investigations revealed extremely low levels of dissolved oxygen in the bottom waters, high dissolved levels of aluminium and iron as well as high total acidity levels (Rose, 2004).

Septic systems are used near the Brunswick River and are associated with a number of properties along the river in its lower reaches. How much the water quality of the Brunswick River is affected by poorly located septic systems is unknown but could be considered a threat to water quality (Rose, 2004).

Erosion & Sedimentation

While some level of erosion and deposition is natural in any waterway, the acceleration of these processes can cause management problems. As noted previously, wide-scale clearing of vegetation in the catchment has resulted in increased creek flows causing significant incision and erosion. This can readily be seen in the main channel downstream from Beela Rd. Disturbance from stock and clearing of fringing vegetation has led to erosion with undercutting and slumping of banks. Issues associated with erosion problems include:

- loss of valuable soil;
- loss of fences as the water course deviates;
- poor water quality resulting from increased turbidity and nutrients;
- increased flood potential due to the silting up of the channel;
- filling of summer pools;
- increased channel width and loss of agricultural land;
- reduced visual amenity and recreational sites associated with the waterways; and
- further loss of native riparian vegetation as severe erosion problems cause subsidence.

Table 3: Water Quality Data (Upper Catchment, Brunswick River). Data from Statewide River Water Quality Assessment 2004, DoE. (Note: Nutrient data not presented due to irregular sampling regime).

Site ID	612022.0 – Upper Brunswick River		
Name	Brunswick River		
pH			
Period	1998-2000	Median	7.41
Classification	neutral		
Colour			
Period	1998-2000	Median	50
Classification	stained		
Turbidity			
Period	1998-2000	Median	5.05
Classification	moderate	Trend	
Trend Param			
Total Suspended Solids			
Period	1998-2000	Median	8.4
Classification	moderate		
Dissolved Oxygen			
Period	1998-2000	Median	8.44
Classification	oxygenated		

Table 4: Water Quality Data (Lower Catchment, Brunswick River)

Site ID	612032.0 – Lower Brunswick River		
Name	Brunswick River		
Total Nitrogen			
Period	2001-2003	Median	1.271
Classification	high		
Total Phosphorus			
Period	2001-2003	Median	0.475
Classification	high		
pH			
Period	2001-2003	Median	7.27
Classification	neutral		
Colour			
Period	2001-2003	Median	80
Classification	stained		
Turbidity			
Period	2001-2003	Median	12.65
Classification	high		
Dissolved Oxygen			
Period	2001-2003	Median	6.38
Classification	low	Trend	decreasing, -0.207 mg/L
Trend Param	obs, 1997-2003, MK, Wks 1-52		
Total Dissolved Salts			
Period	2001-2003	Median	811.735
Classification	marginal		

Stock access

Most of the Brunswick River foreshore is unfenced, allowing stock access to riparian vegetation and the river. A number of problems can arise as a result of unrestricted stock access. They include:

- loss of native fringing vegetation;
- weed invasion;
- compacted soils;
- nutrient enrichment;
- erosion; and
- poor water quality.

Loss of native fringing vegetation

Parts of the Brunswick River, especially in the upper catchment, the riparian zone has a healthy and complete vegetation structure. However, for the rest of the Brunswick foreshore, most of the vegetation is degraded to some degree through weed invasion, clearing, stock access or erosion. In many areas, there is a healthy overstorey of mature trees but little else, while in some areas there is no native vegetation at all. It is important to retain and enhance riparian vegetation as it has many values including; erosion control, dissipating flow, sediment and nutrient retention and providing habitat for many species.

Weed invasion

Large numbers of weeds were found during the foreshore surveys. These are identified on the Foreshore Reach maps in Cbapter 5. Disturbance tbrough clearing, grazing, erosion and modification of the channel provides ideal conditions for weed growth and spread. The main weeds of concern in the study area were blackberry, watsonia, cotton bush, bridle creeper, arum lily and grasses such as kikuyu and couch.

Weeds compete with native vegetation and restrict natural regeneration. They are a significant factor in the degradation of remnant vegetation and are a major threat to biodiversity. In addition, they are a major economic cost to society. According to a recent study (Sinden et al., 2004) the economic cost of weeds in Australia is approximately $4,000 million annually. This includes the costs of control and losses in output in agricultural land ($3,927 million), the cost of control in the natural and built environment ($104 million) and the amount spent on research and development ($8 million). It does not include the considerable amount of volunteer time and labour donated by community groups and landholders in controlling weeds (Cape to Cape Catchments Group, (2005).

All revegetation activities need to include strategic weed management actions to increase the survival rate of plantings and to reduce long-term management activities. If grassy weeds infest a revegetation site, they will out-compete the native vegetation, and may cause a fire hazard. For more information on specific weed control, see Chapter 6.

5. River foreshore condition and recommendations for management

Using the maps

The following page provides an index for the maps, and an overview of the condition of the Brunswick River. For a summary of the condition rating and percentage of the Brunswick River that is fenced to exclude stock, please see Table 1 and Table 2 in Summary.

Maps 1 to 4 show the Brunswick River catchment, the main channel and the adjoining land titles.

The maps show the foreshore condition of the waterways as assessed using the Pen-Scott method (see Chapter 3 for details of the method of assessment). Weeds and management issues are also shown. A legend is provided.

The background aerial photos of the map were taken in 2003 and these are available for purchase from the Department of Land Information (www.dola.wa.gov.au).

Management recommendations

The notes accompanying each map contain background information, the current condition of the river and management recommendations. These management recommendations can be used by a range of organisations as well as landholders.

Management recommendations

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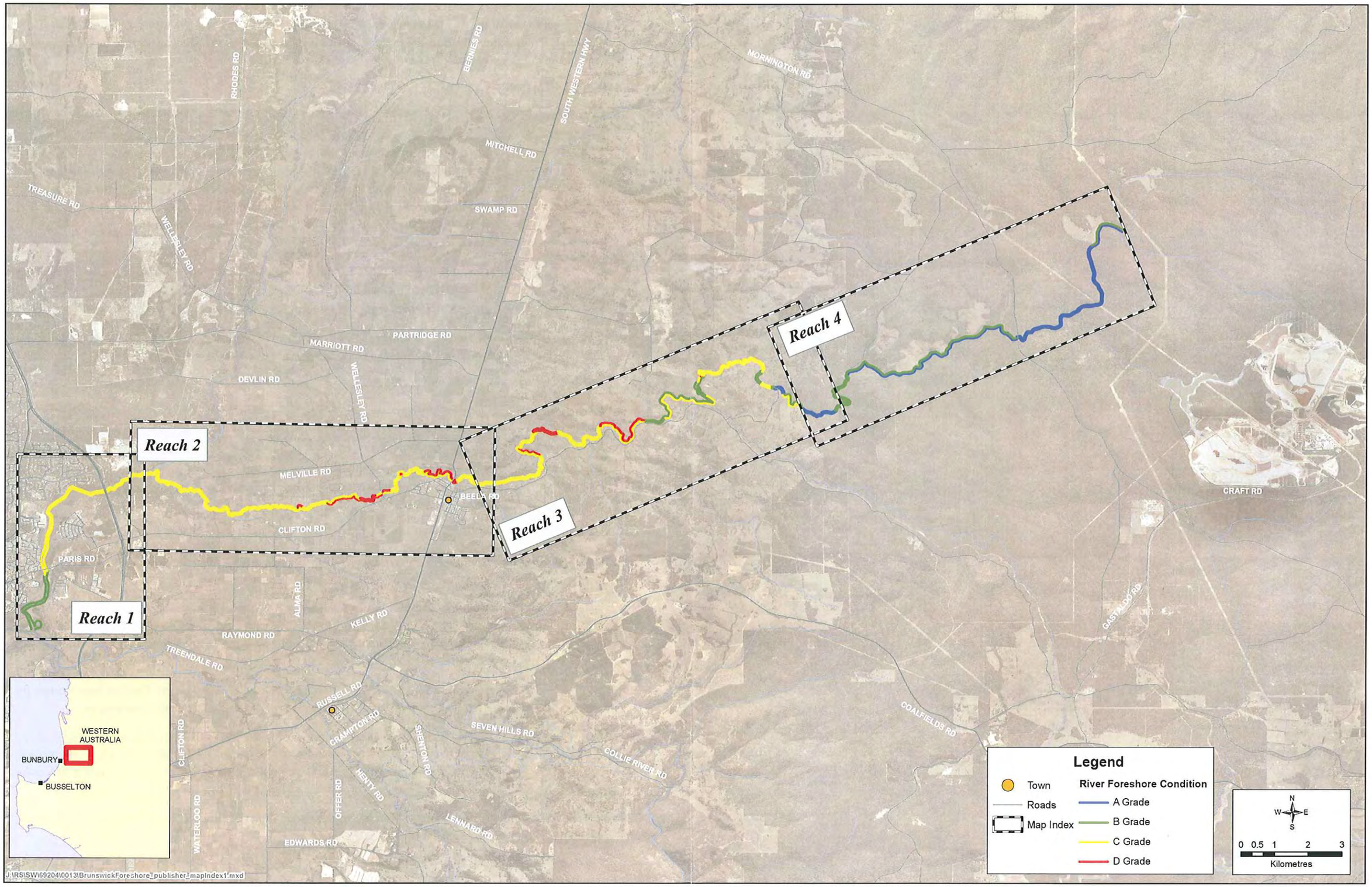

RHODES RD
BERNIES RD
SOUTH WESTERN HWY
MORNINGTON RD
MITCHELL RD
TREASURE RD
WELLESLEY RD
SWAMP RD
PARTRIDGE RD
MARRIOTT RD
DEVLIN RD
WELLESLEY RD
Reach 4
Reach 2
MELVILLE RD
BEELA RD
CLIFTON RD
Reach 3
CRAFT RD
PARIS RD
ALMA RD
Reach 1
KELLY RD
RAYMOND RD
TREENDALE RD
GASTALDO RD
RUSSELL RD
CRAMPTON RD
SHENTON RD
SEVEN HILLS RD
COLLIE RIVER RD
COALFIELDS RD
CLIFTON RD
WATERLOO RD
OFFER RD
HENTY RD
LENNARD RD
EDWARDS RD
WESTERN AUSTRALIA
BUNBURY
BUSSELTON
J:\RS\SW\69204\0013\BrunswickForeshore_publisher_mapIndex1.mxd
Legend
Town
Roads
Map Index
River Foreshore Condition
A Grade
B Grade
C Grade
D Grade
N
W
E
S
0 0.5 1 2 3
Kilometres

Index Map

Index Map

Reach 1

Latour Point to east of the Australind Bypass (Howsens Wetlands).
This reach is approximately 7km long. Much of this area is vested in the Shire of Harvey or Department of Enviroment and Conservation.

Description

Feature	Comments
Landuse	Urban development dominates both foreshores. It includes some of the older residential areas of Australind, as well as new developments including Galway Green, Kingston Estate and Treendale. These new developments have Foreshore Management Plans and are responsible for the management of their foreshore area for a minimum 2 years, after which the foreshore management reverts to either the Shire of Harvey or State Government.
Land tenure	Lots 5146, 14, 5147, 6129, 5512, 5450, 6055, 5734, 5877 &5774 are vested with the Shire of Harvey or a State Government body. Lot 5877 is a crown reserve and Howsen's Wetlands an EPP Wetland in located on this lot. The rest of the lots in the reach are privately owned.
Fencing	Little fencing is required as this is mainly an urban area. Only 2 lots have stock in this reach, and these are both fenced so the stock can not access the foreshore.

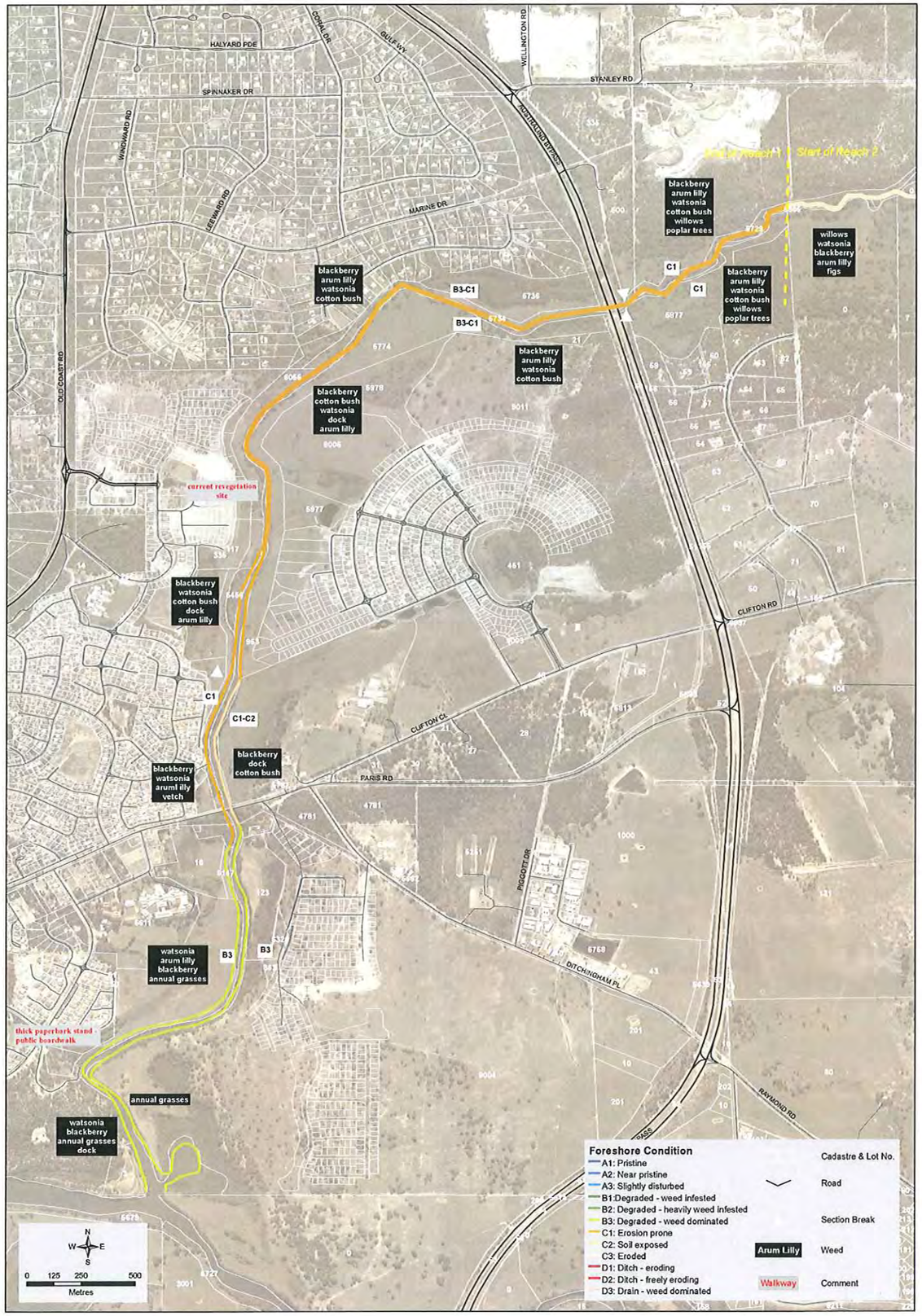
Condition

Feature	Comments
Vegetation	The foreshore in this reach, supports an overstorey consisting of Paperbarks, Rivergums and Peppermints. Native understorey is sparse, with the majority of the understorey consisting of weeds.
Weeds	Watsonia, blackberry, arum lilly, cotton bush are of main concern in this area.
Bank stability & erosion	Erosion is occurring upstream of Paris Rd due to a lack of vegetation on riverbanks. However, west of Paris Rd rushes and sedges stablize the riverbanks.
Special features, other comments	Much of the foreshore in this reach has potential for rehabilitation as this area has been zoned Public Open Space in the Shire of Harvey Strategy or Regional Open Space under the Greater Bunbury Region Scheme. Potential to create a wildlife corridor from Collie River to Howsens Wetlands. Howsens Wetlands is classified as an EPP wetland. A Management Plan has been written for this site and is available from the Department of Environment and Conservation.
Restoration Sites	A riparian native revegetation project was conducted as part of the RAP within this Reach, on a Shire of Harvey managed reserve near Paris Rd Bridge, Australind. This site will require weed maintenance for the following three years and expansion if it is to become a successful restoration site.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.

