Carbunup River

Action Plan

2000

Soil and Land Conservation Council
Western Australia

Water and Rivers Commission

GeoCatch

Natural Heritage Trust

Carbunup River
Action Plan

2000

Prepared for Geographe Catchment Council - GeoCatch
and the Sussex Land Conservation District Committee

by
Community Environmental Management

Funded by the Natural Heritage Trust and GeoCatch

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How to use this River Action Plan

A brief overview of the Action Plan and its findings is contained in the Summary at the start of the document. A map accompanying the Summary shows the study area divided into sections which relate to the individual maps later used in Section 5.

The Introduction explains the aims and objectives of the study, how it came about, who was involved and how it was funded.

Section 2 then provides a detailed description of the area the Action Plan covers including the landscape, climate, vegetation, flora and fauna and cultural history. Additional components included in the report as a result of community interest are:

- heritage sites along the river;
- Aboriginal values;
- water quality data;
- fauna likely to be found in the area; and
- plant species along the river and in nearby reference areas.

Section 3 explains the approach used in the study, how the community was involved and the technical and scientific techniques that were applied.

The findings of the study are set out in Section 4 Management Issues.

This is followed in Section 5 by survey findings and management advice on how to address these issues. To make it as specific as possible the area has been divided into sections. There is a map associated with each section and advice on what can be done to improve that part of the river and its environment. The end of this section contains a schedule which assigns priorities to the work that needs to be done.

A number of recommendations, such as the use of fencing for stock control and revegetation with native species, are common to several sections. Advice on how to implement these strategies is provided in Section 6 Rehabilitation Techniques.

The foldout legend at the end of the document provides information to help in understanding the maps.

Acronyms

AAD	Aboriginal Affairs Department
AGWEST	Agriculture Western Australia
A-MR	Shire of Augusta-Margaret River
ATCV	Australian Trust for Conservation Volunteers
CALM	Department of Conservation and Land Management
DOLA	Department of Land Administration
GeoCatch	Geographe Catchment Council
GIS	Geographic Information System
LCDC	Land Conservation District Committee
LWD	Large Woody Debris
LWRRDC	Land & Water Resources Research and Development Corporation
NHT	Natural Heritage Trust
WRC	Water and Rivers Commission

Acknowledgments

The Carbunup River Action Plan is an initiative of the Sussex LCDC and GeoCatch. The project was funded by GeoCatch and the Natural Heritage Trust.

This is one of a series of Action Plans for the rivers of the Geographe catchment being undertaken by GeoCatch and local communities.

Dr Luke Pen kindly contributed information from previous reports to ensure the consistency of this River Action Plan with others produced in the region and elsewhere in the State. During his site visits he provided much constructive advice which has been included in the report.

Members of the Sussex LCDC provided ongoing input and support. In particular, Neil MacDonald, Ian Carter and Will Oldfield (Development Officer AGWEST) shared their detailed knowledge of the area and gave valued management advice. Elizabeth Andrew, who worked with the LCDC to guide the project, contributed valuable direction and had considerable input. Anthony Sutton, Claire Thorstensen, Ian Carter and Neil MacDonald provided editorial comment and input.

Important contributions included: Shirley Fisher (Bunbury Naturalists' Association) for floristic surveys and plant species identification; Greg Voigt for fauna likely to be found; Tim Shingles for identification of heritage sites; and Dirima Cuthbert for ethnographic research and consultation.

Paul Taylor of Pawl Productions provided fauna pictures and Brett Harrison of Banksia Environmental Mapping undertook mapping. Information has been included from the Geographe Bay Catchment Natural Resource Atlas.

Riparian management fact sheets produced by Land and Water Resources Research and Development Corporation (LWRRDC) were the source of valuable material on issues such as fencing and troughs. These fact sheets are available on the Internet at: http://www.lwrrdc.gov.au/newslets/riparian.htm.

Other fact sheets from the Water and Rivers Commission (WRC) are available from GeoCatch or the Bunbury Office of the WRC.

Summary of content, issues and recommendations

This report provides an outline of the environmental issues identified in a survey of the Carbunup River foreshore and recommends appropriate management strategies.

The aim of the Carbunup River Action Plan is to improve local knowledge and guide rehabilitation works. It also serves as a tool to record the community's future restoration activities.

Considerable community input was obtained for the study, as well as professional technical advice.

Many opportunities have been identified for land managers to protect and enhance the river's health for the long term. Acting now will greatly improve the overall condition of the river and the quality of water travelling through its system.

The most prominent issues of concern along the Carbunup River are:

- erosion;
- lack of native vegetation; and
- weed infestation.

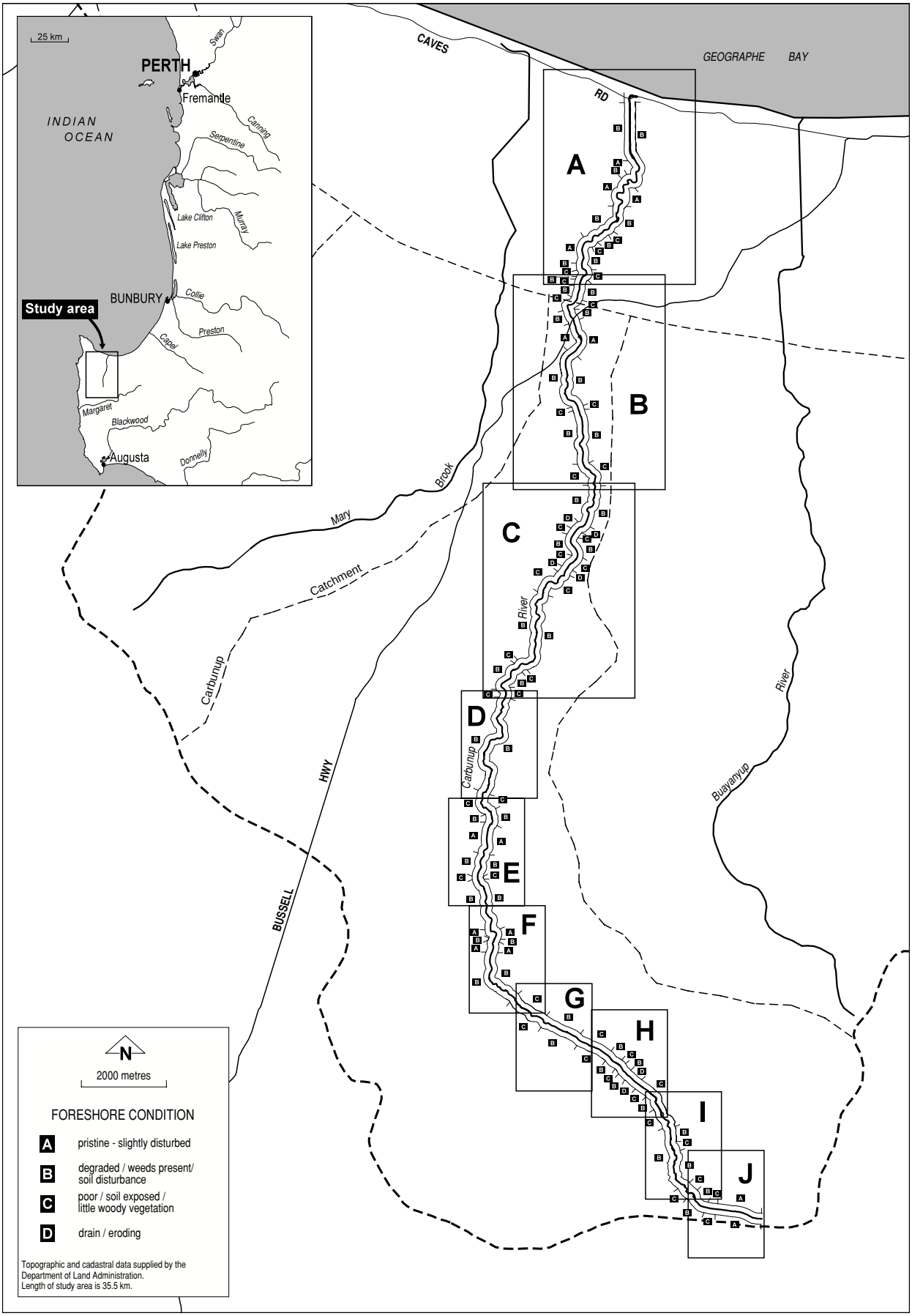
In response to these issues, general recommendations to improve the condition of the Carbunup River are to:

- increase the amount of fringing native vegetation;
- avoid further clearing of native vegetation and protect existing native vegetation;
- obtain environmental management advice and approvals prior to constructing dams or any other structures affecting watercourses;
- investigate formalising stock crossings and access to the foreshore where necessary;
- assist with constructing pools and riffles with on-ground advice and support;
- contain or eradicate weeds wherever possible;
- apply appropriate levels of fertiliser, recognising the retention capacity of soils;
- maintain groundcover where possible by appropriate stock management.

A summary of the foreshore condition ratings along the Carbunup River are shown in the table below and in Map 1, which illustrate that most of the river is in good condition (B). Less than half of the river requires stock access to the foreshore to be controlled

Table i: Summary of foreshore condition rating of the Carbunup River.

Condition Rating	West Bank			East Bank		
	Total Length km	Total Length %	Control of access recommended (eg. fencing) km	Total Length km	Total Length %	Control of access recommended (eg. fencing) km
A (pristine)	5.2	14.6	0.0	4.2	11.8	0.6
B (weedy)	21.7	61.1	10.4	21.9	61.7	8..2
C (erosion prone)	7.9	22.3	5.0	8.8	24.8	5.1
D (ditch)	0.7	2.0	0.5	0.6	1.7	0.3
Total	35.5	100.0	15.9	35.5	100.0	14.2



Map 1: Summary map.