Management

Issue	Management Action/Advice
Weeds	• Currently, Department of Agriculture and Food is conducting weed management of blackberry in this area. Continuation and expansion of the program to include other environmental weeds is required. • Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds. • Provide support and education to landholders and residential developers on how to properly manage their declared weeds. • Support local community groups and weed action groups in weed management. • Target blackberry, arum lilly and cottonbush as a priority in this area.
Urban development	• Encourage new and existing residential developments to implement their foreshore management plans efficiently and effectively.
Loss of native vegetatation	• Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. See Chapter 6 for detailed techniques and information. In particular, planting a variety of understorey species, including rushes and sedges, is a priority in areas degraded by weed invasion or past stock access.
Fish	• Increase fish habitat by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encourage residents in urban catchments to use slow-release fertilisers on lawns and gardens to reduce nutrients entering the river system through stormwater discharges. • Support the ongoing collection and monitoring of water quality data and possible expansion of this program to include the monitoring of sediment loads. • Encourage best management practice for building sites, using the "Clean Site Program" when building. • Encourage residential developments to use water sensitive urban design when planning their stormwater management systems



Reach 1

Reach 1

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Reach 2

Reach 2

Reach 2 extends from Howsens Wetlands to Brunswick Junction. This reach is approximately 12km long. Private agricultural land abuts the river for the majority of this reach.

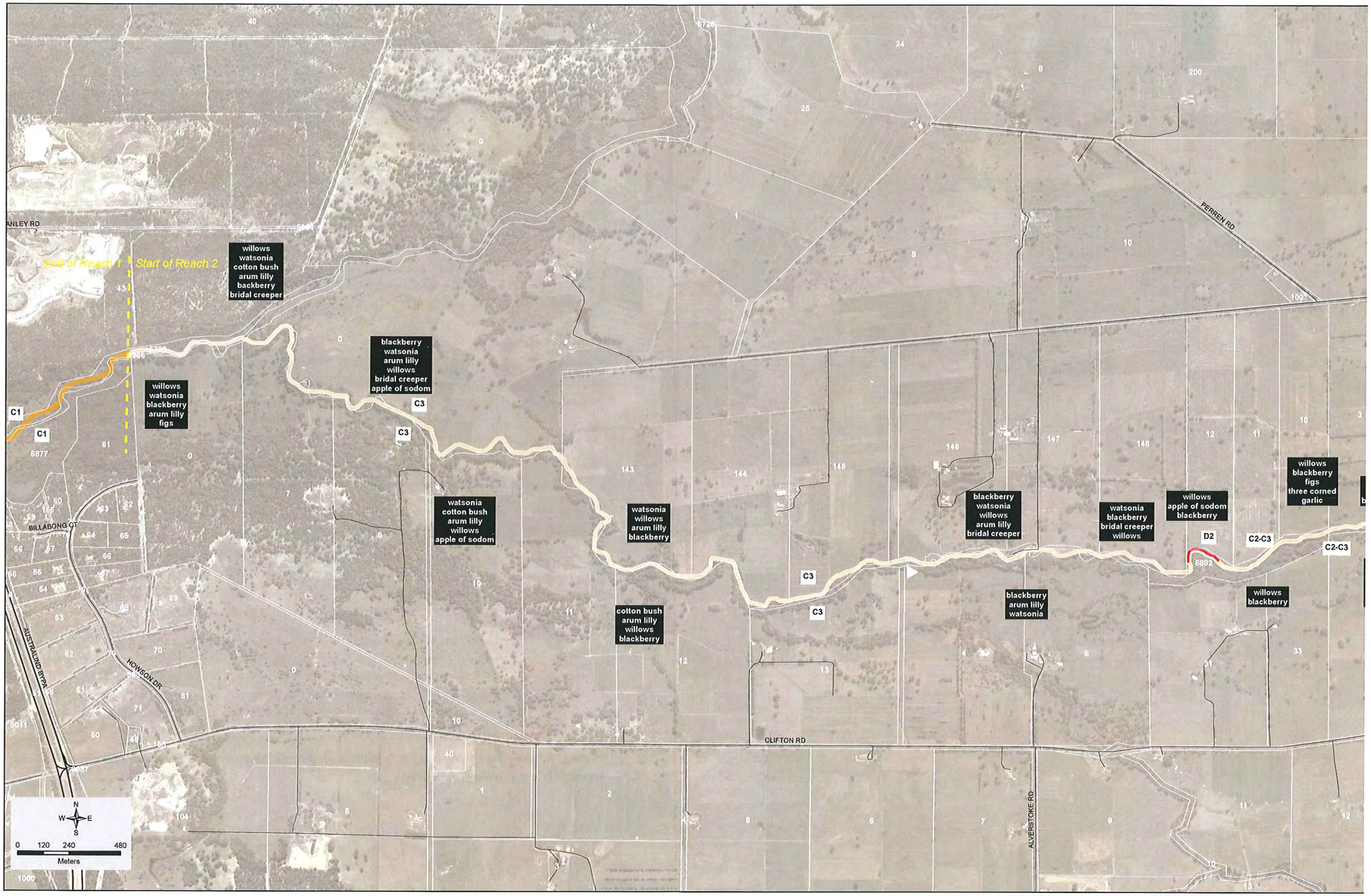
Description

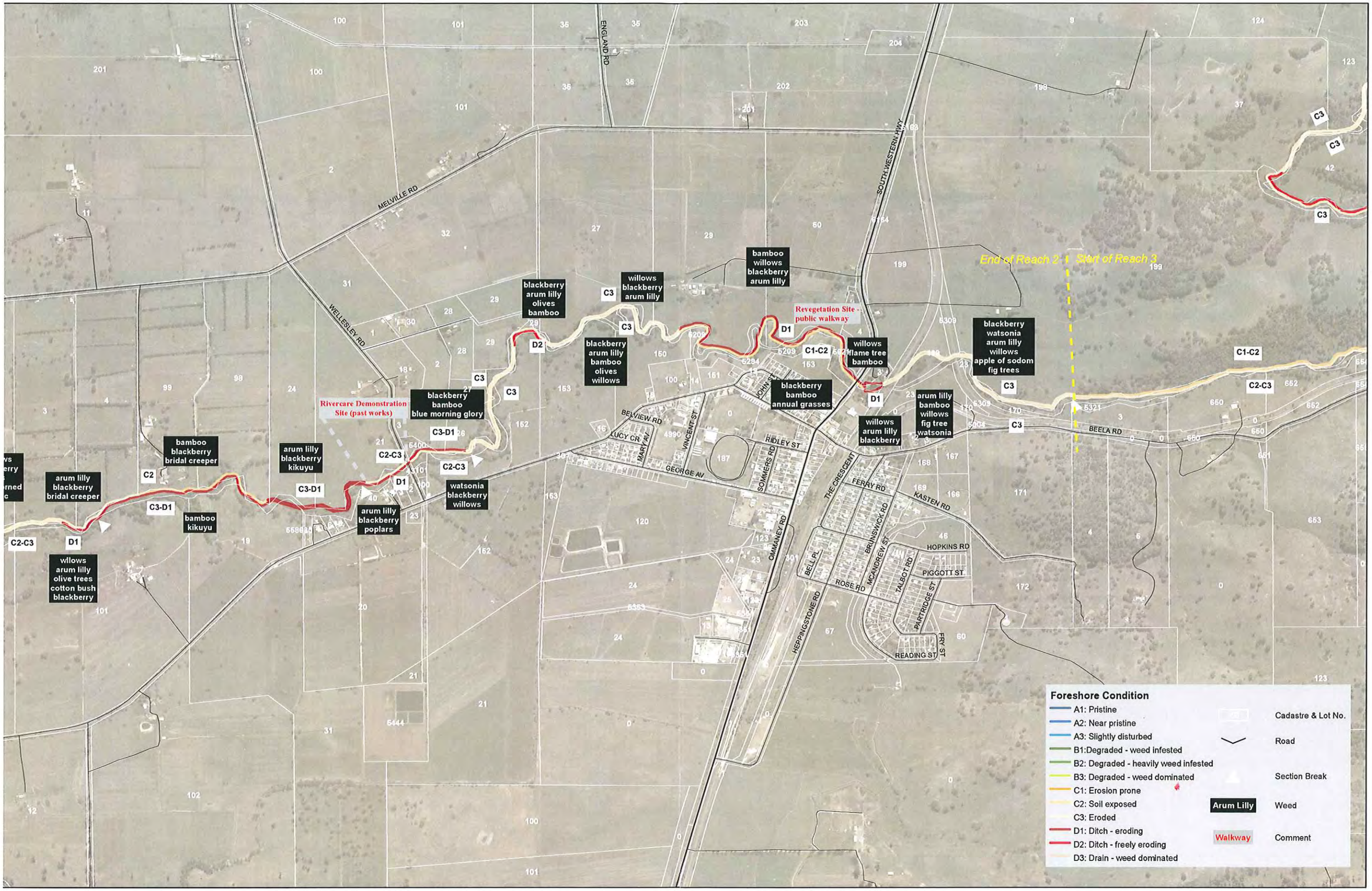
Feature	Comments
Landuse	Agricultural land dominates both foreshores. Mainly beef and dairy industries.
Land tenure	Lots 9082, 9400, 9631 and 5209 are vested with the Shire of Harvey or a State Government body. The rest of the lots in the reach are privately owned.
Fencing	Lots 0, 147, 148, 11, 12, 3, 31, 33, 16, 3, 4, 99, 98, 24, 21 and 50 are fenced. However, in some cases cattle crash gate these areas. The remaining lots are either unfenced or fenced inadequately. For the majority of this reach cattle have access to the river banks, from one side even if the opposite side of the river is fenced.

Condition

Feature	Comments
Vegetation	The foreshore in this reach supports an overstorey consisting of Paperbarks, Rivergums and Peppermints. Native understorey is extremely sparse, with the understorey predominantly consisting of weeds.
Weeds	Watsonia, blackberry, arum lily, cotton bush and willows are of main concern in this area. It should also be noted that kikuyu and couch are also a problem along this entire reach.
Bank stability & erosion	Large sections of this reach are affected by bank slumping and undercutting. Stock access has resulted in a loss of vegetation and bank erosion.
Special features, restoration sites	Two River Restoration Sites occur in this reach. The Brunswick Rivercare Demonstration Site near Wellesley Rd Bridge (Lot 21). This site was previously "D" grade, with very little vegetation and extensive erosion problems. Work carried out by the Water and Rivers Commission (now Department of Water) has rehabilitated this area to "C2" grade. The Brunswick Junction River Restoration Site is located west of Brunswick Junction Bridge. This site was also "D" grade with negligible vegetation. This site has now been reclassification to "C2". Further native revegetation of this site was conducted on Shire of Harvey reserve as part of this RAP. Maintenance of this site is required, especially to manage weed invasion over the next 3 years. Also, maintenance of the hurdles that were put in place to slow erosion during high flows.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.


End of Reach 1
Start of Reach 2
willows
watsonia
cotton bush
arum lilly
backberry
bridal creeper
willows
watsonia
blackberry
arum lilly
figs
blackberry
watsonia
arum lilly
willows
bridal creeper
apple of sodom
watsonia
cotton bush
arum lilly
willows
apple of sodom
watsonia
willows
arum lilly
blackberry
cotton bush
arum lilly
willows
blackberry
blackberry
watsonia
willows
arum lilly
bridal creeper
watsonia
blackberry
bridal creeper
willows
willows
apple of sodom
blackberry
willows
blackberry
willows
blackberry
figs
three corned
garlic
blackberry
arum lilly
watsonia
C1
C1
C3
C3
C3
C3
D2
C2-C3
C2-C3
PERREN RD
CLIFTON RD
ALVERSTOKE RD
HOWSON DR
AUSTRALIND BYPA
BILLABONG CT
ANLEY RD
N
W
E
S
0 120 240 480
Meters


End of Reach 2
Start of Reach 3
Revegetation Site - public walkway
Rivercare Demonstration Site (past works)
bamboo willows blackberry arum lilly
willows blackberry arum lilly
blackberry arum lilly olives bamboo
blackberry arum lilly bamboo olives willows
blackberry bamboo blue morning glory
willows flame tree bamboo
blackberry bamboo annual grasses
willows arum lilly blackberry
arum lilly bamboo willows fig tree watsonia
blackberry watsonia arum lilly willows apple of sodom fig trees
bamboo blackberry bridal creeper
arum lilly blackberry bridal creeper
arum lilly blackberry kikuyu
bamboo kikuyu
arum lilly blackberry poplars
watsonia blackberry willows
wllows arum lilly olive trees cotton bush blackberry
C1
C1-C2
C2
C2-C3
C3
C3-D1
D1
D2
MELVILLE RD
WELLESLEY RD
ENGLAND RD
SOUTH WESTERN HWY
BEELA RD
BELVIEW RD
LUCY CR
MARY AV
VINCENT ST
JOHN ST
RIDLEY ST
SOMMERS RD
GEORGE AV
THE CRESCENT
FERRY RD
KASTEN RD
HOPKINS RD
PIGGOTT ST
ROSE RD
BELL PL
BRUNSWICK RD
McANDREW ST
TALBOT RD
PARTRIDGE ST
FRY ST
READING ST
OMMANEY RD
HEPPINGSTONE RD
Foreshore Condition
A1: Pristine
A2: Near pristine
A3: Slightly disturbed
B1:Degraded - weed infested
B2: Degraded - heavily weed infested
B3: Degraded - weed dominated
C1: Erosion prone
C2: Soil exposed
C3: Eroded
D1: Ditch - eroding
D2: Ditch - freely eroding
D3: Drain - weed dominated
Cadastre & Lot No.
Road
Section Break
Arum Lilly
Weed
Walkway
Comment

Reach 2

Management

Issue	Management Action/Advice
Erosion	• Encourage local landholders to work with engineers from the Department of Water to address serious erosion and sedimentation problems. • Implement erosion control measures in C class areas as a priority. See Chapter 6 for detailed erosion control techniques.
Weeds	• Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds on their land. • Provide support and education to landholders on how to properly manage their declared weeds. • Support local community groups and weed action groups in weed management. • Target blackberry and cottonbush as a priority in this area.
Fencing/loss of native vegetatation	• Where stock are present, continue to fence off the creek to restrict stock access and provide off-river watering points for stock to minimise bank damage and protect water quality. • Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. See Chapter 6 for detailed techniques and information. In particular, planting a variety of understorey species, including rushes and sedges, is a priority in areas degraded by weed invasion or past stock access.
Fish	• Increase fish habitat by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encouraging the use of Best Management Practices (BMP) on farms to increase water quality and river health. The Department of Agriculture and Food water management BMP includes the management of important on-farm issues such as erosion, nutrient inputs, vegetation, grazing and water sources (See Appendix 6). Contact Department of Agriculture and Food for a comprehensive list of BMPs. • Support the ongoing collection and monitoring of water quality data and possible expansion of this program to include the monitoring of sediment loads.