Contents

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

1. Introduction

The Carbunup River Action Plan is a community project. People living along the river and within its vicinity contributed directly with information and, with appropriate technical advice, in preparing the resulting plan.

A living stream is a complex ecosystem supporting a wide range of plants, animals and land uses. It has stable, well-vegetated banks providing a wealth of habitats as it meanders through the landscape sharing its bio-filtering, life giving and picturesque features. The connectivity of a stream system demonstrates the relationships neighbours share with each other and the land.

A stream system and its catchment is recognised as the most appropriate level upon which to base management of the environment, because it is a natural landscape feature which influences much of the activity within its boundaries. A catchment is a drainage area bounded by the highest points in a landscape from which all run-off water flows to a common low point, such as the Carbunup River.

The activities at one end of the stream system and catchment are likely to have effects further down stream. Natural features such as waterways do not recognise the superficial boundaries that are imposed through land ownership; rather they reflect the truly interconnected relationships of our ecological systems that support life.

1.1 Aims and objectives

The Carbunup River Action Plan project is aimed at protecting and improving the long-term ecological condition of the river by providing a description of its present condition and prioritising actions to address riverine degradation.

It was an important aim of the project to involve landholders wherever possible.

This plan is intended to:

- provide a benchmark against which the local community's future work to protect and rehabilitate the river can be gauged;
- provide a tool to guide the limited resources available for weed control, erosion control, tree planting and rehabilitation; and
- provide a sound technical basis for future funding or project submissions.

1.2 Study area

Map 1 shows the area investigated, from the headwaters of the river in the Treeton State Forest to its mouth at Geographe Bay.

The area considered in the foreshore survey includes the channel embankments, the floodway and fringe vegetation. The land uses adjacent to the river were also considered in a discussion of suggested management actions.

1.3 Background to the study

A study of the Carbunup River began in 1997 when the Sussex LCDC worked with the Australian Trust for Conservation Volunteers (ATCV) to survey the condition of the river. This work produced a map rating the condition of the river on a scale of 'poor' to 'excellent' from Geographe Bay to near the boundary of the Busselton Shire[1]. Survey information was also collected for Island Brook.

This information showed that the river drained through an area of intensive agricultural land use with only minimal fringing vegetation along the foreshore.

[1] Three undergraduate university students, who investigated the application of Geographic Information Systems (GIS) to depict graphically the condition of the river foreshore subsequently compiled this survey data.

Much of the foreshore was unfenced, allowing uncontrolled stock access, and parts of the foreshore were degraded and in need of management.

Cooperation between GeoCatch and the Sussex LCDC provided the opportunity to standardise the existing survey information and expand the study to include the entire length of the Carbunup River.

NHT provided a grant through its National Rivercare programme, which has the goal: *To ensure progress towards the management, rehabilitation and conservation of rivers and improve the health of these river systems.*

It was agreed that the Carbunup River Action Plan would build upon the existing work done in the catchment and avoid unnecessary duplication. This was particularly important with regard to the previous survey work undertaken by the Sussex LCDC in 1997.

2. Description of the area

The Carbunup River is located in the Shire of Busselton in the South West of Western Australia. From its headwaters in the Treeton State Forest in the Shire of Augusta-Margaret River, it extends some 36 km to Geographe Bay. It drains in a northerly direction and is one of the major natural drainage systems of the Geographe catchment.

The river remains in a largely unmodified state. Only a small section at the mouth (about 1.6 km) has been channelised and maintained as a drain by the Water Corporation (R 40676).

The catchment area is approximately 170 km^2, of which approximately 55 % is cleared (Pen, 1999).

After leaving the forest, the river travels through agricultural land where a series of pools remain throughout the dry months. It crosses into the Shire of Busselton at Boundary Road and travels between the Bussell Highway to the west and Carbunup South Road to the east, before crossing Bussell Highway near the Carbunup Hall. It then continues north to cross Vasse-Yallingup Siding Road and Caves Road before emptying into Geographe Bay.

2.1 Landscape

The Carbunup River is located in the Leeuwin-Naturaliste area where it crosses two physiographic regions, the Swan Coastal Plain and the Blackwood Plateau. The Swan Coastal Plain is a flat to gently undulating plain formed on Quaternary marine, alluvial and aeolian sediments. It is a narrow strip of land (about 15 km wide) which extends eastwards from Dunsborough to north of Moore River. The Blackwood Plateau is a gently undulating plateau formed on laterised sedimentary rocks where it lies to the south of the Swan Coastal Plain and to the east of the Margaret River Plateau.

Within the two physiographic regions the Carbunup River travels through five land systems identified in the Leeuwin-Naturaliste area by Tille and Lantzke (1990). These land systems are described below.

Swan Coastal Plain

Quindalup Coast land system
- calcareous sands supporting peppermint woodlands
- depressions and slightly raised terraces, poorly drained, supporting tea tree scrub

Ludlow Plain land system
- porous well-drained sandy soils supporting peppermint woodlands or patches of jarrah-marri forest

Abba Plain land system
- well-drained flats with fertile red - brown sand, loam and clay soils
- small, narrow drainage depressions (vales) with alluvial soils

Blackwood Plateau

Yelverton Shelf land system
- narrow drainage depressions and small valleys
- broad U-shaped drainage depressions with swampy floors

Treeton Hills land system
- broad U-shaped drainage depressions with swampy floors
- narrow drainage depressions and small valleys
- well-drained valley flats with alluvial soils, often red-brown loams

2.2 Vegetation

The vegetation of the Carbunup River and its catchment forms part of the moister southern area of the Darling Botanical District, contained within the South-western Botanical Province (Beard, 1990).

The Darling Botanical District has been further divided to represent two subdistricts in the study area, the Drummond subdistrict (the Pinjarra Plain and Spearwood Systems on the coastal plain) and the Menzies subdistrict (the Chapman System south of the coastal plain). This information is summarised in Figure 1.

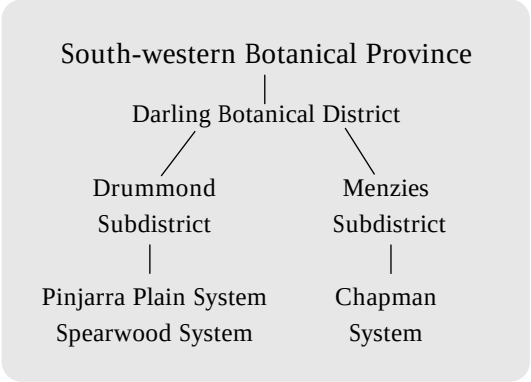


Figure 1 : Botanical Districts and Vegetation Systems for the Carbunup River (Beard, 1990)

Each Vegetation System is defined by the occurrence of a particular series of plant communities in a mosaic pattern. The occurrence of plant communities is linked to soil types, topographical and geographical features.

The Carbunup River passes through three of the plant communities identified by Beard (1981) as it travels northwards to Geographe Bay. These are medium jarrah-marri forest, low peppermint woodland and *Acacia* shrubland.

Species lists have been prepared for several areas in close proximity to the Carbunup River and are included in Appendix 1.

The Carbunup Bushland is one of the largest remaining areas of southern marri and *Banksia* woodlands and is the only known area associated with intact fringing riverine vegetation (Keighery *et al*., 1996). The marri woodlands are the most species-rich woodlands on the Swan Coastal Plain. The Carbunup Bushland contains at least four rare taxa:

Acacia semitrullata; Daviesa elongata subsp. elongata; Lepyrodia heleocharoides and *Taraxis glaucescens* as listed in Keighery *et al.* (1996), which contains a full species list for the reserve.

2.3 Climate

The Carbunup River area experiences a warm Mediterranean-type climate with a cool, wet winter and a warm, dry summer season. The median annual rainfall for the Carbunup catchment is 1050 mm (Pen, 1999). The Carbunup River lies between the evaporation isopleths of 1000 and 1200 mm.

2.4 The community

The River reminds us that we are bound to share the effects of how we manage our natural resources. The management practices of our neighbours, as do our own actions, determine whether we have access to silted, nutrient rich, weed-contaminated waterways or a clean reliable source.

(LCDC Member, *pers.comm*., 1999).

The Carbunup River supports a variety of land uses which are predominantly agricultural pursuits. Historically, dairy farming was widespread but the industry has contracted. Cattle grazing and commercial horticulture (particularly potato farming) continue to be productive and viticulture has more recently become a significant land use.

A large area of land along the river consists of consolidated holdings but a number of smaller lots are being released for more intensive agriculture.

There is limited public land. Five significant parcels are the Lennox River Drain (R 40676) at the mouth of the River, the Railway Reserve (R 3116) at Vasse-Yallingup Siding Road, Carbunup Bushland (R38582) near where the river crosses Bussell Highway, R4225 at the border of the Busselton and Augusta-Margaret River Shires and the Treeton State Forest which supports the headwaters.

2.5 Sussex LCDC

The Sussex LCDC is a community-based group which was formed in mid 1993 and has been assisted by AGWEST throughout this time.

LCDCs are set up under an Act of Parliament and are responsible to the Soil and Land Conservation Commissioner for preventing, remedying or mitigating land degradation, and the promotion of sound conservation and reclamation.

The Sussex LCDC actively encourages the input of landholders and residents within the area through formal and informal contact. Community members are welcome to bring matters of importance to the group to help shape its activities.

The LCDC has been involved in a number of landcare projects including:

- stream monitoring in the catchment;
- facilitation of Know Your Soils course; and
- tree planting with Vasse Primary School.

Recently, the level of activity within the Toby Inlet catchment has resulted in the development of a separate landcare group to manage projects.

2.6 Fauna

The Carbunup River area is included in the species distribution ranges for the following fauna. While not all have been positively recorded, they are likely to be found based on existing habitat and opportunistic sightings.

Fauna

Western Ringtail Possum	*Pseudocheirus occidentalis*
Western Pygmy-Possum	*Cercartetus concinnus*
Echidna	*Tachglossus aculeatus*
Common Dunnart	*Sminthopsis murina*
Brush-tailed Phascogale	*Phascogale tapoatafa*
Southern Brown Bandicoot/ Quenda	*Isoodon obesulus*
Common Brushtail Possum	*Trichosurus vulpecula*
Western Grey Kangaroo	*Macropus fuliginosus*
Yellow-footed Antechinus/ Mardo	*Antechinus flavipes*
Quokka	*Setonix brachyurus*
Woylie	*Bettongia penicillata ogylbyi*
Western Brush Wallaby	*Macropus irma*
Chuditch	*Dasyurus geoffroii*
Honey Possum	*Tarsipes rostratus*
Water Rat	*Hydromys chrysogaster*
Bungarra	*Varanus gouldii*
Marbled Gecko	*Phyllodactylus marmoratus*
Mourning Skink	*Egernia luctuosa*
King Skink	*Egernia kingii*
Bobtail	*Tiliqua rugosa*
Dugite	*Pseudonaja affinis affinis*
Tiger Snake	*Notechis scutatus occidentalis*
Margaret River Marron	*Cherax tenuimanus (Margaret River)*
Oblong Turtle	*Chelodina oblongata*
Freshwater Mussel	*Westralunio carteri*
Western Pygmy Perch	*Edelia vittata*
Western Mud Minnow	*Galaxiella munda*
Swan River Goby	*Psuedogobius olorum*
Western Minnow	*Galaxias occidentalis*
Nightfish	*Bostockia porosa*

Frogs

Burrowing Frog	*Heleioporus inornatus*
Moaning Frog	*Heleioporus eyeri*
Banjo Frog	*Limnodynastes dorsalis*
Guenther's Toadlet	*Pseudophryne guentheri*
Lea's Frog	*Geocrinia leai*
Quacking Frog	*Crinia georgiana*
Squelching Froglet	*Crinia insignifera*
Motorbike Frog	*Litoria moorei*
Glauert's Froglet	*Crinia glauerti*
Slender Tree Frog	*Litoria adelaidensis*

Introduced fauna

Rabbit	*Oryctolagus cuniculus*
European Rat	*Rattus rattus*
House Mouse	*Mus musculus*
Fox	*Vulpes vulpes*
Feral Cat	*Felis catus*
Mosquito Fish	*Gambusia holbrooki*

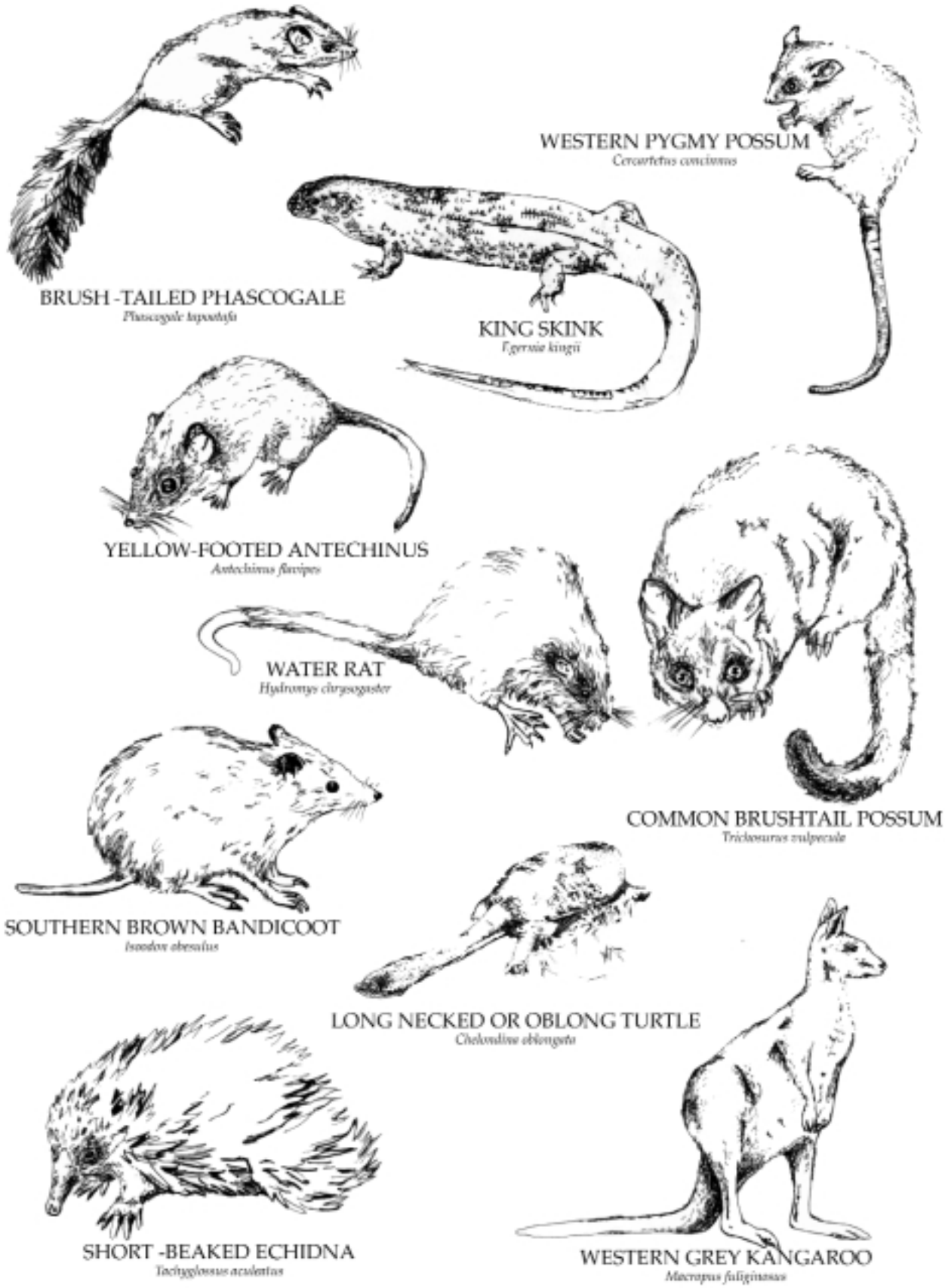


Figure 2: Fauna species whose distribution range includes the Carbunup River.

Figure 3 : Frog and fish species whose distribution range includes the Carbunup River.

2.7 Aboriginal heritage[2]

Carbunup is recorded as an Aboriginal name meaning 'place of kindly stream' (DOLA).

Fresh water represents a significant feature of the landscape for Nyungar people. River systems are an important resource base and hold spiritual value.

Like other fresh water systems throughout the South West of Western Australia, the Carbunup River is believed to be inhabited by the Waugal, an important figure able to influence sickness and death (Bates, 1992).

Local Aboriginal people described the Carbunup River and surrounds as a valuable source of food and water. One elderly woman reported that she camped near the river for weeks at a time as a child while her father was employed on nearby potato farms. They would trap water rats from the river. Others noted that gilgies and marron were important foods obtained from the river.

Rivers were commonly used as walk trails by Nyungar people. In the summer, when the water level dropped, the absence of vegetation in river channels made travelling along watercourses easy. Aboriginal consultants report that the course followed by the Carbunup River, from the forest to the coast at Geographe Bay, was probably a significant factor in its use as an access route to and from these places.

Aboriginal people also noted the Carbunup River's recreational uses. One elderly woman described swimming in the river pools as a child. Another person mentioned that an area nearby was a 'playing field', where people would play football and other games.

Three sites in the vicinity of the Carbunup River have been registered with the Aboriginal Affairs Department:

- S02980 Marybrook 1
Unspecified ethnographic site
- S02981 Marybrook 2
Unspecified ethnographic site
- S02982 Marybrook 3
Unspecified ethnographic site

[2] Section based on research by Dirima Cuthbert.

2.8 European heritage

John Molloy originally named the river the Lennox River in February 1835, in honour of Lennox Bussell. Later it became known as the Carbunup River and the town-site of Carbunup was named after it in 1926.

In 1958 the town's name was changed to Carbunup River to avoid confusion with the town-site of Carbarup in Mount Barker. Carbunup River is also recognised as a locality within the Shire of Busselton.

Four sites of cultural heritage significance near the Carbunup River are recognised under the *Heritage of Western Australia Act 1990*:

1. Route of Busselton to Augusta Railway Line (constructed circa 1920).
2. St John the Baptist Anglican Church, Bussell Hwy, Metricup (circa 1935).
3. Carbunup Hall, Bussell Hwy, Carbunup River (constructed circa 1920).
4. Carbunup Store, Bussell Hwy, Carbunup River (constructed circa 1920).

2.9 Land tenure and use

Most of the land along the Carbunup River is privately owned and zoned for rural use. The river passes through the areas of public land listed in Table 1.

Land use along the Carbunup River has been mapped with the assistance of the local community (see Figure 4). The predominant uses are grazing and horticulture (mostly potatoes) with a more recent trend towards viticulture.

Land use information is valuable in understanding the likely pressures on the river system. For instance, where there is grazing pressure, there is likely to be the need for stock control measures along the river banks.

It is unlikely that access control measures will be necessary where viticulture is practised up to the foreshore. However, effective bio-filtering buffers will be important.