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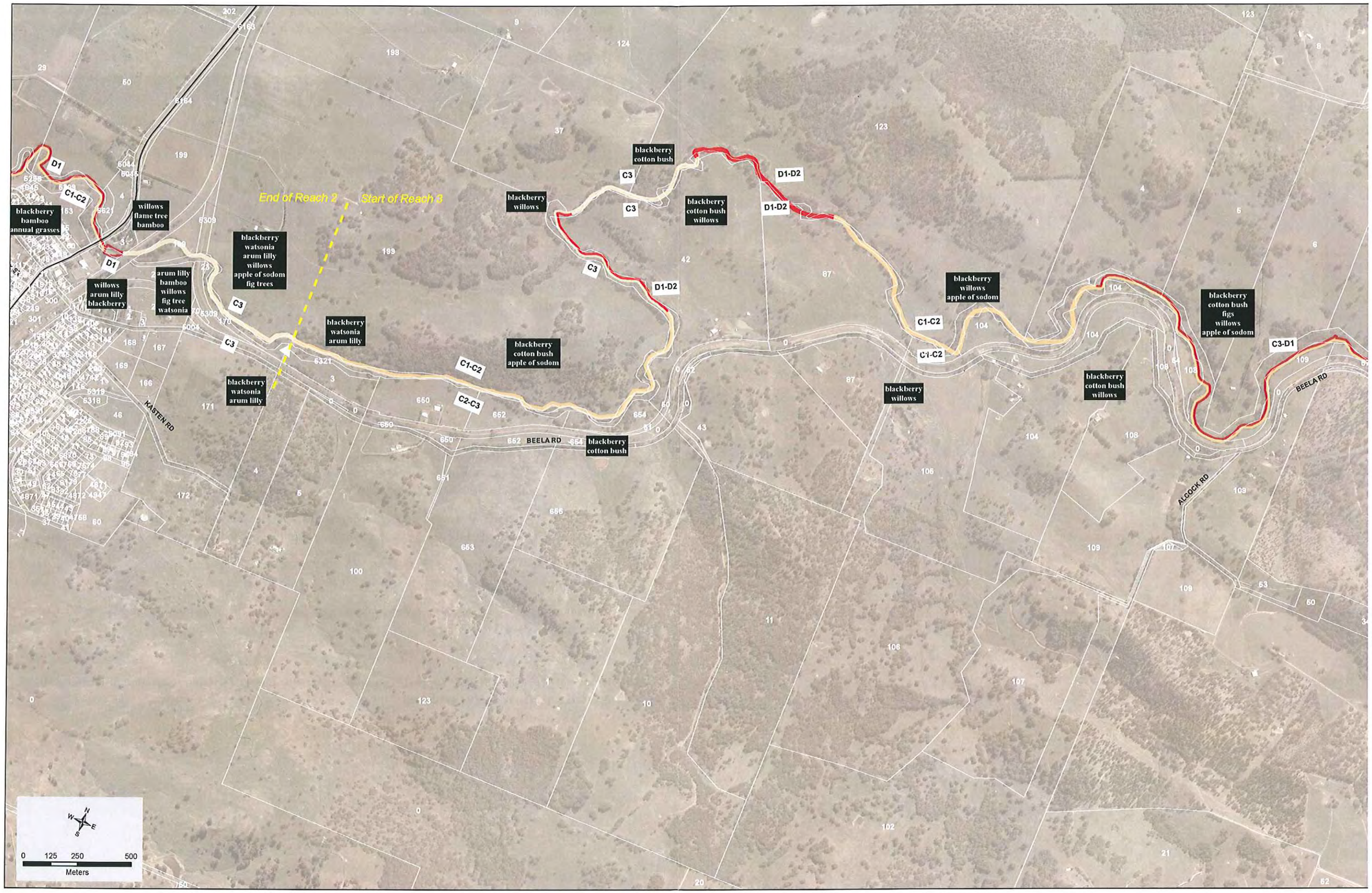

End of Reach 2
Start of Reach 3
blackberry bamboo annual grasses
willows flame tree bamboo
willows arum lilly blackberry
arum lilly bamboo willows fig tree watsonia
blackberry watsonia arum lilly willows apple of sodom fig trees
blackberry watsonia arum lilly
blackberry watsonia arum lilly
blackberry cotton bush apple of sodom
blackberry willows
blackberry cotton bush
blackberry cotton bush willows
blackberry willows apple of sodom
blackberry willows
blackberry cotton bush willows
blackberry cotton bush figs willows apple of sodom
blackberry cotton bush
D1
C1-C2
C3
C2-C3
D1-D2
C3-D1
KASTEN RD
BEELA RD
ALCOCK RD
0 125 250 500
Meters

Reach 3

Reach 3

Reach 3 extends from Brunswick Junction to 1km upstream of Flynn Road. This reach is approximately 16km long. Private agricultural land abuts the river for the majority of this reach.

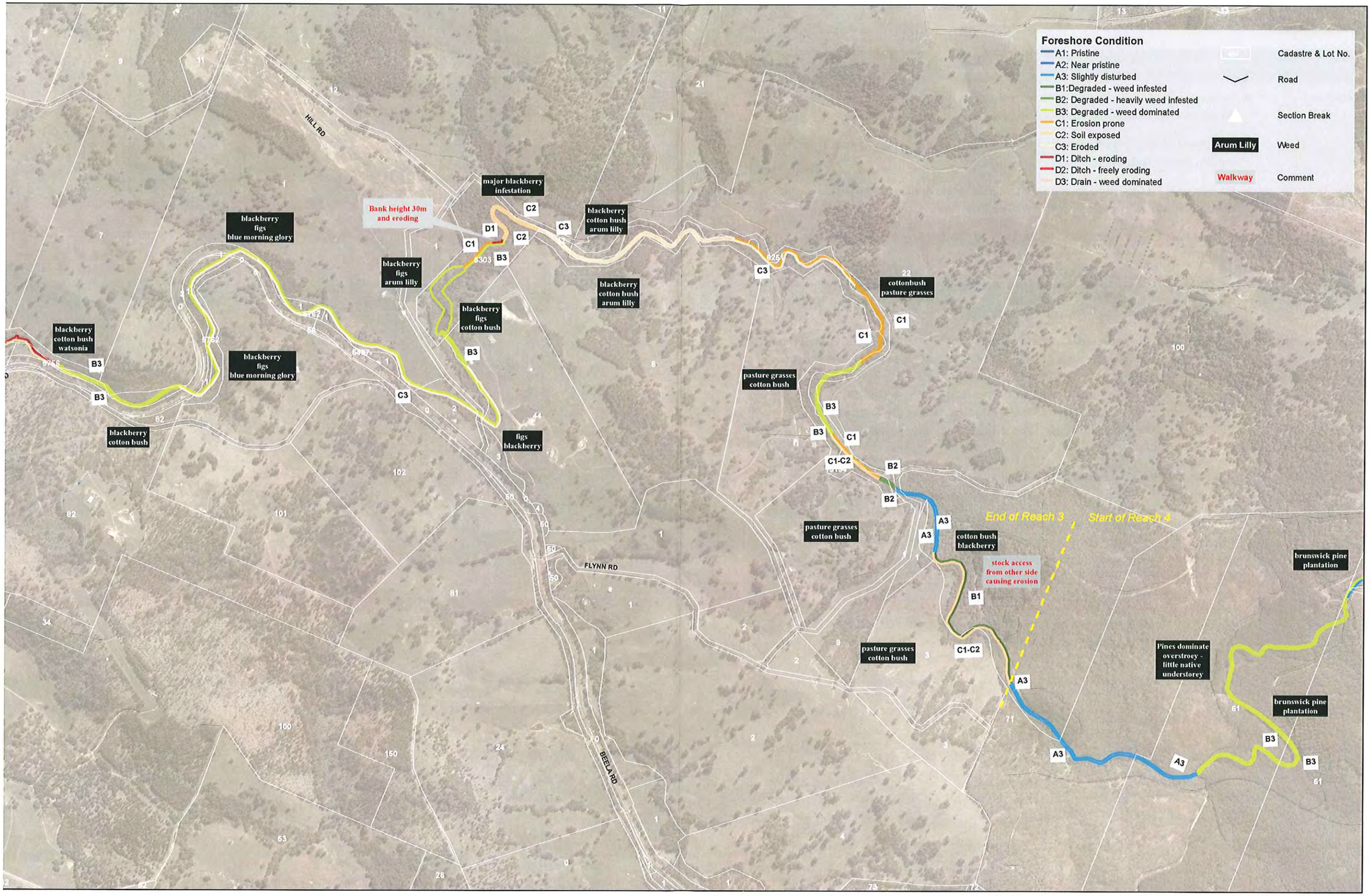
Description

Feature	Comments
Landuse	Agricultural land dominates both foreshores, including both cattle and sheep grazing.
Land tenure	Lots 5363 is a reserve owned by Water Corporation which includes the Beela Dam. Lot 0 beyond Flynn Rd is State Forest owned by CALM. The rest of the lots in the reach are privately owned.
Fencing	Lots 42, 104, 82, 1, 103, 23 & 8 are fenced, however in most cases the land on the other side of the river so these lots is not fenced and as such cattle can still impact on those river bank. The remaining lots are either unfenced or fenced inadequately. For the majority of this reach cattle have access to the river banks from one side even if the opposite side of the river is fenced.

Condition

Feature	Comments
Vegetation	Very little native understorey vegetation exists along much of this section of the river. There is usually one row of native overstorey trees remaining, usually Flooded gums and Peppermints. However, in many cases these trees are under threat due to the riverbanks eroding away under their root system. Many Flooded gums have fallen into the river after the heavy winter rains. Upstream, near the State Forest far more native plants exist and in some places sedges and rushes are well established along the riverbanks.
Weeds	Blackberry and cottonbush infestations occur along sections of both banks. Other weed species such as fig trees, arum lily, watsonia and bridal creeper also occur in some sections.
Bank stability & erosion	Large sections of this reach are affected by bank slumping and undercutting. Stock access has resulted in a loss of vegetation and bank erosion.
Special features, other comments	The Beela Dam Reserve is located in this reach. The Beela Dam is currently not being used as a public water supply. The Water Corporation are still managing the dam and determining its future.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.


Foreshore Condition
A1: Pristine
A2: Near pristine
A3: Slightly disturbed
B1:Degraded - weed infested
B2: Degraded - heavily weed infested
B3: Degraded - weed dominated
C1: Erosion prone
C2: Soil exposed
C3: Eroded
D1: Ditch - eroding
D2: Ditch - freely eroding
D3: Drain - weed dominated
Cadastre & Lot No.
Road
Section Break
Arum Lilly
Weed
Walkway
Comment
HILL RD
FLYNN RD
BEELA RD
Bank height 30m and eroding
major blackberry infestation
blackberry figs blue morning glory
blackberry figs arum lilly
blackberry figs cotton bush
blackberry cotton bush arum lilly
blackberry cotton bush watsonia
blackberry figs blue morning glory
blackberry cotton bush
figs blackberry
cottonbush pasture grasses
pasture grasses cotton bush
pasture grasses cotton bush
cotton bush blackberry
stock access from other side causing erosion
End of Reach 3
Start of Reach 4
brunswick pine plantation
Pines dominate overstroey - little native understorey
brunswick pine plantation

Reach 3

Management

Issue	Management Action/Advice
Erosion	• Encourage local landholders to work with engineers from the Department of Water to address serious erosion and sedimentation problems. • Implement erosion control measures in C class areas as a priority; see Chapter 6 for detailed erosion control techniques.
Weeds	• Encourage Local Governments and State Governments to fulfil their obligations to properly manage declared weeds and priority weeds on their land. • Provide support and education to landholders on how to properly manage their declared weeds. • Support local community groups and weed action groups in weed management • Target blackberry, arum lily and cottonbush as a priority in this area
Fencing/loss of native vegetatation	• Where stock are present continue to fence off the creek to restrict stock access and provide off river watering points for stock to minimise bank damage and protect water quality. • Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. See Chapter 5 for detailed techniques and information. In particular, planting a variety of understorey species, including rushes and sedges, is a priority in areas degraded by weed invasion or past stock access.
Fish	• Increase fish habitat by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encouraging the use of Best Management Practices (BMP) on farms to increase water quality and river health. The Department of Agriculture water management BMP includes the management of important on-farm issues such as erosion, nutrient inputs, vegetation, grazing and water sources (See Appendix 6). Contact Department of Agriculture for a comprehensive list of BMPs. • Support the ongoing collection and monitoring of water quality data and possible expansion of this program to include the monitoring of sediment loads.

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Reach 4

Reach 4

Reach 4 extends from 1km upstream of Flynn Road to where the Ernest River begins. This reach is approximately 14km long. State Forest abuts the river for the majority of this reach.

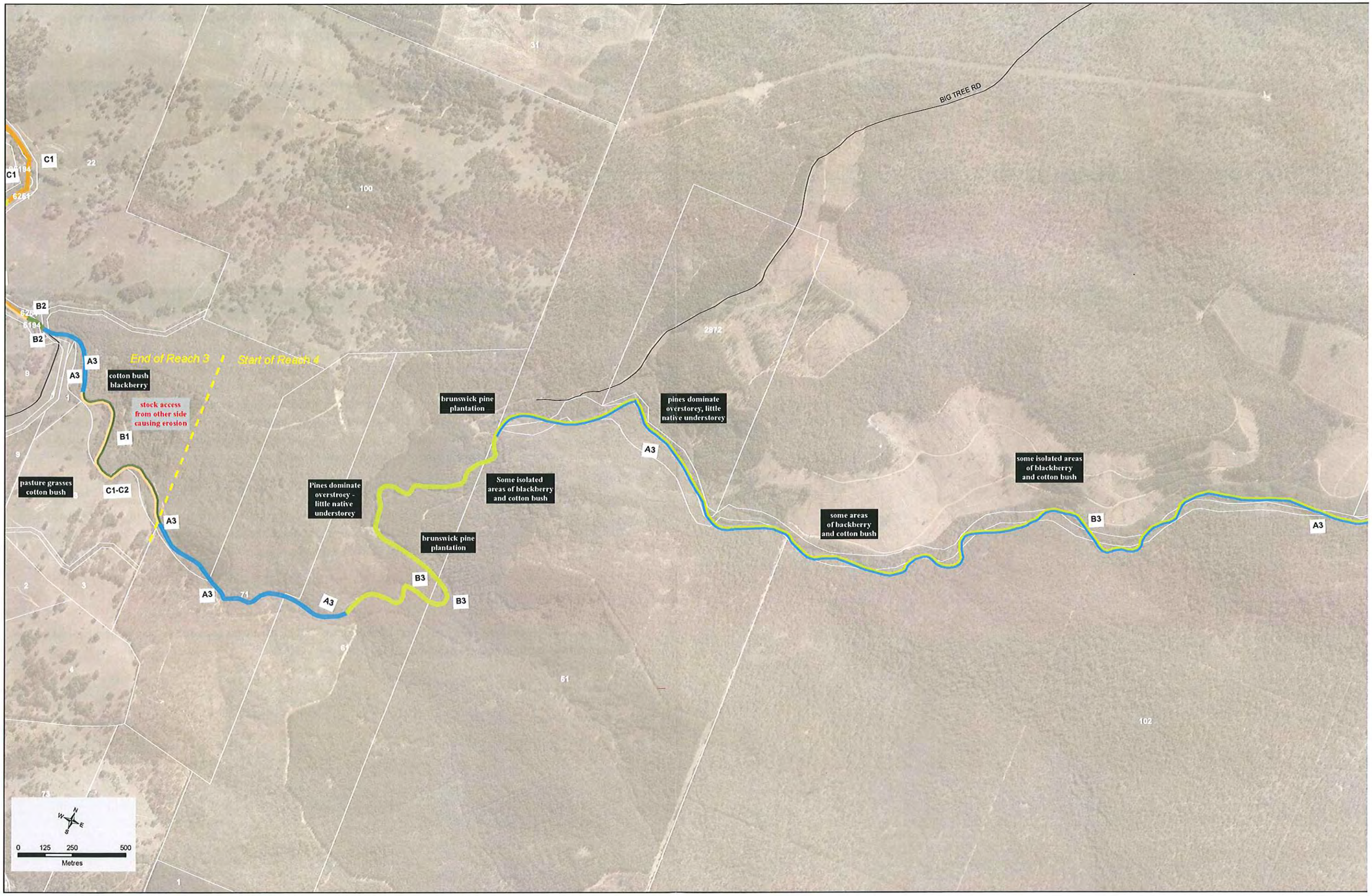
Description

Feature	Comments
Landuse	The major landuse is State Forest and Pine plantation.
Land tenure	Lots 2173, 2176, 3683, 101, 2764 and 4177 are privately owned. The rest of the lots are State Forest.
Fencing	Little fencing required as no stock present on lots visited. Lots 2173 and 2176 were not visited as landowners were unreasonable to provide access.

Condition

Feature	Comments
Vegetation	Mosaic of open forest of *Eucalyptus marginata* subsp. *Marginata* (jarrah) *Corymbia calophylla* (marri), with some admixtures with *Eucalyptus laeliae* (Darling range ghost gum) in the north (subhumid zone), with occasional E*ucalyptus marginata* subsp. *Elegantella* (jarrah) (mainly in subhumid zone) and *Corymbia haematoxylon* (mountain marri) in the south (humid zone) on deeper soils adjacent to outcrops, woodland of *Eucalyptus wandoo* (wandoo) (subhumid and semiarid zones), low woodland of *Allocasuarina huegeliana* (rock sheoak) on shallow soils over granite outcrops, closed heath of *Myrtaceae-Proteaceae* species and lithic complex on or near granite outcrops in all climate zones.
Weeds	Blackberry and Cottonbush are the main weeds in this reach.
Bank stability & erosion	Stock access has resulted in a loss of vegetation and bank erosion, in those sites that have stock. However, in the forested sections of the reach there is far less erosion as sedges and rushes are established on the riverbanks.
Special features, other comments	This reach has high biodiversity value, due to its diverse vegetation and limited clearing.

Please note "encourage" and "support" can mean to; provide financial support, education or technical advice, depending on the resources available.