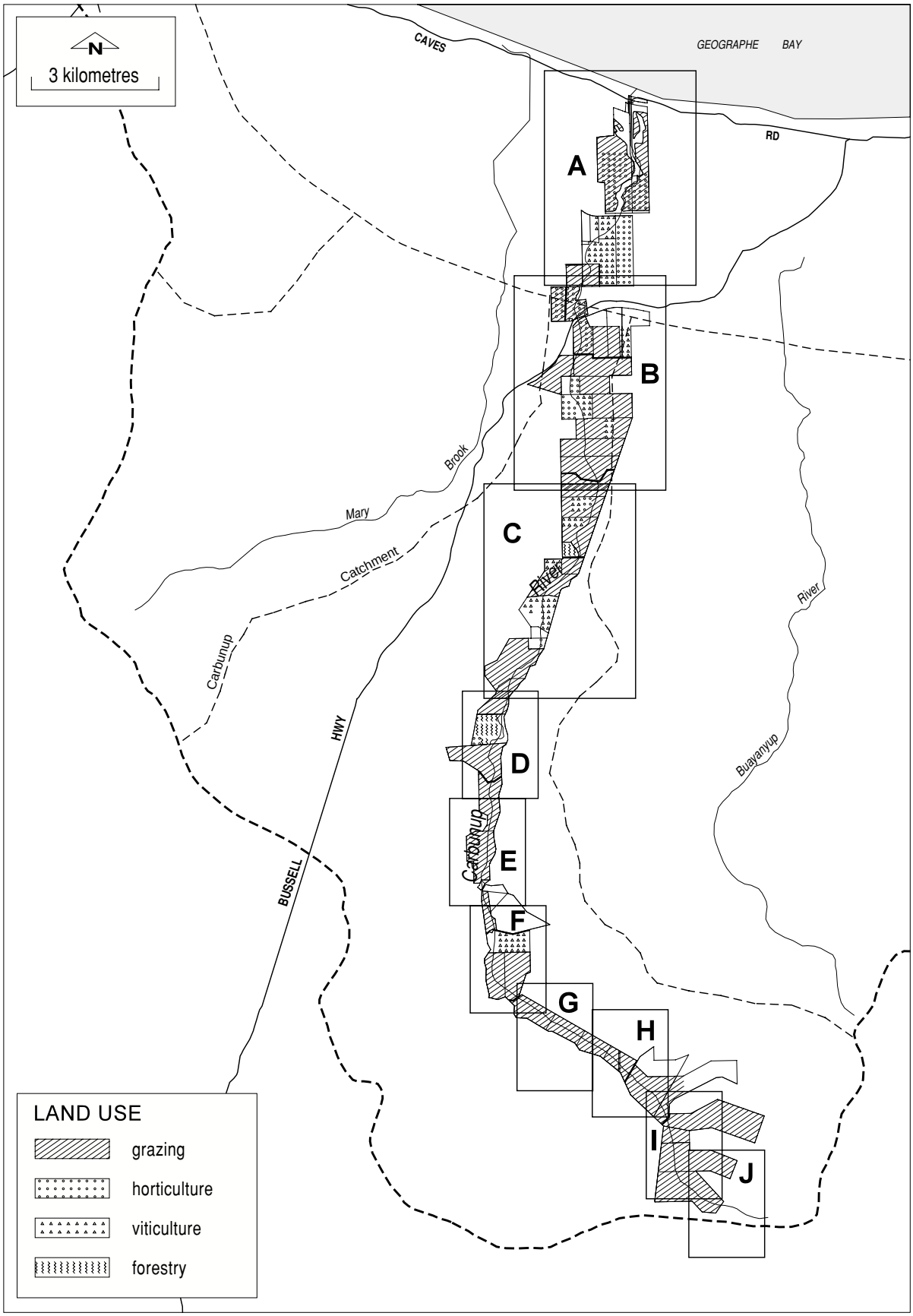


Figure 4: Land use along the Carbunup River. The areas marked with letters A-J correspond to the maps in Section 5.

Location/Lot No.	Shire	Vesting	Purpose
Lennox River Drain R40676	Busselton	Water Corporation	Drainage
Busselton to Augusta Railway Reserve R3116	Busselton/A-MR		
16, 17 &19/R38582 *(Carbunup Bushland)*	Busselton	Shire of Busselton	Parks & Recreation
R4225	Busselton	Shire of Busselton	Parkland
Treeton State Forest	A-MR	Lands and Forests Commission	State Forest

Table 1: Public land along the Carbunup River.

2.10 Water quality and flow

Flow data for the Carbunup River shows peak flows typically occurring during the months of July and August (Figure 5). The total volumes recorded for the month of greatest flow in each year between 1995 to 1998 exceed 14 million cubic metres, which is a flow typically associated with a moderate-size river for south west WA.

Flow data from the Vasse River and Wilyabrup Brook over the past 25 years, indicates a gradual increase in both peak flows and total flow. Anecdotal reports indicate this pattern may also be evident along the Carbunup River.

It has been suggested that due to land clearing and improved drainage in the region, greater volumes of water may be moving off the surface of the land and into the drainage systems at a faster rate.

Sampling

Water sampling is routinely conducted by the WRC at the gauging station on Lennox Vineyard and through 'snapshot' exercises by Ribbons of Blue. Sampling results provided by WRC indicate that the recommended level for Total Phosphorus (TP) is periodically exceeded and the recommended level for Total Nitrogen (TN) is frequently exceeded.

Nutrient levels are a reflection of surrounding land use practices. The Carbunup River is one of the healthiest rivers in comparison to others in the Geographe catchment.

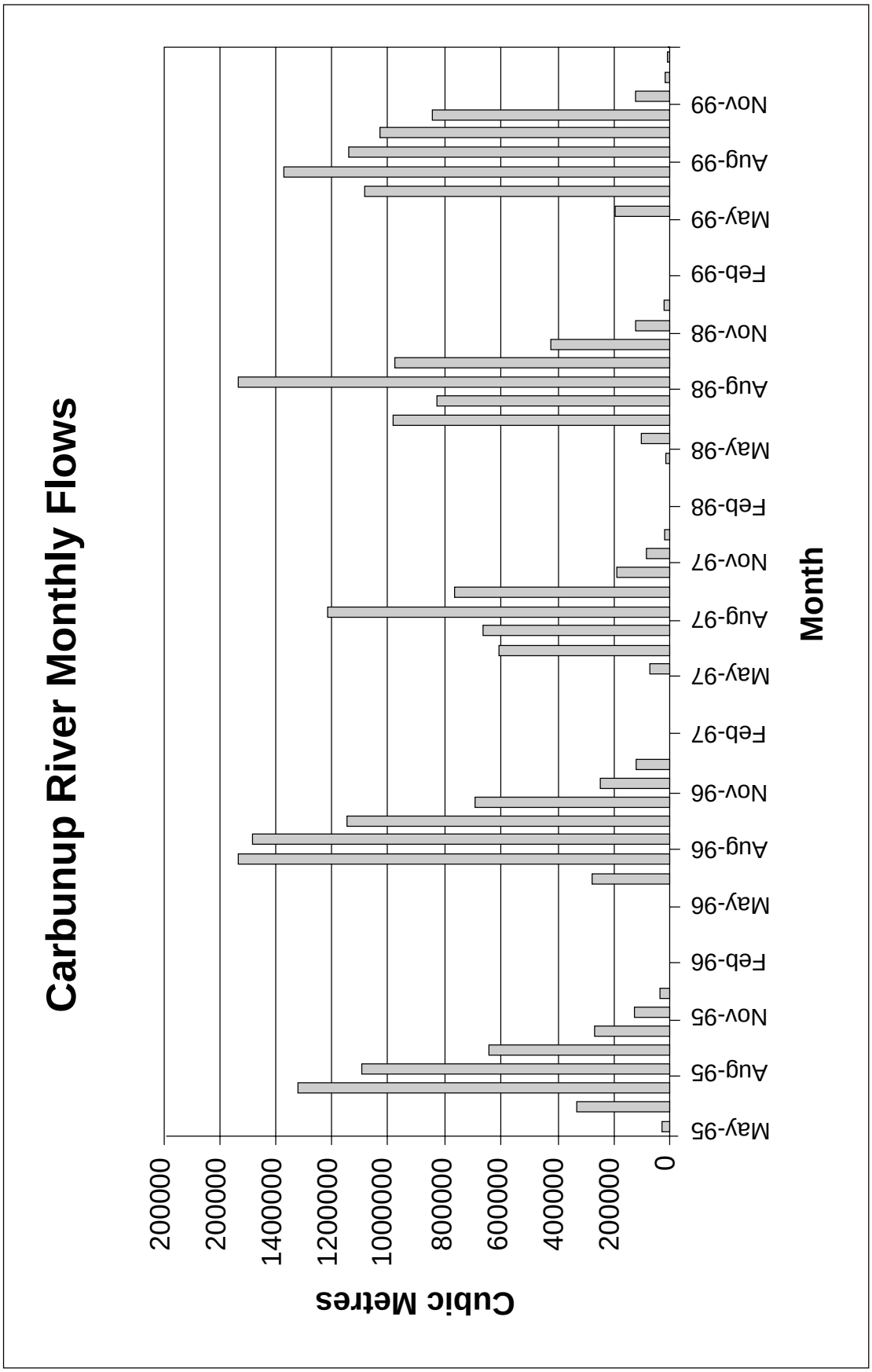


Figure 5: Carbunup River - Monthly flows.

3. Approach

The Carbunup River Action Plan was prepared in two main stages:

- an assessment of the river; and
- preparation of recommendations to guide future rehabilitation work.

The assessment incorporated the compilation of existing information and landholder knowledge and a field survey of the upper catchment area.

Survey information for the lower reaches had been previously gathered by the LCDC with assistance from the ATCV. This information was the basis for the survey details provided in Maps 1a to 1c.

The overall assessment of the river was based upon the Stream Foreshore Assessment survey technique, a standard method of assessing the condition of waterways (Pen and Scott, 1995).

3.1 Consultation

Consultation with members of the community formed an integral component of the project. Community members directly contributed a wide range of knowledge to the report such as land use, stock access and management advice. This input has helped make the report more responsive to local conditions. Figure 6 shows the milestones of community involvement in the Carbunup River Action Plan.

3.2 Foreshore assessment technique

The stream foreshore assessment technique used was developed in response to a need for rapid, inexpensive assessment of waterways that could be undertaken by the community, agencies and professionals alike. The basis for this technique comes from expert observations by Dr Luke Pen of waterway degradation in the South West.

The assessment technique consists of a range of grades A, B, C and D which represent the condition of the foreshore from *pristine* to *completely degraded*. Each grade can be further separated into two or three sub grades which allow for more detailed assessment.

The grading system is as follows (see Figure 7 for illustrations):

A Grade Foreshore

A1: Pristine

The river embankments and floodway are entirely vegetated with native species and there are no weeds or soil disturbances.

A2: Near Pristine

Native vegetation dominates but weeds are occasionally present in the understorey, though not to the extent that they displace the native species. Otherwise there is no human impact.

Figure 6: Community consultation flow diagram.

A3: Slightly Disturbed

Here there are areas of localised human disturbance where soil may be exposed and weeds are present, such as along walking or vehicle tracks. Otherwise, native plants dominate and would quickly recolonise disturbed areas should human activity decline.

B Grade Foreshore

B1: Degraded /weed infested

Native species remain dominant; a few have probably been replaced or are being replaced by weeds.

B2: Degraded/ heavily weed infested

In the understorey, weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined. Soil disturbance may be common, but not extensive.

B3: Degraded/ weed dominated

Weeds dominate the understorey, but many native species remain. Some tree and large shrub species may have declined or disappeared altogether.

C Grade Foreshore

C1: Erosion Prone

While trees remain, possibly with some large shrubs or grass trees, the understorey consists entirely of weeds, mainly annual grasses. Regeneration of most of the trees will be at most below replacement level or at worst negligible. In this state, where the soil is supported by short-lived weeds, a small increase in physical disturbance will expose the soil and render the river embankments and floodway vulnerable to erosion.

C2: Soil Exposed

Here the foreshore is exposed in significant areas and has begun to erode.

C3: Eroded

Soil is washed away from between any tree roots and trees are being undermined. Unsupported embankments are subsiding into the waterway. Localised erosion is present.

D Grade Foreshore

D1: Ditch Eroding

Fringing vegetation no longer acts to control erosion. The waterway resembles a drain with few or no remaining trees. Erosion and siltation is commonly occurring. Sediment deposits are common along the river channel.

D2: Ditch/ weed dominated

The waterway is highly eroded. Weeds dominate the streamline, such as kikuyu, buffalo grass and weedy rushes. The waterway has become a simple drain.

In the rating of areas covered by this Action Plan the bridging grading B3-C1 has been used to identify areas which clearly hold both B3 and C1 characteristics. This classification is used where the area surveyed does not fully fit in either a B or C grade.

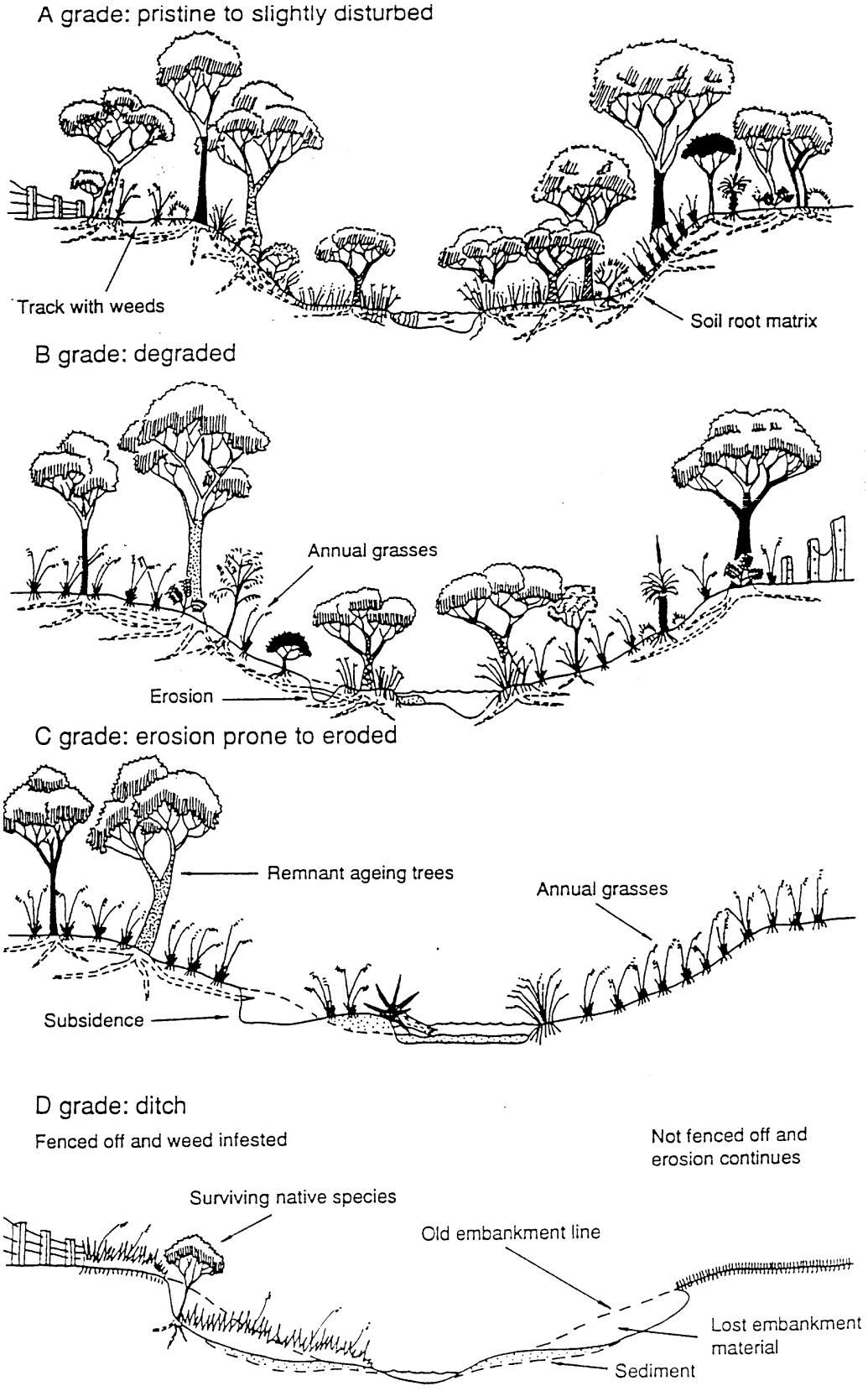


Figure 7: River foreshore stages of degradation - A (pristine) to D (ditch).

4. Management issues

4.1 Uncontrolled stock access

Uncontrolled access by stock, especially hard-hoofed animals, is almost always destructive to the sustainable functioning of riparian environments. It contributes to loss of vegetation, bank collapse, soil erosion, downstream sediment deposition, and an increase in nutrient loads entering the waterway.

Importantly, stock pressure limits the ability of vegetation to regenerate which in the long term limits its resilience. Resilience is the ability of the vegetation to self-regenerate after significant events such as flooding and fire. A well-vegetated foreshore with a diversity of trees and shrubs will be more resilient to such events. For instance, a stable vegetated foreshore should limit the impacts of flooding and quickly rehabilitate areas that have been affected.

Where the Carbunup River has stock grazing as an adjacent land use or within the foreshore itself, the overall condition rating for the river is generally low.

The impacts of uncontrolled stock access to riparian areas described by LWRRDC (1996) are:

Erosion - overgrazing can bare the stream bank and pug the toe of the stream, causing erosion during rainfall or streamflow.

Loss of species - stock selectively graze particular species, leading to greatly reduced biodiversity, weed invasion and loss of habitat.

Soil compaction - continued stock pressure physically compacts the soil, affects the ability of vegetation to germinate, reduces the infiltration of rainfall and increases run-off.

Weed invasion - disturbance created by overgrazing and increased levels of nutrient encourages weed establishment.

Contamination - manure and urine directly contribute phosphorus and nitrogen to streams. Under conditions of increased sunlight and temperature this can lead to excessive algal growth. Animal excrement is a source of bacteria and viruses.

4.2 Erosion

Erosion and siltation is a significant issue throughout the length of the Carbunup River due to modification of the land within or adjacent to the riparian zone. Undercutting and bank slumping are the two main types of erosion along the river.

A degree of erosion and sediment deposition is a natural process as the stream creates a meandering path to absorb the power of water flow. It is the level of erosion and its result that creates a management issue.