BIG TREE RD
C1
C1
194
6261
22
100
31
2872
B2
6261
6194
B2
A3
A3
End of Reach 3
Start of Reach 4
cotton bush
blackberry
stock access
from other side
causing erosion
B1
brunswick pine
plantation
pines dominate
overstorey, little
native understorey
A3
some isolated areas
of blackberry
and cotton bush
pasture grasses
cotton bush
C1-C2
A3
Pines dominate
overstroey -
little native
understorey
Some isolated
areas of blackberry
and cotton bush
some areas
of backberry
and cotton bush
B3
A3
brunswick pine
plantation
B3
A3
A3
B3
71
61
51
102
0 125 250 500
Metres

Management

Issue	Management Action/Advice
Weeds	• Encourage Forest Products Commission and Department of Environment and Conservation to continue their weed control program within the State Forest. • Provide support and education to landholders on how to properly manage their declared weeds. • Target blackberry and cottonbush as a priority in this area.
Loss of native vegetatation	• Encourage Forest Products Commission and Department of Environment and Conservation to rehabilitate the riparian zone within the Brunswick Plantation • Assist regeneration of native vegetation and expand the riparian zone through planting of local native species. Appendix 1 contains a list of local species suitable for planting. See Chapter 6 for detailed techniques and information.
Fish	• Increase fish habitat by encouraging rehabilitation works such as erosion control using large woody debris, or planting of emergent vegetation such as rushes and sedges.
Declining water quality	• Encouraging the use of Best Management Practices (BMP) on farms to increase water quality and river health. The Department of Agriculture and Food water management BMP includes the management of important on-farm issues such as erosion, nutrient inputs, vegetation, grazing and water sources (See Appendix 6). Contact Department of Agriculture and Food for a comprehensive list of BMPs. • Support the ongoing collection and monitoring of water quality data and possible expansion of this program to include the monitoring of sediment loads.

6. Management advice

What can be done?

There are a number of management options available to landholders for addressing issues associated with protection of the Brunswick River and its foreshore including; stock control, revegetation, weed control and erosion control. These management approaches can be undertaken in isolation or as a combined, integrated approach. The approach taken at each site will depend on the scale of the issues present and the landholders willingness and capacity to undertake the required work. There are community groups, such as the Leschenault Catchment Council (LCC) that may be able to assist with site assessment and contribution to works.

The information in this chapter is largely taken from the River Action Plan for the Sabina, Abba and Ludlow Rivers (GeoCatch, 2002) by Genevieve Hanran-Smith, the River Action Plan for the Ellen Brook (Cape to Cape Catchments Group, 2005) by John Mckinney and Luke Pen's guide (Managing our Rivers, 1999).

Where to start

The main principles for riparian management are:

- conserve the best areas first;
- move on to those reaches showing signs of recovery; and
- then treat the more degraded parts of the system.

This advice applies to both individual properties and the system as a whole.

It is most cost effective to protect areas still retaining native vegetation. These areas are the most stable and the most likely to regenerate naturally. Assisting natural regeneration is a lot cheaper and easier than restoring degraded areas.

Work on the more degraded parts will be easier if the creek upstream is in good condition. Erosion and weed infestations impact on areas downstream.

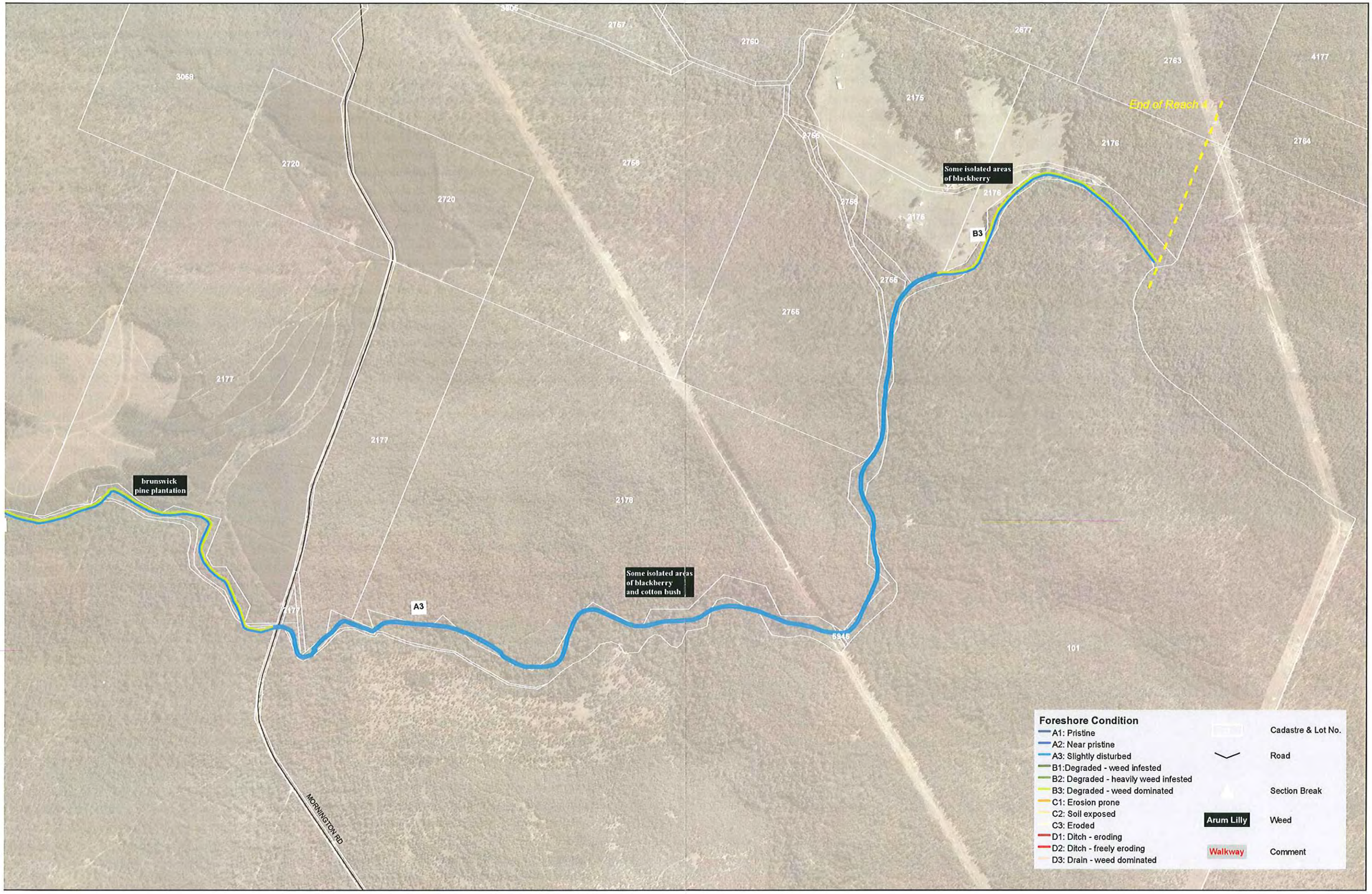
Both the Cape to Cape Landcare Companion (Cape to Cape Catchments Group, 2004) and the Geographe Catchment Companion (GeoCatch, 2004) contain excellent advice on planning a restoration and revegetation project. These manuals are available free, or at very little cost, from CCG and GeoCatch. This advice and the lessons learnt from the implementation of other River Action Plans should be applied during the planning and prioritisation of individual on-ground activities. The Vasse River Action Plan contains excellent advice on planning a restoration and revegetation project. Parts of this advice are included in Appendix 3 of this plan.

Stock control

The control of livestock access is the most important management tool in the protection and restoration of waterways and vegetation. Fencing is the best method to achieve this.

APACE Green Skills & Pen (1997) provide good advice on the placement of fences alongside waterways:

> 'Ideally, fences should be placed above the river valley. Depending on the steepness of the embankment, the fence should be placed 5 m to 20 m back from the edge of the river valley (Figure 4A). Five metres is sufficient for a shallow valley of a couple of metres deep. In a broader zone, a setback to fencing greater than ten metres is required for valleys deeper than five metres. The purpose of fencing off the shoulders of the river is to enable trees on the upper part of the embankment and those above the river valley to anchor the adjacent land, and thereby prevent subsidence.
>
> In the case of shallow river valleys, there is little chance that embankments will subside. Nevertheless, fence-lines should be located above the river valley (Figure 4B). This is because fences and firebreaks located within the river valley will be damaged and eroded by floodwaters. When they occur, firebreak washouts can be severe and contribute large quantities of sediment to the river system.
>
> If the river valley is particularly broad and floodplains have been cleared for grazing, fencing them off may mean sacrificing good farmland. In this case it is necessary that only those areas that are prone to water erosion or stock damage, such as embankments and secondary river channels which only flow strongly at times of flood, need to be fenced off (Figure 4C). Some of these fence-lines will be prone to flood damage, but this can be minimised if fences run, as much as possible, parallel to the direction of floodwaters.


3068
2720
2720
2177
2177
2757
2760
2769
2765
2766
2766
2765
2175
2176
2176
2176
2677
2763
4177
2764
End of Reach 4
Some isolated areas of blackberry
B3
brunswick pine plantation
2177
2178
Some isolated areas of blackberry and cotton bush
A3
6946
101
MORNINGTON RD
Foreshore Condition
A1: Pristine
A2: Near pristine
A3: Slightly disturbed
B1:Degraded - weed infested
B2: Degraded - heavily weed infested
B3: Degraded - weed dominated
C1: Erosion prone
C2: Soil exposed
C3: Eroded
D1: Ditch - eroding
D2: Ditch - freely eroding
D3: Drain - weed dominated
Cadastre & Lot No.
Road
Section Break
Arum Lilly
Weed
Walkway
Comment

Reach 4

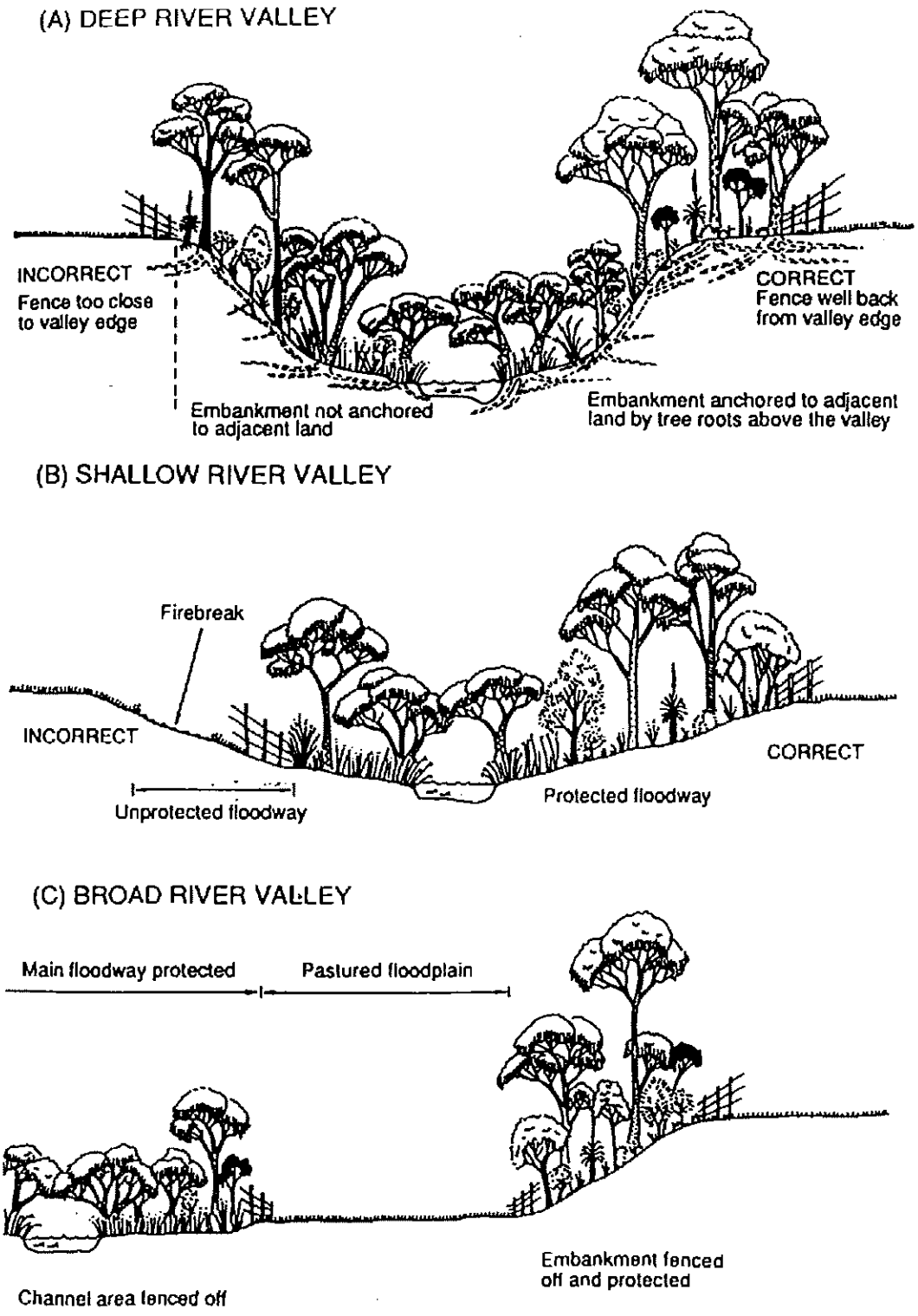


Figure 4: The correct placement of fences in relation to the river valley: (A) the deep river valley, (B) the shallow river valley and (C) the broad river valley with broad floodplain (APACE Green Skills & Pen, 1995).

In the flatter and broader valleys it may be acceptable to use fences to control the level of grazing rather than to exclude it altogether. A careful watch would need to be kept to ensure that the grazing is sustainable and is not so heavy as to prevent the regeneration of native trees, shrubs and sedges.'

Fencing may be used to exclude stock entirely from the river, or to allow restricted grazing. Once native species have regenerated or been re-established it may be appropriate to allow careful grazing for short periods to control weeds. Grazing may also be used to control weeds prior to planting. Heavy grazing that would degrade the riparian zone and ultimately eliminate native plant species should be avoided. Total exclusion of stock will be necessary where the bank is steep and sandy, or prone to collapse, or where the objective is to maintain high quality riparian habitat. It is important to note that there may be increased grassy weed growth if previously grazed areas are fenced off. A long-term weed management and revegetation plan needs to be developed prior to fencing off riparian land.

In areas where stock are not present, there is no need to fence. However on properties where stock are present even for only part of the time, it is important to restrict stock access to the banks.

During the surveys and community consultations, a number of issues regarding restricting stock access arose, including the cost of fencing and the need for summer water. These are all valid concerns. At the time of writing this report, LCC was actively seeking funds to provide financial incentives to landholders to restrict stock access to waterways and undertake rehabilitation activities.

Useful references on stock control

- Water and Rivers Commission Water Note 18, *Livestock Management: Fence Location and Grazing Control.*
- Water and Rivers Commission Water Note 6, *Livestock Management: Construction of Livestock Crossings.*
- Water and Rivers Commission Water Note 7, *Livestock Management: Watering Points and Pumps.*
- Water and Rivers Commission Water Note 19, *Flood Proofing Fencing for waterways.*

Water quality

Waterways in agricultural areas receive large quantities of nutrients, either dissolved in water, adhering to small soil particles eroded from the land or in dead plant and animal material, including manure washed from paddocks. Outlined below are a number of ways to improve water quality (Pen, 1999).

Vegetative buffers

Vegetated buffers alongside waterways can intercept and slow runoff and thereby trap suspended sediment, including organic material. Research has shown that vegetative buffers 10-50 m wide can achieve phosphorus and nitrogen filtration rates in the order of 50-100% (Pen, 1999). A vegetative buffer need not be of native vegetation and can be a simple grassy strip that is fenced off to control grazing. The nutrients assimilated by the vegetation can be utilised by crash grazing or preferably in hay production since the latter does not involve livestock returning nutrients to the grassy border as urine and manure.

Vegetation within the waterway itself forms a longitudinal buffer which similarly slows the flow rate, reduces erosion and traps soil, sediment and organic matter.

Farming practices (from Kingdon, 2000)

To reduce soil erosion, the key is to keep reasonably high levels of vegetation on the soil for as long as possible, and especially during times of high erosion risk. Achieving these conditions requires:

- use of reduced tillage and direct drilling;
- use of crop and pasture rotations that include well-managed perennial grasses and legumes;
- in row cropping, use of permanently raised beds and controlled traffic;
- managing organic matter by retaining stubble and including pastures in a crop rotation; and
- ensuring vigorous plant growth through appropriate soil, crop and water management.

Cultivation along the contours, rather than at right angles to them, will slow the rate at which water flows

across the land, reducing soil erosion by as much as 50% (Pen, 1999).