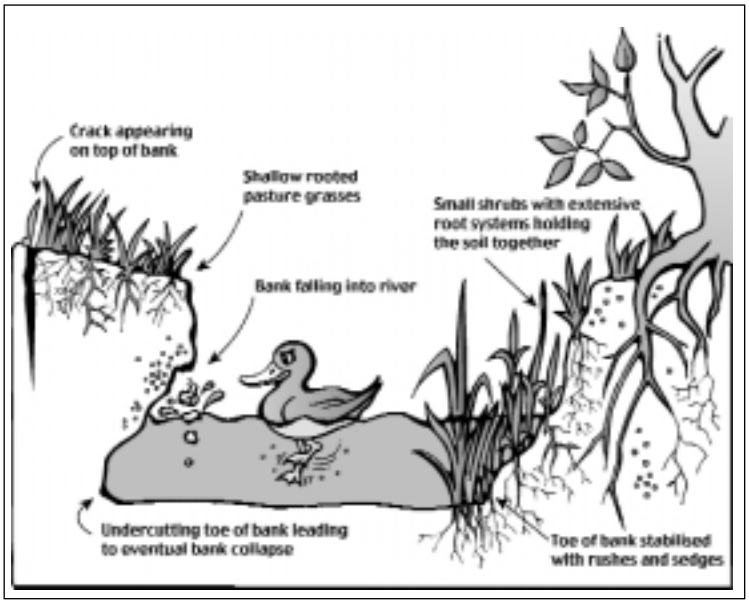


Figure 8: Undercutting of river bank. Picture courtesy of Stephen Elphick.

Where natural erosion occurs there is generally rapid re-colonisation of the banks by native seedlings. This helps to re-establish a balance.

Induced erosion is often an ongoing process that is out of balance and continually contributes sediment to the stream.

Some of the management problems associated with increased erosion and siltation are:

- silting of dams;
- filling of pools;
- reduced water quality;
- disruption to pumping equipment;
- degraded aquatic habitat ;
- increased erosive power of stream flow; and
- increased flood potential due to a raised channel.

Undercutting may occur where soil is washed from the toe of the bank, removing bank support and encouraging subsidence (Raine and Gardiner, 1995). The bank appears to have been 'cut' at or under the water level (Fig 8). Bank slumping occurs where the bank collapses into the channel.

4.3 Loss of native riparian vegetation

A large area of the catchment has been cleared for livestock grazing and horticultural production. Land managers report that much of the original riparian vegetation was also cleared but there has been valuable regeneration, mostly by tea tree (*Agonis linearifolia*).

Native vegetation is increasingly recognised for its important role in sustainable farm management. Some values of native vegetation are described below:

Ecological

- soil conservation
- water conservation and moisture retention
- biological diversity and habitat
- recycling and filtering of nutrients
- conservation of rare species

Economic

- shade and shelter for livestock and crops to increase productivity
- increase in property values by up to 10% (LWRRDC, 1996)
- salinity control
- eco-tourism and farm-stay potential
- seed source for regeneration
- commercial products (eg. honey, firewood, cut flowers)

Social

- preservation of local identity and sense of place
- historical record and heritage
- recreation

Values of fringing vegetation have been described in detail by Pen (1994) and are summarised below.

Streambank stabilisation and soil conservation

The soils of the natural stream valley support a varied flora of trees, shrubs, sedges and herbs. In turn, the vegetation supports the stream bank and protects it from erosion and subsidence.

Fringing vegetation increases stream bank roughness which dissipates the energy of running water and reduces the erosive capacity of the stream flow (Troeh *et al*., 1980).

Roots and rhizomes bind and reinforce the soil of the embankments. The large roots of trees anchor the embankment in place and the smaller roots and rhizomes of shrubs, sedges and grasses hold the soil firmly in place at the surface between the large tree roots. In fact, the soil root matrix can add extra cohesion of the order of ten times that of an un-vegetated embankment (Thorne, 1990).

Roots and rhizomes also act to loosen and break up the soil, with the result that a well-vegetated bank enables rapid infiltration of rain water (Thorne, 1990; Riding and Carter, 1992). Together with the extraction of the water by the plants themselves, greater hydrological conductivity causes the bank to be drier than a similar unvegetated bank.

In wet weather this means that the embankment is less likely to become saturated with water and thus is less prone to mass failure, such as subsidence and toppling caused by the added bulk weight of the water (Thorne, 1990).

Riparian vegetation is highly resilient, exhibiting quick regeneration and re-colonisation following the effects of severe flooding. In this way, the vegetation helps stabilise the river system against the effects of severe erosion and sedimentation (DeBano and Schmidt, 1990; Wissmar and Swanson, 1990).

Sediment and nutrient retention

Ongoing international research increasingly highlights the important function that riparian zone vegetation has in filtering out sediment and nutrients carried in flowing waters. Work on vegetated buffer strips along waterways or between waterways and agricultural land has shown that vegetation of many forms, including grasslands, sedgelands, woodlands and forests, can filter out and retain substantial amounts of sediment and nutrients thereby improving in-stream habitat (Knauer and Mander, 1989). Dissolved nutrients, especially nitrate, are readily taken up and assimilated by plants (Pinay *et al*., 1990).

By reducing stream flow, riparian vegetation promotes sediment deposition. Sand can be deposited even where water is fast moving and silt will settle out where vegetation causes a marked reduction in flow. However, near- still water, such as that caught in densely vegetated flood plains, is required for the deposition of the very fine clay fractions (Troeh *et al*., 1980). Over time, substantial stream bank and floodplain accretion can occur in certain areas as a result of sediment deposition, and this can alter hydrological processes (Thorne, 1990). The removal of suspended sediment by vegetation is especially important. Water carrying sediment has a greater momentum, is more abrasive than clean water and has an enhanced capacity to cause erosion as it moves downstream (Troeh *et al*.,1980).

Much of the nutrient trapped in the vegetation of waterways or in buffer strips is assimilated by the vegetation (Odum, 1990). Generally, the longer the water is held, the greater the uptake of nutrients (Howard-Williams and Downes, 1984). The nutrients may eventually be released back into the water when plant material decays, but much of this will once again be assimilated. In this way the riparian system retards the rate of transfer of nutrient particles downstream in a process known as nutrient spiralling (Pieczynska, 1990, Pinay *et al*., 1990).

Nitrogen can be removed from riparian systems completely. This occurs via the biochemical process of denitrification, which causes nitrate to be converted to gaseous nitrogen. This can be the major form of removal in certain riparian zones and during particular environmental conditions such as during and after flooding (Jacobs and Gilliam, 1985).

Ecological values

Streamline vegetation not only has natural resource value in its own right but also provides a range of habitats for plants and animals, particularly species which are restricted to moist or aquatic environments or species which are restricted to particular rivers or streams. For example, the pouched lamprey (*Geotria australis*), which migrates upstream from marine to fresh water, is known to occur in the Carbunup River (Pen, pers. comm., 1999).

Furthermore, as stream systems are linear and cover large distances, their vegetation helps to create ecological corridors. These natural corridors, along with unnatural ones such as vegetated strips planted along road and rail reserves, enable plant and animal species to move between larger patches of remnant habitat (Hussey *et al*., 1989).

Well-vegetated streams also provide habitat for insect-eating birds, which in turn help protect adjacent crop lands. Native vegetation provides benefits for aquatic animals, including insects and the fish that feed on them.

Recreational and landscape value

Recreational and landscape value is dependant upon the health of the riparian vegetation and the quality of water which, in turn, affects the aesthetics and habitat value of the river.

Foreshore areas along the Carbunup River have important recreational and landscape protection values. This is particularly evident where the river winds past the Carbunup Store.

This has been recognised by residents and efforts to improve the foreshore have already commenced.

Anecdotal evidence from real estate agents suggests that healthy riparian frontage and access can add up to 10 % to the market value of property (LWRRDC, 1996).

4.4 Water quality

The WRC and Ribbons of Blue monitor water quality in the Carbunup River through routine sampling.

Periodically these sampling exercises have identified levels of nutrients (phosphorus and nitrogen) in excess of the recommended levels for fresh flowing streams.

Impacts of reduced water quality may include:

- eutrophication and algal blooms;
- impact on pumping equipment (through silt blockages);
- impact on stock watering;
- degraded aquatic habitat (eg. for marron and fish).

4.5 Weeds

Western Australia has about 10,000 scientifically described plants, of which about 10 per cent have been introduced (Hussey *et al.*, 1989).

A plant is considered a weed when it causes problems or is not wanted in an area. In areas of native vegetation, introduced plants are considered environmental weeds; in agricultural areas plants may be considered weeds because they are troublesome in economic terms.

Weeds are commonly found in areas that have been disturbed, suggesting the native vegetation has incurred some setback. Weeds are strong competitors in these situations, often displaying faster, more vigorous growth rates. Weeds disturb the existing balance to compete strongly with the native vegetation, displacing habitat among other things.

Competing weeds may destroy the relationships between native plant species and fauna. Weeds are typically not subject to the same control by pests and diseases, which play an important and natural role in balancing ecosystems. As weeds flourish and the natives are forced out, the richness, diversity and resilience of the native bushland is replaced by relatively homogeneous vegetation. Changes may occur in nutrient cycling and soil acidity and fire hazard may be increased.

Weed infestation along the river may reduce bank stability as:

- growth is often annual, leaving soil exposed or easily exposed;
- coverage is more easily disturbed by stock;
- root matrix is often shallow or not complex, which limits its ability to bind soil and anchor the banks.

Weeds may typically appear to stay in relatively small numbers for quite some time until some change in the ecological balance (eg. fire, removal of vegetation etc.) causes a population explosion.

Weed control

The Agriculture and Related Resources Protection Act administered by AGWEST may declare native or introduced plants which become problems to agriculture. A declared plant is assigned a category that is determined according to the appropriate management strategy. Declared plants and their category may vary between areas, usually based on a local government area. Landowners are obliged by the Act to control declared species on their property.

A local government authority may prescribe a plant a 'pest plant' which then permits a by-law to be made to effect control of the plant. The by-law should identify plants which are not declared, and which may adversely affect the value of property or the health, comfort or convenience of the residents.

The Sussex LCDC and members of the wider community have identified a weed problem along the Carbunup River because weeds may:

- create a fire hazard;
- compete with agricultural production;
- smother the native vegetation and create a degraded environment;
- infest and block the river channel;
- reduce the amenity value of the river;
- reduce the habitat value of the river for local fauna;
- reduce biological diversity;
- significantly reduce the regeneration of native plants.

Table 2 shows the weeds identified along the Carbunup River during the survey.

Table 3 identifies other weeds that have been reported by the community as likely to be found in the vicinity.

Table 2: Weed species identified along the Carbunup River.

Species name	Common name	Requiring priority treatment
Acacia melanoxylon (at Treeton Rd Bridge)	blackwood wattle	*
Alisma lanceolatum[3]		
Alternathera pungens	khaki weed	
Angallis arvensis	pimpernel	
Briza maxima	blowfly grass	
Chamaecytisus	tagasaste	*
Cirsium vulgare	spear thistle	*
Cotula sp.		
Cyperacea spp.		
Cyperus involucratus		*
Hypochaeris radicata	flatweed	
Isolepis prolifera	budding club rush	*
Juncus microcephallus		*
Lactuca serriola	prickly lettuce	
Lathyrus tingitanus	tangier pea	
Lavendula sp.	garden lavender	
Mentha pulegium	pennyroyal	*
Paspalum dilitatum	paspalum	*
Penisetum clandestinum	kikuyu	
Phalaris angusta	canary grass	
Polygala myrtifolia	milkweed/ butterfly bush	
Raphanus raphanistrum	wild radish	
Rubus fruticosus	blackberry	*
Rumex crispus	dock	*
Solanum nigrum	nightshade	*
Sonchus asper	prickly sowthistle	
Tryfolium spp.	clover	
Vellereophyton dealbatum	white cudweed	
Zantedeschia aethiopica	arum lily	*

[3] Alisma lanceolatum is reported to be naturalised in the South West of Western Australia.

Table 3: Other weed species likely to be found along the Carbunup River.

Species name	Common name	Priority treatment
Arctotheca calendula	cape weed	
Asparagus asparagoides	bridal creeper	*
Cotula australis	carrot weed	*
Echium plantagineum	Paterson's curse	*
Emex australis	double gee	*
Erodium spp	corkscrews	
Homeria flaccida & H.miniata	cape tulip	*
Romulea rosea	onion weed	
Watsonia bulbillifera	watsonia	*

Some weed species have been identified by the LCDC as a priority for control, suggesting that eradication and control measures should focus on these species in the first instance. These weeds include those listed as declared plants and those know to be vigorous colonisers and invaders.

Zantedeschia aethiopica - arum lily

Watsonia bulbillifera - watsonia

Rubus fruticosus - blackberry

Figure 9: Weed species identified by the LCDC as requiring priority treatment.

5. Carbunup River foreshore condition and management advice

5.1 Overview

The rehabilitation advice provided in this River Action Plan is offered as a guide only.

Implementation will be a voluntary co-operative effort amongst the interested community, assisted by the Sussex LCDC and GeoCatch through funding such as Streamlining.

Each land manger may voluntarily introduce the suggested actions.

Implementation is encouraged for the benefits it can bring to land productivity and environmental quality in the long term, including the long-term viability of the Carbunup River and its supporting landscape.

Any rehabilitation work should initially involve consideration of the specific causes of the site problems.

These can be complex and interrelated and rehabilitation works may have corresponding effects downstream.

Staff at GeoCatch or Water and Rivers Commission can be contacted for technical support and advice.

The information provided in this chapter should be read in conjunction with Map 1 and Maps 1a to 1j.

It includes:

- the condition ratings along the Carbunup River
- the current, predominant land use
- stock access to the foreshore (approximate km, including both sides of the river bank)
- recommended rehabilitation advice

The survey information for Maps 1a to 1c relies on field observations by the Sussex LCDC and the ATCV. All field surveys in the upper catchment area were conducted with the landowners.

At the end of this section there are a summary of findings and a recommended priority schedule for implementation of the proposed strategies.

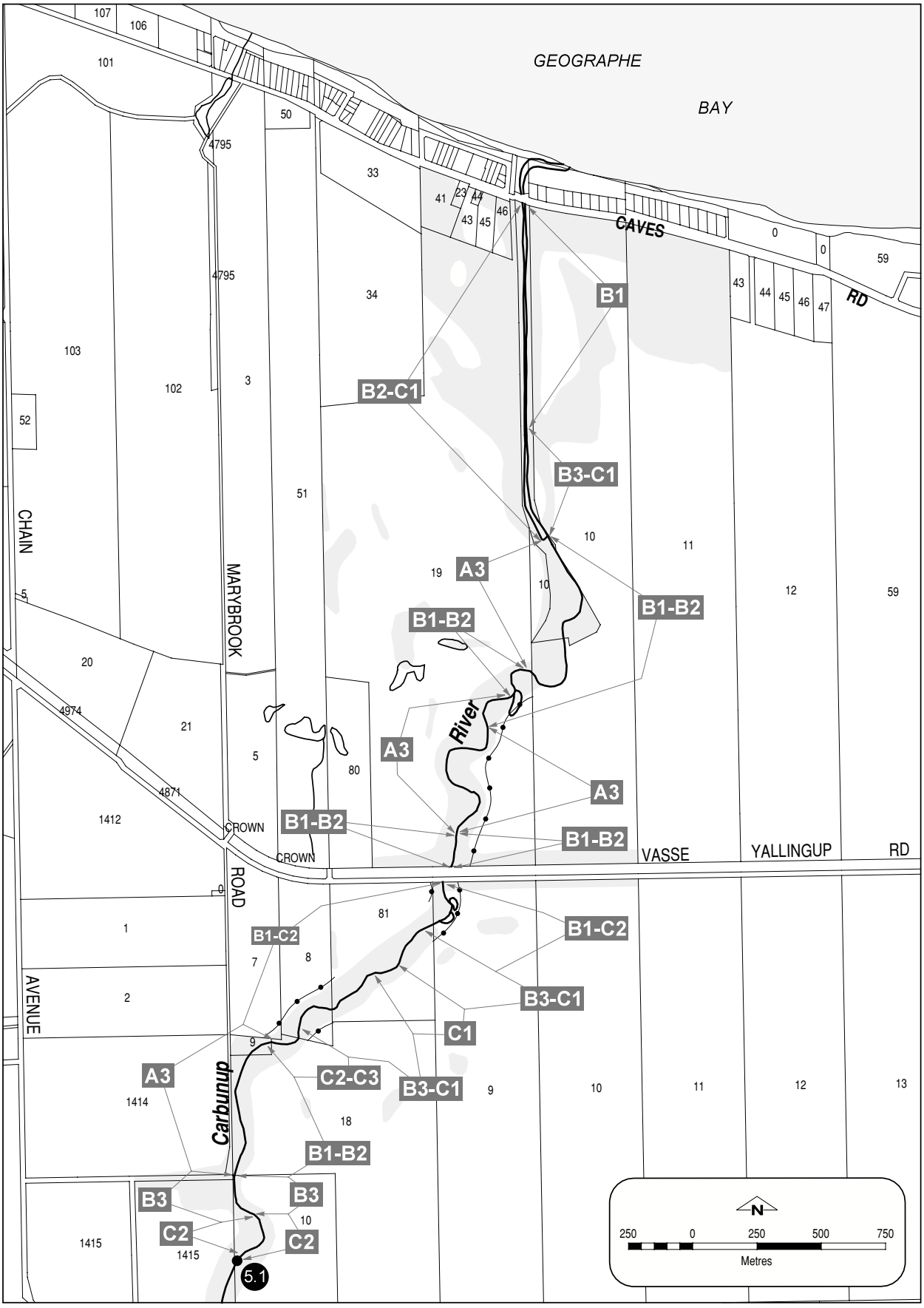
Map 1a

The river meanders northwards across Vasse-Yallingup Siding Road to Geographe Bay. Drainage was historically connected to the farmland on either side of the river but the Lennox Drain has limited this interaction.

Summary Information

Distances from river mouth (approx.)	0 km - 5 km
Loc./lot numbers of adjacent properties	4794; 10; 19; 9; 51; 8; 18; 9; 10; 3986
Date surveyed	1997, Sussex LCDC
Foreshore condition rating	A 25% B 43% B3-C1 12% C 20%
Vegetation cover	Originally low peppermint woodland, acacia shrubland and medium jarrah-marri forest, now largely cleared for agricultural purposes. Fringing vegetation along the river remains, with healthy regeneration where stock is excluded.
Land use	Horticulture, viticulture, dairy and grazing.

Issues	Management Advice
Vegetation	Species recorded in Appendix 1 provide a range of suitable rehabilitation plants.
Weeds	Gardens near the river should be carefully maintained to prevent future invasion of river foreshore by species such as fig trees, morning glory and arum lily.
Erosion and stock access	Control stock access by use of stabilised crossing points and seasonal access. Where erosion has been caused by loss of vegetation and the banks are now steep (> 45˚), fortifying the banks with LWD will limit erosion and encourage soil deposition to assist regeneration.