Soil testing and fertiliser use

Fertiliser is generally applied according to traditional practice, usually some time before the winter/spring growing season. Today, we know that after a number of years of fertiliser application, many soils are rich in nutrients but may be deficient in a few trace elements (Pen, 1999). Soil should be tested to determine fertiliser requirements and avoid excess application of nutrients, a portion of which will find their way into waterways.

Mycorrhizal and soil bacteria testing is another related tool. Past farming practices have led to the gradual sterilisation of soils. Soil organisms interact with the root hairs of pasture and native plants and assist with nutrient uptake. A number of landholders in the catchment are trialling the use of organic and biodynamic solutions to improve soil health, with an ultimate goal of reducing fertiliser, herbicide and pesticide use whilst maintaining or improving yields. Contact the Department of Agriculture for more information.

Useful references for protecting water quality through farming practices

- Kingdon, B.K. (2000) *Fertiliser Use Guidelines for the Swan Coastal Plain of WA*. Vasse-Wonnerup LCDC, Busselton, WA
- Prosser, I., Karssies, L., Ogden, R. & Hairsine, P. (1999) *'Using buffers to reduce sediment and nutrient delivery to streams'. In: Riparian Land Management Technical Guidelines: Volume Two: On-ground Management Tools and Techniques*, Price, P. & Lovett, S. (eds). LWRRDC, Canberra.
- Lavell, Summers and Weaver (2005), *Best Management Practices*, Department of Agriculture and Food, Western Australia (see Appendix 6).

Erosion control

Erosion is an issue requiring attention in many parts of the Brunswick River, with areas showing signs of severe incision, undercutting and bank slumpage.

It should be noted that a detailed river geometry survey and a variety of calculations are required for the correct design of engineering works. It is also important to remember that rivers are part of a dynamic system, that is, they are in a constant state of change. Care should therefore be taken when attempting to predict the outcome of alterations to channel form and capacity. Site-specific technical advice should be obtained prior to commencing any form of physical modification to the river channel. Engineers from the Department of Water can provide technical support.

A number of approaches to erosion control as outlined in the Capel River Action Plan by Kirrily White and Sarah Comer (GeoCatch, 1999) and are discussed below.

Point bars

Once a river bank becomes disturbed to the point where it is actively eroding, there is large potential for this to create further erosion downstream through the formation of point bars. Currents remove material from the outside banks of meanders and deposit it on the inside banks where water moves more slowly, forming a point bar (Raine & Gardiner, 1995). Over time these sand bars trap more sediment and continue to accumulate, to a point where they may even start to support in-channel vegetation growth. Some point bars are located and shaped in such a way that they actually divert the river flow onto the opposite bank further downstream, thus creating a new erosion point on the next outside bend. This cycle of erosion and deposition often continues downstream, and is a classic sign of a river in which the hydrological balance has been disturbed (Figure 5).

Removal of point bars may sometimes be needed in order to halt the progression of the erosion downstream. Generally, this should be undertaken in conjunction with other forms of restoration and care must be taken not to exacerbate the disturbance to the river channel. As discussed previously, a detailed river geometry survey of the problem areas is essential before this type of restoration procedure should be contemplated.

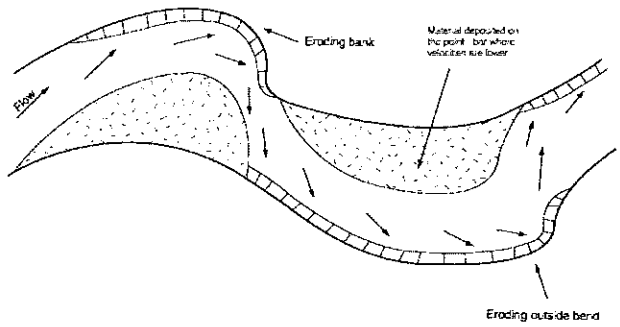


Figure 5: Outside bend bank erosion – Arrows mark the direction of flow showing that outside bends have the greatest erosion potential, so the meanders migrate downstream (Raine & Gardiner, 1995).

Undercutting

Undercutting often occurs in conjunction with the formation of point bars. Material is scoured from the toe of the bank, resulting in loss of bank support; this often results in subsidence as illustrated in Figure 6 (Raine & Gardiner, 1995). Previous experience has shown that supporting and protecting the toe of the bank can prevent undercutting. Generally, undercutting will occur where there is a meander. If this is the case, only the outside bends ueed to be supported as the flow velocity on the inside bend is much lower. Once an outside bend is stabilised, the corresponding inside bend will usually adjust its width to cater for the change in flow.

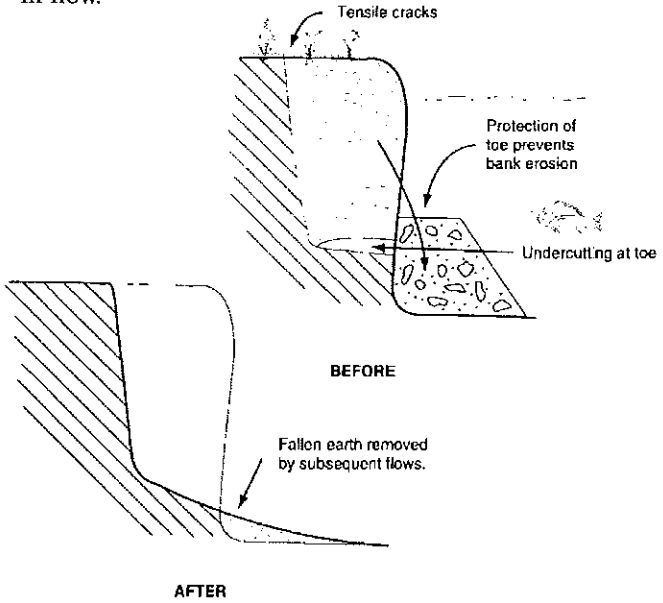


Figure 6: The use of structural works, such as a rock toe, will prevent the process of undercutting (adapted from Raine & Gardiner, 1995).

Bank slumping

Bank slumping can occur when poorly drained material within the bank becomes heavy with saturation and collapses into the river channel (Figure 7). This can occur with or without prior undercutting. It will often occur in response to the loss of native deep rooted riparian vegetation which is critical to bank stability. The best way to manage this problem is to exclude stock with fencing set well back from the river channel, and revegetate the foreshore with suitable species. Raine and Gardiner (1995) provide the following advice on this process:

- Replant the toe with species that can withstand high flow velocities (e.g. native sedges). This replanting should be dense with spaces between plantings of less than 1 metre;

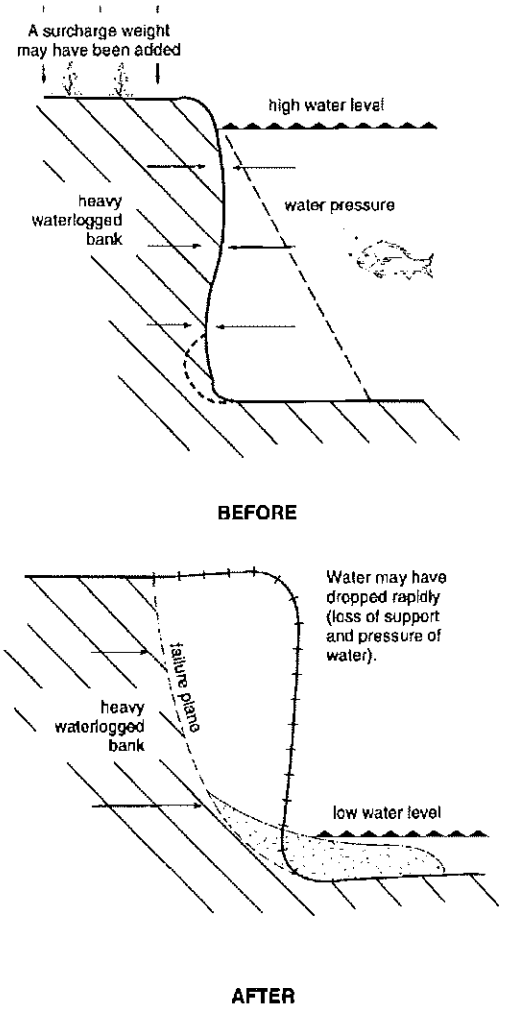


Figure 7: The process of bank slumping caused by excessive weight and lack of support (adapted from Raine & Gardiner, 1995).

- Replant the middle to upper bank areas with fast growing, deep rooted trees and large shrubs. These will hold the bank together, enhance drainage and remove excess moisture through transpiration;
- Vary the species that are planted to ensure differing root structures; and
- Extend plantings from the toe to the floodplain. If a narrow band of trees is planted, this may serve only to add to the weight of the bank without providing the necessary network of root support.

Large woody debris

Snags, or large woody debris, are a natural component of the river system. They play an important role in river ecology by providing a range of flow conditions within the channel and habitat for aquatic life forms. Occasionally snags can divert the flow onto the bank and subsequently cause erosion in areas lacking support from native vegetation. While de-snagging rivers has been a common practice in the past, the current management emphasis is to leave as much woody debris as possible. Rather than removing large woody debris from the channel, it should be repositioned at an angle of 20° to 40° to the stream bank (Figure 8). This action will minimise the effect of the snag on flow levels and direction, whilst maintaining the habitat available for plants and animals that benefit from low flow conditions. Large woody debris can also be added to deflect flows from unstable areas.

Repositioning LWD
The capacity of a river channel can be improved by rotating the LWD at an angle of 20° - 40° to the streambank.

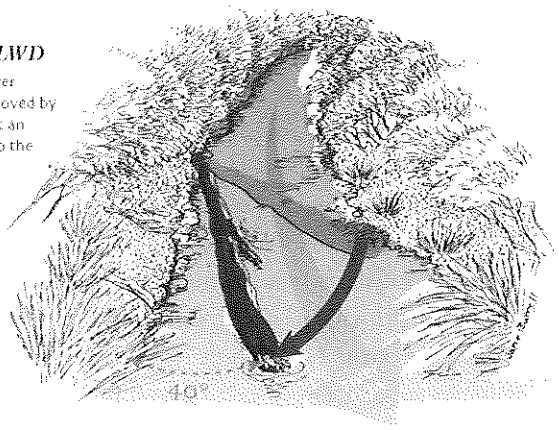


Figure 8: Repositioning large woody debris (Gippel et al., *1998).*

Useful references on erosion control

- Pen, L.J. (1999) *Managing Our Rivers.* Water and Rivers Commission, Perth.
- Water and Rivers Commission (2001) *Stream Stabilisation.* River Restoration Report No. RR 10.
- Raine, A.W. & Gardiner, J.N. (1995) *Rivercare — Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation.* Land and Water Resources Research and Development Corporation, Canberra.

Regeneration and revegetation

In areas that still retain native trees and understorey, natural regeneration is the cheapest and easiest management option. Control of stock access and invasive weeds is essential to this strategy, and should be the first step taken. Natural regeneration can be assisted by making small piles of branches and burning to promote germination through smoke and heat. Smoke water can also be applied to encourage germination. Another technique to assist regeneration involves laying the seed bearing parts of native plants directly onto the ground, allowing seeds to fall from them. This is called brushing, and works best after weed control measures such as spraying to reduce competition once the seedlings start growing.

Sections of riparian vegetation that have been heavily grazed and cleared generally contain more weeds and have a diminished seed bank. Options for these areas include: direct seeding; brushing with woody natives that contain seed; pre-seeded matting; and planting of tube stock. The riparian zone should be planted in a wide band with a diverse suite of species including trees, shrubs, sedges, rushes, herbs and native grasses. This not only improves the habitat value of the foreshore, but also provides a matrix of different root structures that will improve bank stability and assist in erosion control. Where possible, seed should be collected from nearby as this will ensure that the species used are suitable, local and part of the existing ecological web. Appendix 1 provides a list of species that were found in the area. Species for revegetation projects in the catchment should be selected from this list, choosing plants that are represented in nearby communities. Leschenault Community Nursery can assist with species selection.

Good site preparation is crucial to successful revegetation. Elements that need to be considered are weed removal; soil amelioration; and preparation of the soil surface for direct seeding or planting. Ongoing pest and weed control will need to be part of the project. Planting and sowing at the right time of year and at the appropriate depth will influence the success of the revegetation effort. Different revegetation techniques are outlined below.

Direct seeding

Direct seeding involves placing seeds directly on or into the soil on the site, either by hand or with machinery. For individual farm sized projects a mix of local seeds can be prepared in clean (weed free) sand and sown into lightly cultivated or raked soil. For an increased cost but higher success rate, tree bags can be placed over these areas to protect seedlings from dehydration, wind and predation. These bags will also help to identify and protect plants during follow-up spot spraying for weeds over the coming seasons. Several areas in the catchment have been identified as having good potential for the collection of local provenance[3] seed.

Direct seeding has a few distinct advantages over other revegetation methods:

- it is less time consuming and requires less labour than planting tube stock;
- a mixture of trees, shrubs, sedges and groundcovers can be planted at the same time, resulting in a plant community with a more natural look, and better resilience due to increased diversity and synergy;
- seeds will germinate over several years, giving a range of ages and growth forms, resulting in a more natural look;
- it is less expensive than using tube stock; and
- the natural root development of seedlings grown from seed usually results in plants developing deeper taproots, requiring less follow-up care.

However, direct seeding can be less reliable than planting, due to predation, specific germination requirements not being met, and poor conditions for direct seeding. Direct seeding may not be possible when high winds or strong water flow is present.

Planting

Planting is an appropriate technique for embankment and in-stream revegetation, and where direct seeding is difficult due to insufficient seed, excessive weed competition, or other factors. In these cases, nursery tube stock is ideally supplied from local provenance seed. A rule of thumb guide for planting densities is 3-4 rushes per 1 m^2, 1 shrub per 1 m^2, and 1 tree every 3 m^2. When selecting plants and designing the revegetation of an area, it is also important to take into account the budget for follow-up management; the availability of water over summer; the range of species available; existing vegetation cover such as tree canopy; soil types; and the intended weed management approach.

Rushes and sedges should be planted in spring, when the water table is beginning to fall and the soil is still moist. Other seedlings should be planted when the surrounding soil is moist and follow-up rain is likely (usually between May and July). Care should be taken to ensure that specimens are not root bound, and that minimal damage to the roots occurs when removing from pots. Planting requires significant prior planning, as it is best to collect local seed and contract a nursery to raise them in time for planting in the following wet season. The Leschenault Community Nursery specialises in growing local native plants for revegetation purposes.

Brushing

Brushing is an excellent technique for all zones apart from the channel bed. This technique can be used to spread seed and assist with erosion control simultaneously. Brush should be harvested from plants at seed maturity and laid immediately on the revegetation site. Brush along the embankment should be secured in place. Species suitable for this technique are those that retain seed on the plant, but shed it when the plant dries out. This includes many of the myrtaceous species (peppermints, tea trees, Melaleucas, and Eucalypts such as marri, jarrah and flooded gums). Brushing is easy to combine with other revegetation activities such as direct seeding, and provides shelter to plantings, increasing seedling survival rates.

[3] The term provenance is used to identify the geographic origin of seeds or parent plants. Often, genetically distinct local forms or varieties of a plant have evolved to suit a specific range of conditions, including soil, climate and water regimes. Direct seeding with local provenance seed ensures that the resulting plants will be suited to the localised environmental conditions and maintain the ecological integrity of existing native plant communities (GeoCatch, 1999).

Pre-seeded matting

Pre-seeded matting involves sowing seeds onto an appropriate fibre mulch, and laying the mat on-site in early winter after germination. This technique is excellent for steep embankments, since it provides erosion control and revegetation in a single step. It is generally only suitable for seeding with rushes and sedges, since matting usually requires rolling for transport to the site once seeds have germinated (like instant lawn). It can be difficult to source matting with seeds of local provenance.

Division and transplanting of rushes and sedges

Many rushes and sedges propagate very well by vegetative division – plants can be easily split into individuals plants (ramets) every two months or so under good conditions. With planning the prior year and a small initial outlay, a large number of these difficult to propagate (from seed) species can be raised by division. Some species of rushes and sedges such as Juncus, Carex, Isolepis and Schoenoplectus are suitable for growing from seed, but others are difficult to propagate.

Farmers often grub out or spray rushes and sedges in paddocks as they may limit options for crop cultivation. In some circumstances, paddocks adjacent to restoration sites may contain large numbers of these rushes and sedges that could be transplanted with success. This can be a cheap, but labour intensive form of revegetation. Care must also be taken to minimise erosion and to not spread dieback.

Useful references on natural regeneration and revegetation

- Bradley, J. (1988) Bringing Back the Bush: *The Bradley Method of Bush Regeneration*. Lansdowne Press, Sydney.
- Buchanan, R.A. (1989) *Bush Regeneration: Recovering Australian Landscapes*. TAFE Open Training and Education Network, Strathfield, NSW.
- Scheltema, M. (1993) *Direct Seeding of Trees and Shrubs. Greening Western Australia*, Perth.
- Water and Rivers Commission (1999) *Revegetation: Revegetating Riparian Zones in South-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR4.
- Water and Rivers Commission (1999) *Revegetation: Case Studies from South-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR5.
- Water and Rivers Commission (1999) *Using Rushes and Sedges in Revegetation of Wetland Areas in the South West of WA*. Water and Rivers Commission River Restoration Report No. RR8.
- Water and Rivers Commission (2000) Water Note 20; *Rushes and Sedges*.
- Geographe Catchment Council (2004) *Geographe Catchment Companion*.
- Cape to Cape Catchments Group (2004) *Cape to Cape Landcare Companion*.

Weed control

Weed invasion of native vegetation is a major threat along the Brunswick River, and in the catchment as a whole. Fencing the river and restricting stock access will result in the need for extra weed control. Weed control should be coordinated across the whole catchment for any action to be really effective. In foreshore areas, removal or control of weeds must take account of the erosive power of water. Clearing weeds in an unplanned manner could result in erosion in the river channel. Weed control principles to keep in mind include:

- Weeds thrive in disturbed areas and on bare ground.
- Fire promotes weeds. Burning a remnant that is weed infested can make the weeds worse, unless there is follow-up weed control and revegetation. Native plants cannot compete with the rapid regrowth of weeds, which then become a greater fire hazard.
- Aggressive perennial weeds that spread readily along riparian corridors should be eradicated first, for example, bridal creeper, blackberry and cotton bush.
- If weed control is carried out, revegetate to prevent further weed invasion in the bare soil.
- Some native plants look and act like weeds. Do not begin weed control until you are sure a plant is a weed.

Chemical control of weeds on waterways requires careful planning. Issues which must be considered prior

to any type of chemical control include the effects of the herbicides on native flora and fauna, and on water quality. If you decide to use a herbicide, choose one that has a modified surfactant to reduce impact in waterways and wetlands, such as Roundup® Biactive. In surface or sheet erosion prone sites, spot rather than blanket spraying can help to reduce erosion from loss of weed cover whilst still providing opportunities for planting.

In some cases it may be appropriate to use restricted grazing to control weeds. Where banks are steep and sandy or prone to collapse, or where the objective is to maintain high quality riparian habitat, grazing should be avoided. However, where the riparian zone has a history of grazing and the exclusion of stock would lead to an explosion of weeds, maintenance of the zone by light grazing is an option. The landholder should keep a careful eye on the riparian zone to see that it has an adequate cover of a mixture of native and pasture plant species and that erosion is not occurring.

Troublesome major weeds should be identified at an early stage and eradicated immediately (Pen, 1999).

Specific notes on certain weeds

A number of declared weeds (according to the Agricultural and Related Resources Protection Act 1976) were found in the study area. They are: apple of sodom, arum lily, blackberry, and cotton bush. According to legislation, declared plants need to be controlled or contained depending on their status, and reported to the local Agricultural Protection Officer. More information on the requirements for control and treatment is available from the Department of Agriculture WA.

Information on these weeds and other priority weeds in the catchment is provided below. This is sourced from Southern Weeds and their Control (Moore & Wheeler, 2002), Bushland Weeds: A Practical Guide to their Management (Brown & Brooks, 2002), and Declared Plants Handbook: Recommendations for the Control of Declared Plants in Western Australia (Department of Agriculture, 2002).

Southern Weeds is a useful guide to landholders in the south west and provides information on weed identification and control. It is available from Department of Agriculture offices. Also useful for weed identification is Western Weeds (Hussey *et al.*, 1997).

Apple of Sodom (*Solanum linnaenum*)

An erect perennial shrub with deeply lobed prickly leaves, and prickly stems and branches. It has purple star shaped flowers often throughout the year and the fruits are bright yellow when mature. Introduced from South Africa, it is a serious problem in parts of the south west, especially in grazed paddocks and creeklines. Small plants may be grubbed out, however all root fragments must be removed. Chemical control using a 1:80 solution of Amitrole plus wetting agent is most effective.

Arum lily (*Zantedeschia aethiopica*)

A tufting perennial with dark green, shiny leaves arising from a tuberous root. Easily recognised by large white 'flower' with a central yellow column of minute male and female flowers. Toxic to stock. Berries are spread by birds and along watercourses. A serious threat to riparian vegetation. Slashing, if undertaken regularly (at least three times per season) over a long period, may be effective but is very time and labour intensive. Chemical control with low rates (0.5 grams per 10 L of water) of Glean® (Chlorsulfuron) or Metsulfuron as flowers start to wither is most effective. Little effect will be noticeable immediately, however the following year very few plants will come up. Glyphosate is not an effective control. Blanket or hockey stick wipers should be used near waterways to prevent spray drift or runoff. In areas with very dense infestations, multiple applications will be required to ensure any new seedlings are controlled.

Blackberry (*Rubus* spp.)

A perennial plant with arching prickly stems (canes) that was introduced from Europe as a fruit crop. Highly invasive, especially along creeklines. Mechanical control is difficult except for small infestations. Care must be taken to ensure that all root material is removed. Herbicide control is most effective, with Triclopyr and Triclopyr plus Picloram having good results, but care must be taken near waterways with the latter. Some success has been had with mixtures of Metsulfuron and Glyphosate. Further research is currently underway to develop effective biological controls with some trials in local areas expected to commence mid-2005.

Bridal creeper (*Asparagus asparagoides*)

A perennial climber with wiry stems that was introduced from South Africa as a garden plant. It is extremely invasive and spreads very rapidly, eventually smothering native vegetation. A variety of new bio-control methods seem to be having good results in the area. A small (2-3 mm long) leafhopper and a 'rust' (fungus) are available for release. Contact Department of Agriculture for more information and release locations.

The rust appears to be spreading well, and no bridal creeper was found during the survey that was not infected with rust. It many places where previously bridal creeper was extremely thick, the rust has worked very well. However care must be taken not to become complacent about bridal creeper. Due to the nature of biological controls, the rust will never eradicate bridal creeper, it will just make it manageable. Further control methods such as wiping individual stems with a 1:2 Glyphosate solution as they emerge is an excellent follow up technique.

Cotton bush (*Gomphocarpus fruticosus*)

This South African native forms a shrub up to 2m high favours moist sites. A garden escapee, cotton bush can be pulled from damp soils (up to late October/November). Alternatively it can be cut at or just below ground level. The plant seldom regrows following removal. Seed heads must be removed for this method to be effective. This weed contains cardiac glycosides and gloves should be worn and contact with sap avoided when undertaking control. Infestations should be sprayed between September and December with an appropriate herbicide.

Edible fig (*Ficus carica*)

A large tree with distinctive lobed leaves and fleshy fruit. A garden escapee that tolerates damp conditions. Takes root readily from cuttings and root fragments, with birds and animals also dispersing seeds. Hand pull seedlings, inject larger specimens with 50-100% Glyphosate in summer. Can be treated with the cut and paint method, however all branches, twigs and fruit must be removed and burnt.

Kikuyu (*Pennisetum clandestinium*), Buffalo Grass (*Stenotaphrum secundatum*), Couch (*Cynodon dactylon*) and Water Couch (*Paspalum distichum*).

These perennial introduced grasses all spread from runners or rhizomes and are very invasive. Manual control (except large scale scalping) is not effective. A spray-burn-spray regime using Glyphosate appears to work well in areas where water levels recede (allowing herbicide and fire use).

Victorian tea tree (*Leptospermum laevigatum*), deciduous trees and other woody Weeds

Woody weeds like Victorian tea tree and deciduous species like willows (Sailx spp.) and poplars (Populus spp.) can be controlled using stem injection or cut and paint with undiluted Glyphosate. To stem inject, holes should be drilled around the trunk and spaced no more than 5 cm apart into the sapwood (just beyond the bark, but not into the heartwood) and herbicide injected immediately. The tree may take up to 3 months to die and can then be felled or left as habitat. To cut and paint, the tree should be felled with a chainsaw as close to the ground as possible and painted immediately with undiluted herbicide. All material must be removed and monitoring for suckers should occur for at least 2 years.

Watsonia (*Watsonia* sp.), Gladioli (*Gladiolus* sp.) and African cornflag (*Chasmanthe floribunda*)

These have been grouped together as growth form and control methods are similar. All are tufted bulbous species from South Africa with erect sword shaped leaves, and tall spike-like white, pink, yellow or orange flowering stems. Manual control (digging out) of African cornflag and watsonia can be effective in small areas but is very labour intensive and requires many years of follow-up. Manual control of wavy gladioli should not be attempted as numerous cormels will break off and cause a more severe problem than before. Spraying with Glyphosate or 2,2-DPA just prior to flowering gives best results. In sensitive areas, using a sponge glove or a hockey stick wiper is best.

More information on weed control is available from the Department of Agriculture.

Useful references for weed identification and methods of control

Brown, K. & Brooks, K. (2002) *Bushland Weeds: A Practical Guide to their Management with Case Studies from the Swan Coastal Plain and Beyond.* Environmental Weeds Action Network, Greenwood, Western Australia.

Department of Agriculture (1999) *Wetlands not Weedlands.* Weed Note No. 1/99, Department of Agriculture, Perth, Western Australia.

Department of Agriculture (2002). Declared Plants Handbook: *Recommendations for the Control of Declared Plants in Western Australia.*

Dixon, B. & Keighery, G. (1995) 'Suggested methods to control weeds'. In: *Managing Perth's Bushlands*, Scheltema, M. & Harris, J. (eds). Greening Western Australia, Perth, WA.

Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. & Lloyd, S.G. (1997) *Western Weeds: A Guide to the Weeds of Western Australia. Plant Protection Society of Western Australia*, Victoria Park, Western Australia.

Hussey, B.M.J. & Wallace, K.J. (1993) *Managing Your Bushland.* Department of Conservation and Land Management, Como, Western Australia.

Moore, J. and Wheeler, J. (2002) *Southern Weeds and their Control* Department of Agriculture, Bulletin No. 4558. Perth, Western Australia.

Water and Rivers Commission (1999) *Revegetation: Revegetating Riparian Zones in South-west Western Australia.* Water and Rivers Commission River Restoration Report No. RR4.

Water and Rivers Commission Water Note 22, *Herbicide Use in Wetlands.*

Water and Rivers Commission Water Note 15, *Weeds in Waterways.*

Water and Rivers Commission Water Note 25, *Effects and Management of Deciduous Trees on Waterways.*

Feral animal control

Rabbits, foxes and wild pigs were evident throughout the catchment, particularly in the rural and state forest areas of the middle and upper catchment. Wild Pigs severely damage native vegetation, hindering regeneration and revegetation, and can cause localised erosion. Landholders and managers are encouraged to control feral animals through baiting, shooting, fumigation and destruction of warrens.

Currently the Department of Agriculture and Food are doing trials on baiting wild pigs, this may be an option to farmers in the near future. At this point in time, the Department of Agriculture and Food are assisting farmers along the Brunswick River in trapping the pigs, by providing traps and disposing of the pigs when caught.

The value to native fauna of vegetated corridors along the rivers is undermined by the presence of foxes. Large numbers of landholders were concerned that foxes preyed on native fauna which has limited habitat options in the area. Baiting and shooting can control foxes. The Department of Agriculture and Food has an on-going fox control program for local landholders.

Fire Hazard

The information below was taken from the Vasse River Action Plan (Geocatch 2000) by Margaret Scott but is equally applicable for the Brunswick River Action Plan.

While a balance has yet to be struck between burning for fire protection and maintaining bush for habitat and species conservation, some general principles are well recognised.

Frequent burning of bush denies most plants the opportunity to reach maturity, seed and continue the species. Many plants need five to seven years or more to produce their first seeds. Consequently, the most resilient species (usually trees) survive, but even these are seldom replaced by young seedlings in a regime of
annual burns.

Any reduction of the understorey, or disturbance of the leaf litter mulch below trees and shrubs, allows weed invasion. Weeds out-compete most native species and annual burning promotes their seeding. With an understorey of flash fuels like wild oats, lovegrass or veldt grass, roadsides, reserves and drains catch fire easily, burning fiercely and spreading quickly.

For more information on fire management contact the Department of Environment and Conservation.

7. Implementation

Implementation of Management Techniques on the Brunswick River: Restoration Case Studies

Learnings, hurdles and successes of implementing on-ground works

As part of the funding for developing the River Action Plan Project, between 2005 and 2006 monies were allocated to delivering on-ground works.

These on-ground activities that were to be funded under a cost-sharing arrangement with landholders included;

- Fencing (up to the value of $2500/km)
- Erosion control
- Revegetation – providing native plants
- Weed Control

Below are some of the learnings, hurdles and successes experienced in implementing on-ground works along the Brunswick River. These experiences will hopefully help others to learn from past mistakes and build on the successes of this project.

Choosing Sites – The Best Bits First

Using the steps outlined in Chapter 5, it was determined to aim the funding in areas of higher foreshore condition. 'A' grade condition was only found in Reach 3 and 4 in the Department of Environment and Conservation forest areas, 'B' class condition was scattered through-out the Reaches, whilst 'C' & 'D' grade dominated Reaches 2 and 3. Below is a summary of the on-ground works carried out in each Reach.

Successes

Reach One

Project/ Activity	Location/Name	Description of Activity
1	Paris Rd Bridge Restoration Site	This site was chosen due to its B3-C1 classification and thus had a good chance of repair. It is also a highly visual site, with easy public access. Weed control was carried out at this site to control the annual grasses (especially couch) and blackberry in the area. Approximately 1000 natives were planted at this site, along with a number of sedges and rushes at the small wetland. Weed management at this site will be required for the next 3 years. As the foreshore downstream of this site is B3, it would be beneficial to continue the revegetation project along the river as there is great potential for this entire area to be restored. If a diverse range of plants are used in the revegetation programs, there is also potential for this area to become a wildlife corridor. This area is managed by Shire of Harvey and zoned public open space.
2	Galway Greenies	This group does weed maintenance and revegetation along the foreshore in the Galway Green Estate. A similar group is set to start up at the Kingston Estate.
3	Foreshore Management Plans for New Residential Developments	In the new residential developments in the area, the Developers are required to manage the foreshores for the next two years. The developments have Foreshore Management Plans which include weed control and revegetation programs. These foreshores may need maintenance in the future.

Reach One (continued)

Project/ activity	Location/name	Description of activity
4	Clean Site Demonstration Day	Due to the high number of new developments and thus building sites along this Reach, Leschenault Catchment Council (LCC) funded a Clean Site Demonstration Day. The South West Regional College of TAFE's Bunbury, ecoHOME team joined with LCC to provide on site sustainability training for the building industry. Local Builders and developers were invited to learn ways to reduce erosion and control sediment on building sites and protect our waterways.

Reach Two

Project/ activity	Location/name	Description of activity
5	Fencing along three sites along Reach Two	As this reach consists mostly of C&D class foreshore, the priority along this Reach was to fence the river to exclude stock from accessing the forshore. Three Farmers agreed to fence, one farmer directly on the Brunswick River, the other two farmers are on tributaries of the Brunswick. 2km of foreshore was fenced.
6	Brunswick Junction Restoration Site	Downstream of the South West Hwy bridge in Brunswick is a restoration site that was established in 2001 and managed by the Department of Water (then Water and Rivers Commission). This site has had extensive restoration works done over the past few years on the left bank (facing downstream). Funding from this RAP was used to extend this restoration site to include the right bank. Weed control was carried out, along with the planting of 500 trees.
7	Brunswick River Restoration	The Brunswick River Restoration Action Group was formed at the RAP Workshop held in May 2006. Weed control was conducted along the foreshore Action Group between Australind Bypass and Brunswick Junction. This group of community (BRRAG)representatives will work together to help restore the Brunswick River. For further details on the group contact 9726 1087.

Reach Three

Project/ activity	Location/name	Description of activity
8	Easton Property Restoration Site	This site was chosen as a restoration site because it had; good overstorey cover and a good chance of repair, minimal erosion problems and most importantly, the landholders were keen and willing to carry out maintenance of the site in the future. At this site fig trees were of main concern, so they were eradicated along with blue morning glory Once these weeds were controlled, the cleared area under the Flooded gums and Peppermints were planted out with native shrubs, sedges and rushes. A total of 500 plants were planted in this area. This site will require further plantings and weed control over the next few years, to which the landholders have committed.

Reach Four

Project/ activity	Location/name	Description of activity
9	Beela Dam	Beela Dam is currently managed by Water Corporation. Prompted by the results of the RAP, Blackberry control was carried out in 2006. They have verbally committed to the ongoing management.
10	DEC State Forest	State Forest within Reach 4 is managed by Department of Environment and Conservation (DEC). Within the State Forest much of the foreshore is 'A' grade. Weeds being the only concern in this area, DEC have a weed control program in place. For more information contact Collie DEC office on 9725 4300.

Hurdles and Challenges

While the above tables identifies some of the successes of the Project, work in other priority areas was not achieved due the following reasons.

Getting Farmers to Fence

The land use along reaches 2 and 3 is dominated by agricultural land, mainly beef grazing. These reaches are also the most degraded in terms of erosion of the river banks. The priority for these reaches is to fence out stock. While some landholders have fenced part of the river, it was difficult to get remaining landholders to commit to fencing due to a number of concerns which included;

- Fencing the river would cause a weed issue along the riverbanks and lead to a major fire hazard.
- Stock would not have easy access to water. Off river stock watering points which involve pumping from the river require ongoing maintenance and can break down easily.
- Too much of their grazing land would be lost by fencing off the river.
- The maintenance of river fencing too costly, as they are susceptible to damage in times of flood.
- The incentive of $2500/km was too low for it to be a financially viable option.

Time and resource constraints when dealing with erosion control techniques

Much of the Brunswick River requires extensive erosion control works. However, in order to carry out such works a number of important steps are required;

- Consultation with an engineer from the Department of Water may be needed to ensure that the erosion control techniques will be successful. A engineering survey may also be required.
- Permits are required before carrying out such works, such as a permit for "interfering with bed and banks" under the *Right in Water and Irrigation Act 1914* or *Under the Aboriginal Heritage Act 1972*, the Department of Indigenous Affairs should be contacted to see if the site is registered. For a more extensive list of permits required, see Appendix 8.
- The works must be carried out in summer when the river is at its lowest and the banks are dry and easy to work on.

These steps can be time consuming. Thus, within a one year project it is extremely difficult to carry out a successful erosion control program.

Time is not the only constraint in carrying out erosion control works; it can also be extremely costly, and as such needs to be budgeted appropriately.

Learnings

Below are four points to remember when implementing on-ground works;

- Where possible the first work should be on the high grade foreshore the "best bits".
- Plan ahead, ensure you have the time and resources required to make the project successful. See Appendix 5 for a Landcare Project Timeline.
- Work with the willing, as they will ensure the work is successful into the future
- Try to allocate funding for maintenance and evaluation. It is essential to monitor and evaluate the works carried out, in order to check progress against objectives and learn from the experience.

"Never doubt that a handful of committed people can change the world. Indeed it is the only thing that ever has"

Margaret Mead

8. References

AGMAPS (2005) Land Manager for the Shires of Serpentine-Jarrahdale, Kwinana, Rockingham, Mandurah, Murray, Boddington, Waroona and Harvey, Department of Agriculture.

Bradley, J. (1988) Bringing Back the Bush: *The Bradley Method of Bush Regeneration*. Lansdowne Press, Sydney.

Brown, K. & Brooks, K. (2002) *Bushland Weeds: A Practical Guide to their Management with Case Studies from the Swan Coastal Plain and Beyond*. Environmental Weeds Action Network, Greenwood, Western Australia.

Buchanan, R.A. (1989) *Bush Regeneration: Recovering Australian Landscapes*. TAFE Open Training and Education Network, Strathfield, NSW.

Cape to Cape Catchments Group (2005) *River Action Plan for Ellen Brook*, Department of Water.

Cape to Cape Catchments Group (2004) *Cape to Cape Landcare Companion*. CCCG, National Heritage Trust, Margaret River, WA.

Connell, S., Franke, B. & Alder, J. (2000a) *Remnant Vegetation Strategy for the Geographe Catchment*. Busselton, Western Australia.

Connell, S., Franke, B. & Alder, J. (2000b) *Remnant Vegetation Handbook for the Geographe Catchment*. Busselton, Western Australia.

Department of Agriculture (1999) *Wetlands not Weedlands*. Weed Note No. 1/99, Department of Agriculture, Perth, Western Australia.

Department of Agriculture (2002) *Declared Plants Handbook: Recommendations for the Control of Declared Plants in Western Australia*. Department of Agriculture, Perth, Western Australia.

Department of Water (2005), *Environment Assessment Report for Worsley Alumina Refinery*, Western Australia.

Dixon, B. & Keighery, G. (1995) 'Suggested methods to control weeds'. In: *Managing Perth's Bushlands*, Scheltema, M. & Harris, J. (eds). Greening Western Australia, Perth, WA.

Donohue, R, Parsons, G and Deeley, D (1994); *Estimated Annual Loads of Nutrients to the Leschenault Estuary*, 1984-1992, Report No. 47, Waterways Commission.

GeoCatch (1999) *Capel River Action Plan*. Water and Rivers Commission, East Perth, Western Australia.

GeoCatch (2000) *Vasse River Action Plan*. Water and Rivers Commission. East Perth, Western Australia.

GeoCatch (2002) *River Action Plan for the Sabina, Abba and Ludlow Rivers*. Water and Rivers Commission, East Perth, Western Australia.

GeoCatch (2004) *Geographe Catchment Companion: A Practical Guide to Caring for Land and Water in the Geographe Bay Catchment*.

Geographe Catchment Council (2004) *Geographe Catchment Companion*.

Government of Western Australia (2003) *Securing our Water Future: A State Water Strategy for Western Australia. Perth, WA*.

Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. and Lloyd, S.G. (1997) *Western Weeds: A Guide to the Weeds of Western Australia*. Plant Protection Society of Western Australia. Victoria Park, Western Australia.

Hussey, B.M.J. & Wallace, K.J. (1993) *Managing Your Bushland*. Department of Conservation and Land Management, Como, Western Australia.

Hennessy, K.J. (2002) Australian rainfall trends. (webpage) retrieved 22/09/2003 from http://www.dar.csiro.au/publications/Hennessy_2000b.htm(.)

Kingdon, B.K. (2000) *Fertiliser Use Guidelines for the Swan Coastal Plain of WA*. Vasse-Wonnerup LCDC, Busselton, WA

Lavell, Summers and Weaver (2005), *Best Management Practices*, Department of Agriculture and Food, Western Australia (see Appendix 6).

McLaughlin, A and Jeevaraj, C, (1994) *The Brunswick River Flood Study Hydrology*, Water Authority of Western Australia Report No. WS137.

Moore, J. & Wheeler, J. (2002) *Southern Weeds and Their Control*. Department of Agriculture. Bulletin No. 4558. Perth, Western Australia.

Morgan, D & Beatty, S (2006), *Fish and freshwater crayfish communities of the Brunswick and Preston Rivers*, Murdoch University.

Pen,L.J. & Scott, M. (1995) *Stream Foreshore Assessment in Farming Areas*. Blackwood Catchment Coordinating Group, Western Australia.

Pen, L.J. (1999) *Managing Our Rivers*. Water and Rivers Commission, East Perth, Western Australia.

Prosser, I., Karssies, L., Ogden, R. & Hairsine, P. (1999) *'Using buffers to reduce sediment and nutrient delivery to streams'. In: Riparian Land Management Technical Guidelines: Volume Two: On-ground Management Tools and Techniques*, Price, P. & Lovett, S. (eds). LWRRDC, Canberra.

Raine, A.W. & Gardiner, J.N. (1995) *Rivercare — Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation*. Land and Water Resources Research and Development Corporation, Canberra.

Rose, T (2004) Draft Interim Environmental Guidance Position Background Paper, *The Brunswick River: Considerations For Assessing Small Scale Water Extractions And Possible Effects On The River And Lower Collie*, Aquatic Sciences Branch DOE.

Scheltema, M. (1993) *Direct Seeding of Trees and Shrubs. Greening Western Australia*, Perth.

Sinden, J., Jones, R., Hesten, S., Odom, D., Kalisch, C., James, R. and Cacho, O. (2004) *The Economic Impact of weeds in Australia: Report to the CRC for Weed Management. CRC for Australian Weed Management Technical Series No.8*. CRC for Australian Weed Management, University of Adelaide, South Australia.

Stanley, B (1999), *When Blue was True, A brief History of the Brunswick Area*, Bunbury Western Australia.

Water and Rivers Commission (1999) *Revegetation: Revegetating Riparian Zones in South-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR4.

Water and Rivers Commission (1999) *Using Rushes and Sedges in Revegetation of Wetland Areas in the South West of WA*. Water and Rivers Commission River Restoration Report No. RR8.

Water and Rivers Commission (2001) *Brunswick Catchment Area Water Source Protection Plan*, Water and Rivers Commission, Water Resource Protection Series No WRP 39.

Water and Rivers Commission (2001) *Stream Stabilisation*. River Restoration Report No. RR 10.

Western Australian Water Resources Council. Perth (1992) *The State of the Rivers of the South West*, Publication No. WRC2/92.

Water and Rivers Commission Water Notes

Water and Rivers Commission Water Note 6, *Livestock Management: Construction of Livestock Crossings.*

Water and Rivers Commission Water Note 7, *Livestock Management: Watering Points and Pumps.*

Water and Rivers Commission Water Note 15, *Weeds in Waterways.*

Water and Rivers Commission Water Note 18, *Livestock Management: Fence Location and Grazing Control.*

Water and Rivers Commission Water Note 19, *Flood Proofing Fencing for waterways.*

Water and Rivers Commission Water Note 20; *Rushes and Sedges.*

Water and Rivers Commission Water Note 22, *Herbicide Use in Wetlands.*

Water and Rivers Commission Water Note 25, *Effects and Management of Deciduous Trees on Waterways.*

Appendix 1. Native vegetation of the Brunswick River Catchment

This information was supplied by Shirley Fisher of the Leschenault Community Nursery

Trees and large shrubs

Scientific name	Common name	Characteristics
Acacia saligna		Large shrub
Agonis flexuosa	Peppermint	
Agonis linearifolia (taxandria)		Shrub wet feet
Aginis juniperina (taxandria)		Wet feet
Agonis parviceps (taxandria)		Shrub wet feet
Banksia litoralis and *seminuda*		River banksias wet feet
Casuarina obesa	River sheoak	Salt tolerant wet feet
Calystachus lanceolata	wonnich	Shrub pea flower wet feet
Euc. Calophylla (Corymbia)	marri	Drier ground
Euc. rudis	Flooded gum	Wet feet
Euc. Megacarpa and *Patens*	Bullich/blackbutt	Need river loam
Euc. Wandoo (higher ground)	wandoo	Drier ground
Grevillea diversifolia	Valley grevillea	Shrub
Hakea lassianthoides		Open small tree
Kunzea ericifolia	spearwood	Shrub in winter wet sands
Melaleuca preisiana	Paperbark	Large tree wet feet
Melaleuca viminea and uncinata	mohan	
Oxylobium lineare	River pea	Wet feet
Paraserithianthes lophantha	Albizia	Wet feet

Shrubs under 3m

Scientific name	Common name
Acacia alata, wildoweniana	Strappy wattles
Acacia extensa, pulchella, dentifera, urophylla	Wiry wattle
Astartia fascicularis	River myrtle
Chorizema cordata/illicifolia	
Hakea varia	
Hovea elliptica	Tree hovea
Kunzea rostrata, recurva, micromera	
Mel. Incana, lateritia	Grey melaleuca/robin redbreast
Pericalymma ellipticum	
Regelia cilliata	
Viminaria juncea	Swish bush

Creepers and ground cover

Scientific name	Common name
Hardenbergia comptoniana	Native wisteria
Kennedia prostrata	Running postman
Clematis pubescens/microphylla	Clematis
Chorizema diversifolia	Yellow pea
Brachysema praemorsa	

Sedges and monocots

Scientific name	Common name
Baumea articulatum/rubignosa/juncea	Jointed twigrush
Bolboschoenus caldwellii	
Carex appressa	Carex
Dianella revoluta	Dianella blue flowers
Gahnia trifida	
Isolepis nodosa	Knotted club rush
Juncus krausii/pallidus/sub secundus	Sea rush
Lepidospermum effusus	Coastal sword sedge
Leptocarpus diffusus	
Orthrosanthus laxus	Morning iris
Pattersonia occidentalis	Native iris

Appendix 2. Common weeds found in the study area

Name	Common name
**Agapanthus praecox*	Agapanthus
**Amaryllis belladonna*	Easter lily
**Ammophila arenaria*	Marram grass
**Anagalis avensis*	Pimpernel
**Arctotheca calendula*	Capeweed
**Arundo donax*	Giant reed
**Asparagus asparagoides*	Bridal creeper
**Avena barbata*	Bearded oat
**Brassica tournefortii*	Mediterranean turnip
**Briza maxima*	Blowfly grass
**Briza minor*	Shivery grass
**Bromus* spp.	Brome grass
**Cakile maritima*	Sea rocket
**Carduus* spp.	Scotch thistle
**Cerastium glomeratum*	Mouse ears
**Conyza albida*	Fleabane
**Crepis* spp.	Hawksbeard
**Cynodon dactylon* var. *dactylon*	Couch grass
**Cyperus* spp.	
**Ehrharta longiflora*	Annual veldt grass
**Ehrharta villosa*	Pip grass
**Emex australis*	Doublegee
**Erythrina sykesii*	Coral tree
**Euphorbia paralias*	Sea spurge
**Euphorbia peplus*	Petty spurge
**Euphorbia terracina*	Geraldton carnation weed
**Ficus carica*	Edible fig
**Gladiolus undulatus*	Wavy gladioli
**Hedera helix*	Ivy
**Holcus lanatus*	Yorkshire fog
**Hordeum* spp.	Barley grass
**Hypochaeris glabra*	Flatweed
**Isolepis prolifera*	Budding club rush
**Juncus articulatus*	Jointed rush
**Juncus microcephalus*	
**Lagarus ovatus*	Hare tail grass
**Leptospermum laevigatum*	Victorian tea tree
**Lolium perenne*	Perennial rye grass

Name	Common name
**Lotus* spp.	Lotus
**Mentha diemenica*	Garden mint
**Mentha pulegium*	Pennyroyal
**Modiola caroliniana*	Red flowered mallow
**Monadenia bracteata*	South African orchid
**Morus nigra*	Mulberry
**Olea europa*	Olive
**Orbanche minor*	Lesser broomrape
**Oxalis pes-caprae*	Soursob
**Oxalis purpurea*	Mauve oxalis
**Paspalum dilatatum*	Paspalum
**Passiflora edulis*	Passionfruit
**Pelargonium capitatum*	Rose pelargonium
**Pennisetum clandestinum*	Kikuyu
**Petrorhagia velutina*	Velvet pink
**Phalaris aquatica*	Canary grass
**Physalis minima*	Chinese gooseberry
**Pinus* spp.	Pine tree
**Plantago lanceolata*	Ribwort plantain
**Psuedognaphalium luteoalbum*	Jersey cudweed
**Ranunculus muricatus*	
**Raphanus raphanistrum*	Wild radish
**Romulea rosea*	Guilford grass
**Rorippa nasturtium-aquaticum*	Watercress
**Rubus* spp.	Blackberry
**Rumex* spp.	Dock
**Samolus valerandi*	Water pimpernel
**Senecio elegans*	Purple groundsel
**Silene gallica* var. *gallica*	Silene
**Solanum linnaeanum*	Apple of Sodom
**Solanum nigrum*	Nightshade
**Sparaxis bulbifera*	Freesia
**Stellaria media*	Chickweed
**Stenotaphrum secondatum*	Buffalo grass
**Tetragonia decumbens*	Sea spinach
**Trifolium* spp.	Clover
**Vinca major*	Vinca
**Vitus* sp.	Grape
**Watsonia meriana*	Watsonia
**Zantedeschia aethiopica*	Arum lily

Appendix 3. Planning advice from the Vasse River Action Plan

The following planning advice is taken from the Vasse River Action Plan and was prepared by Marg Scott and Jenny Dewing (GeoCatch, 2003).

Planning a project

Write down your objectives:

- What work will be done?
- Who will do the work?
- What will the work achieve?
- Who and what will benefit from the work?

A written list of objectives:

- helps planners to stay within the goals;
- encourages recruitment of volunteers;
- helps volunteers to understand their roles; and
- provides benchmarks of progress and success.

Site selection:

- Choose a workable-sized site, small enough to complete the job.
- Select a site within easy travelling distance for volunteers.
- Favour a site which enables the volunteers, and if possible the general public, to view their achievements.

Organising a planning committee:

- Select a diverse group of people with various skills and interests.
- Choose leaders in the community.
- Draw on different groups of people within the community.
- Identify those people with supervising and planning skills.
- Enlist the local media to contribute their support.

Planning creek rehabilitation

Planning a revegetation project should commence in the year preceding the proposed planting or seeding and include researching the best revegetation approach.

Issues to be addressed include:

- the design of remedial work on the banks;
- the selection of suitable plant species;
- how to propagate (by green stock or direct seeding);
- where to obtain seed;
- who to get to propagate the seed;
- the position and design of fencing;
- identifying likely weed problems, developing a weed action plan; and
- where to access funds if you intend applying for a grant.

It is essential to study the project site thoroughly. A thorough site survey will provide an inventory of assets such as:

- existing indigenous vegetation;
- plants that are naturally regenerating;
- seed sources;
- potential problems, for example, rabbit activity, weed infestations, eroding banks, areas of sedimentation.

The survey may result in the decision to manage the area to encourage natural regeneration rather than to restore the native vegetation by planting or direct seeding.

A survey can also be used for monitoring the effectiveness of a particular management activity over time.

Bank erosion and/or sedimentation may require remedial action prior to revegetation. Advice should be sought from the Department of Water.

When to survey

Late autumn to early winter is a good time to survey when weed problems are apparent. Impacts of river activity can be easily seen – sections of eroding or slumping banks, and areas where sediment is being deposited. Later in winter, a survey of the river or stream in full flow is more likely to reveal the behaviour of the river rather than its impact.

What's growing on the creek or river bank

A list of existing native vegetation is useful for identifying suitable plant species for revegetation and potential populations of plants for obtaining seed. It is important to establish the position on the stream bank that each plant occupies and the type of soil in which it grows – sand, clay, loam etc.

Native plants are easier to identify when flowering. While different species flower in different seasons throughout the year, the peak season is spring. Fringing species flower later to coincide with falling water levels. They flower and produce seed after winter flooding, to complete their cycle before the next winter rains. It may take several visits from winter onwards to identify all plants.

In summer, flowering suites of plants go mostly unnoticed as they flower when few people are walking and looking. Some of these include Astartea fasicularis (a tea tree), *Taxandria linearfolia* (swamp peppermint) and Banksia littoralis (swamp Banksia).

There is a slightly different community of plants growing along the banks of each local creek. These variations reflect the topographical features of the landscape and the soil types unique to that site.

It is not difficult to compile a list of plants specific to a site. The revegetation is then tailored to suit local insects, reptiles, frogs, birds and small mammals, and looks similar to existing remnant vegetation.

Identifying plants

Native rushes and sedges are difficult for untrained people to identify, and are often excluded from revegetation plant lists. The easiest way to identify them is to collect samples, including the base of the plant, and compare them with specimens in the regional or state herbarium. Generally perennial grasses, including spear, wallaby and kangaroo grasses, flower from late spring to summer. Rushes flower at the same time, while sedges flower from late spring through to autumn, depending on the species. These are important plants that help to hold the bank together, acting as 'foot soldiers' to the trees.

Where most understorey plants have been lost through clearing and grazing, selecting a vegetated site nearby with similar soil type and topography will assist in compiling a species list to use.

The Department of Environment and Conservation (formerly Department of Conservation and Land Management (DCLM)) publication *How to Create a Local Herbarium* is recommended for landholders who wish to collect and preserve their own set of field specimens.

Appendix 4. Permits Required Prior to Commencing Works in Rivers

This information was provided by Department of Water.

1. The riverbed and banks, which proposed works would affect, are located in a corridor of Crown Land. In order to undertake any work on this land, permission must be sought from and provided in writing by the Department of Planning and Infrastructure (i.e. the landowner). Permission should be requested by sending a letter to the address given below, detailing the proposed works and the reasons for carrying out these works:

Department of Planning and Infrastructure
Land Asset Management Services
9th Floor, Bunbury Tower
61 Victoria Street
Bunbury WA 6230

2. Under the *Rights in Water and Irrigation Act 1914* a permit to "interfering with bed and banks" must be obtained prior to undertaking work in a proclaimed waterway. This permit is applied for by completing and submitting a Form H, which can be obtained from:

Department of Water
South West Region
PO Box 261
Bunbury
WA 6231
08 9726 4111

3. Under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* a permit for "clearing of native vegetation" may be required for these works. It is only required if areas of native vegetation are to be cleared in addition to that affected by the proposed works (e.g. clearing required to gain access to the site or to stockpile materials). This permit is applied for by completing and submitting a Form C1, which can be obtained from:

Department of Environment and Conservation
North Boyanup Rd
Bunbury
WA 6230
08 9725 4300

4. There are several other legal issues that may arise under the *Aboriginal Heritage Act 1972* and *Native Title Act 1993*:

   - Under the *Aboriginal Heritage Act 1972*, the Department of Indigenous Affairs should be contacted to:

     1. Advise them of the proposed project.
     2. Identify if your project is going to affect a registered Aboriginal site, and of so:
     3. Request the names and contact details for the relevant Aboriginal people for consultation purposes.

   - Under the *Native Title Act 1993*, the Department of Land Administration should be contacted to determine if the project area is subject to a native title claim. If there is a claim, the Department of Land Administration will be able to provide contact details of the claimants, as consultation with representatives from the Native Title Claimant groups will be required.

Appendix 5. Landcare Project Time Line Template

This information was provided by the Peel Harvey Catchment Council.

This is a suggested plan for landcare projects in the region. Each specific site may have different problems and challenges. Climatic variations each season may affect the timing of some actions.

August	• Plan your landcare project. • Apply for funding assistance.
September to October	• Control weeds with Glyphosate spray. This early spray is important especially if couch or kikuyu are present. • Early fencing and spraying may discourage kangaroos from visiting the site and reduce damage when the seedlings are planted.
November to December	• Order seedlings from your preferred nursery. Early orders usually receive a discount so check the early order closing dates. • Control grasshoppers in the area by spraying or using bran baits. Check the high sandy areas for early hatchings and spray before the grasshoppers start to move.
January to February	• Plan your tree lines to follow the contours to prevent erosion. • Deep rip tree lines (minimum of 3 rows) to a depth of at least 50 – 70cm. Rows should be about 3m apart to allow for vehicle access while spraying and planting. • Monitor previous year's projects for pests and weeds. • Poison rabbits and rip warrens.
March to April	• Disc or rotary hoe along rip lines to help break up the soil and weeds. This will ensure a better-formed mound especially on clay sites or if there is a lot of persistent weeds like couch or kikuyu. • Fence off the project area before mounding the site to restrict access, as cattle will destroy unprotected mounds. • After the first rains mound along the rip lines in most soils. The mounds are essential in low-lying waterlogged areas but also provide a good growing environment for the seedlings in the higher areas. On deep sand sites it is better to furrow along the rip line to direct water to the roots which will improve survival rates.
May	• Good weed control is vital. Spray the weeds along the mounds/furrows. The use of a Glyphosate and Simazine mix has been found to give better weed control. (Glyphosate is a knockdown herbicide that kills on contact and Simazine is a residual chemical that will stop weeds germinating through winter and spring.) • Allow at least 2 weeks before planting out seedlings.3
June to July	• Plant seedlings, 2 – 3m apart and a mix of trees and shrub or you can make a more effective windbreak by planting one row of shrubs, then a row of tall shrubs and smaller trees and then a row of larger trees. • Monitor for pests – rabbits, kangaroos, ducks and black beetle to name a few. • Use tree guards if necessary. • Return your trays to the nurseries.
August to September	• Monitor weed growth – spot spraying may be necessary if initial weed control was not done properly. • Start planning for next year!!!!

Appendix 6. Best Management Practice (BMP)

Best Management Practice – 4.0 Water Management

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Definition

Management of important on-farm issues such as, erosion, nutrient inputs, vegetation, grazing and water sources, are all part of an integrated water quality management plan. This approach will have a greater cumulative effect than any one of these strategies used individually.

Description

The Western Australian dairy industry relies on a constant supply of fresh water for irrigation and stock watering. For this reason, production is usually located close to ground and surface water resources.

A major objective of this fact sheet is to maintain the high quality water resources that exist in most of Western Australia's dairy farming areas. These resources invariably have current or potential value for uses other than dairying.

Wetlands have nature conservation values. Dams on streams need to have 'environmental flows', that is, sufficient flowing water to maintain the natural biodiversity in the water and on the banks. Fresh groundwater aquifers may be required for potable water supplies in the future. Many estuaries are used for recreation and tourism activities and fisheries. The water quality of these resources must be maintained at levels suitable for all current and potential uses.

Pollution of water resources by agricultural nutrients and chemicals are major issues for the industry. Excessive levels of phosphorus and nitrogen can cause algal blooms in surface water during summer. Groundwater may be contaminated if management fails to prevent the downward leaching of fertilisers. In some parts of Europe and the USA, agricultural activities are regulated because groundwater aquifers have become so badly polluted by nitrates from fertilisers and by the chemical atrazine that they are unfit for human consumption.

Whilst the impact on stream water quality and health is enormous, of equal importance is the impact of poor water quality on the health and happiness of both livestock and people in the community.

By following the water management practices discussed below, the expected environmental outcomes include:

- Water resource quality is maintained at levels acceptable for all of its beneficial existing and potential uses.
- Fertilisers and chemicals used for dairying do not pollute water resources.
- Stability and character of waterways are maintained and where possible enhanced.

Implementation

The first and most desirable strategy for erosion control is to prevent erosion and the subsequent transport of the sediment. Erosion management addresses sheet and rill erosion, wind erosion, stream bank erosion and erosion from construction and irrigation sites. Erosion and sediment control systems can and should be designed to protect against contaminating surface and ground water.

Erosion Management

Useful tools for erosion management;

- *Conservation*

Developing perennial cover will protect soil and water resources. Growing crops of grasses, legumes, or small grain will provide seasonal protection and soil improvement. Maintaining at least 30 percent soil surface cover by residue after planting will reduce soil erosion by water. Planting vegetation on high risk areas will help reduce erosion. Growing windbreaks will reduce wind erosion.

- *Contour farming*

Farming sloping land on the contour will help stop erosion and reduce sediment and nutrient flow. This includes following established grades of terraces or diversions. Growing crops in an arrangement of strips or bands on the contour also reduces water erosion.

- *Water management structures*

Developing grassed waterways, whether natural or constructed for the stable conveyance of runoff. Planting a strip or area of vegetation for removing pollutants from runoff will reduce the amount of sediment reaching the waterways. Building grade stabilization structures and basins to collect and store debris or sediment will reduce sediment loss. Building sediment traps and water detention basins will also reduce the effects of erosion.

Nutrient Management

Nutrient management focuses on preventing nutrient loss. Efficient fertiliser use through nutrient management is important. Carefully planning nutrient applications is the key to controlling nutrient runoff.

Useful tools in nutrient management.

- *Testing*

Using soil surveys will help to identify nutrient loss sites. Soil testing for nutrients and plant leaf analysis helps identify the correct nutrient for each location and provides information on the right quantity to be applied.

- *Nutrient Inputs*

Using proper timing, formulation, and application methods for nutrients will maximise utilization and minimise loss. Split applications and banding of the nutrients, use of nitrification inhibitors and slow-release fertilizers will all help control nutrient loss. Use of gypsum instead of super phosphate as a sulphur source will help reduce the amount of phosphorous from either leaching into the soil or entering the waterways.

- *Buffer areas*

Use buffer areas around high-risk areas such as; land near surface water, areas at high risk of erosion or leaching soils and any irrigated land, to prevent nutrients entering the water flow or the water table. Buffer zones should include vegetation to filter nutrients.

- *Engineered water structures*

Developing grassed waterways, whether natural or constructed will help runoff control. Building grade stabilization structures and basins to collect and store debris or sediment will allow for nutrients to settle out. Building sediment traps and water detention basins will also reduce nutrient loss.

Vegetation management

Native vegetation intercepts rainfall and prevents rain splash erosion and also reduces gully, rill and sheet erosion by slowing runoff and binding soil together with root matter. It can take up nutrients and can be used in buffer strips for streams and surrounding nutrient intensive developments. Vegetation also acts to slow and filter sediment from runoff.

The following practices can be used.

- Plantings

Planting deep rooted perennials like lucerne and grasses to prevent erosion will reduce nutrient runoff. Plant local native vegetation in buffer zones surrounding intensive nutrient use to capture runoff and filter nutrient concentrations.

- *Remnant vegetation management*

Managing stands of remnant vegetation on paddocks, riparian areas and recreation and wildlife areas by biological means or by prescribed burning will ensure a vigorous stand and thereby reduce nutrient concentrations in runoff.

- *Fencing*

Fencing areas of good quality remnant vegetation and riparian zones will ensure these areas are protected from the pressures of grazing stopping erosion and direct animal manure input.

Grazing management

Appropriate grazing management adjusts grazing intensity to reflect the available feed for livestock, and controls animal movement around paddocks. This ensures enough live vegetation and litter cover to protect the soil from erosion during winter and will protect riparian areas.

The focus of nutrient and sediment loss management is on the riparian zone. Erosion control from pastures and other grazing lands above wetland areas is vital. The key

options to consider when planning a grazing management approach for a sensitive location, such as stream banks, wetlands, estuaries, and riparian zones include:

- Limit livestock access, best management practice is to exclude livestock. Grazing should only be considered in extreme situations;
- Providing stream crossings or hardened watering access for drinking;
- Providing alternative drinking water locations;
- Locating additional shade, if needed, away from sensitive areas;
- Reducing the physical disturbance and reduce direct input of animal waste and sediment caused by livestock.

Available information shows that

(1) aquatic habitat conditions are improved with proper livestock management;

(2) pollution from livestock is decreased by reducing the amount of time spent in the stream through the provision of supplemental water; and

(3) sediment delivery is reduced through the proper use of vegetation, stream bank protection and planned grazing.

Water source management

Providing alternative water sources away from streams will help keep livestock away from sensitive stream banks and riparian zones. The establishment of alternate water supplies for livestock is an essential component of sediment and nutrient loss management.

Providing water can be accomplished through the following practices.

- *Pipelines*

Piping water to watering points away from streams decreases sediment and nutrient pollution from livestock. This will prevent bank destruction with resulting sedimentation, and will reduce animal waste directly entering the water.

- *Fencing*

Fencing acts as a barrier to livestock. Preventing livestock from being in the water or walking down the banks improves water quality. Fencing will protect wetland areas and riparian zones acting as sediment traps and filters along water channels and impoundment.

A controlled crossing or watering access point for livestock will control bank and streambed erosion.

- *Constructed wetlands*

Building dams, sediment basins, extended storage ponds or restoring existing wetlands will trap nutrients and sediments. Wetlands reduce the amount of water that flows downstream from the catch

Landholders working together, helping each other to plan and implement strategies not only on a farm-by-farm basis but in a whole catchment effort is the philosophical basis of the approach.

Advantages

- Guarantees suitable water supplies will be available in the future for irrigation and stock watering.
- The quality of water resources are maintained and enhanced to preserve all environmental, social, economic and recreational values.
- Healthy waterways located on private properties increases the land value.

Reference

- Department of Agriculture. (no date). *Management strategies for nutrient and sediment loss in the Ellen Brook Catchment.* Department of Agriculture, Western Australia.

Appendix 7. Useful contacts and phone numbers

Leschenault Catchment Council
PO Box 21, Bunbury WA
Ph: (08) 9726 4111
Web: www.lechenaultcc.com

GeoCatch
72 Duchess St, Busselton
PO Box 269, Busselton, 6280
Ph: (08) 9781 0111
Fax: (08) 9754 4335
Email: geocatch@environment.wa.gov.au
Web: http://www.geocatch.asn.au

Department of Agriculture and Food (Bunbury)
North Boyanup Rd, Bunbury
Ph: (08) 9780 6100
Web: http://www.agric.wa.gov.au

Department of Water (Bunbury)
35-39 McCombe Rd, Bunbury
Ph: (08) 9726 4111
Web: http://www.water.wa.gov.au

Department of Environment and Conservation (Bunbury)
North Boyanup Rd, Bunbury
Ph: (08) 9725 4300
Web: http://www.naturebase.com.au

Ribbons of Blue (Leschenault)
c/o Department of Water
35-39 McCombe Rd, Bunbury
Ph: (08) 9726 4111

WA Museum
Perth Cultural Centre, James Street, Perth
Email: reception@museum.wa.gov.au
Web: http://www.museum.wa.gov.au