Carbunup River Map 1a

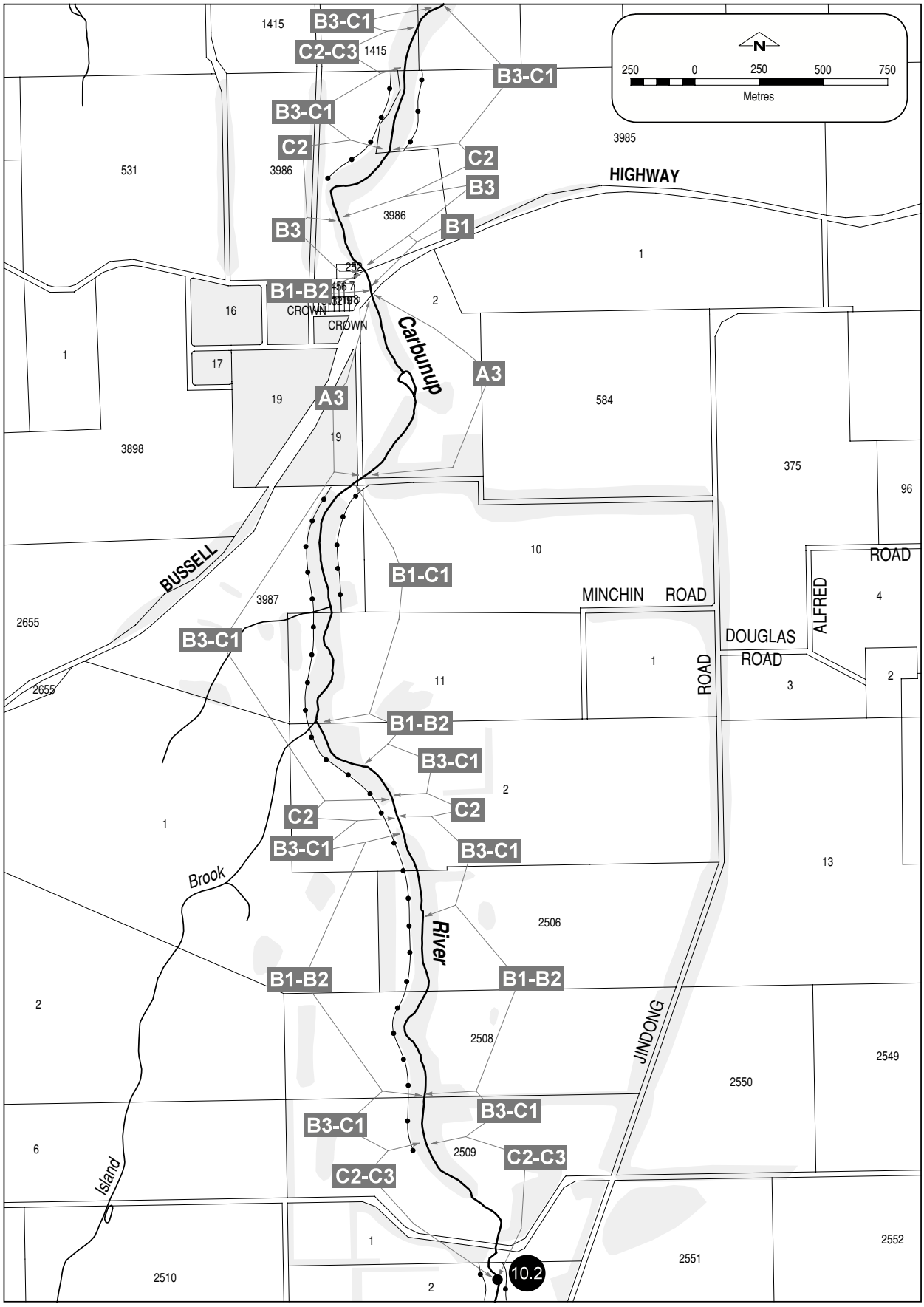
Map 1b

The river travels between Bussell Highway and Jindong Road. From where it is joined by Island Brook it continues northwards past the Carbunup Bushland and the Carbunup town-site before crossing Bussell Highway.

Summary Information

Distances from river mouth (approx.)	5 km - 10 km
Loc./lot numbers of adjacent properties	2/253; 19 (R38582); 3987; 11/3988; 2/2505; 2506; 2508; 2509; 1/2584
Date surveyed	1997, Sussex LCDC
Foreshore condition rating	A 14% B 27% B3-C1 27% C 32%
Vegetation cover	Remnants of original medium jarrah-marri forest remain along foreshore.
Land use	Grazing, horticulture and viticulture.

Issues	Management Advice
Vegetation	Species growing in the Carbunup Bushland are recommened for revegetation. See also sites 1, 2 and 3 in Appendix 1.
Weeds	Weed species requiring eradication include pasture grasses. Weeds can be identified through Appendix 3.
Erosion and stock access	Controlling stock access at stabilised points and limiting access seasonally will assist in preventing soil loss.



Carbunup River Map 1b

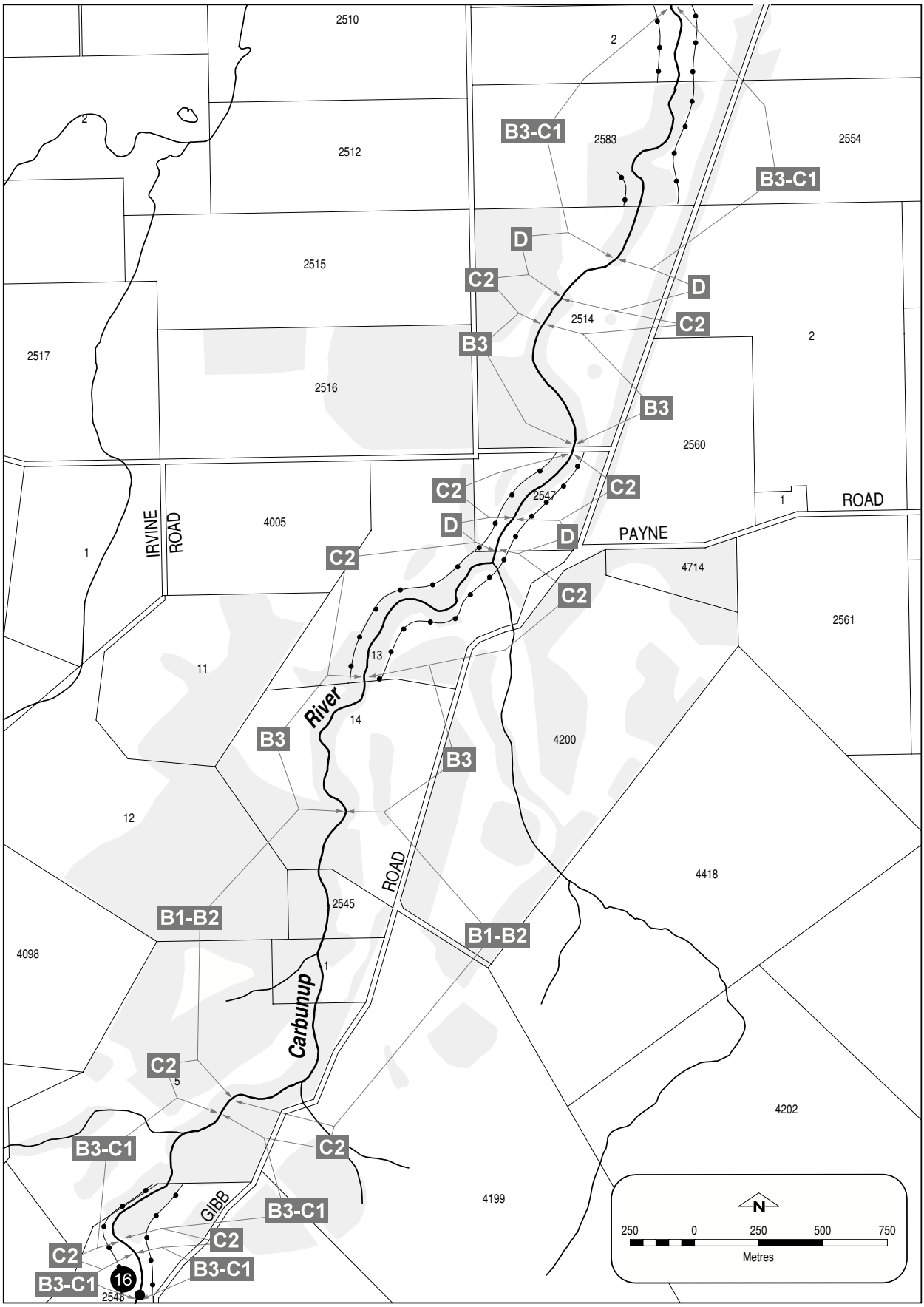
Map 1c

The river travels northwards from the Yelverton Shelf land system and into the Abba flats, just west of Gibb Road. Small tributaries join the river. One of the tributaries passes through an area of gravel extraction that would benefit from revegetation where extraction has ceased.

Summary Information

Distances from river mouth (approx.)	10 -16 km
Loc./lot numbers of adjacent properties	2/2584; 2583; 1/2514; 2547; 13/2546; 14/2546; 2545; 1/2544; 5/2544; 2543
Date surveyed	1997, Sussex LCDC
Foreshore condition rating	B 39% B3-C1 24% C1 31% D 6%
Vegetation Cover	The original jarrah-marri forest has been significantly cleared but some healthy stands remain. Much of the remaining fringing vegetation is dominated by tea tree (*Agonis linearifolia*).
Land use	Grazing, horticulture, viticulture and forestry.

Issues	Management Advice
Vegetation	Ripping and mounding across the gentle slopes in preparation for planting will increase the survival and growth rate of planted species. Direct seeding would also be beneficial where thorough weed control can be achieved and stock access is limited.
Weeds	Where stock is excluded (intermittently or otherwise) weed control will need to be considered. Appendix 3 will assist in identifying weed species.
Erosion and stock access	Limiting stock access will allow for revegetation of cleared areas which will bind the soil of the banks. Stock may be watered from troughs or on the inside of a meander bend where soil deposition naturally occurs. Stabilised crossings may be established where exposed ironstone occurs.



Carbunup River Map 1c

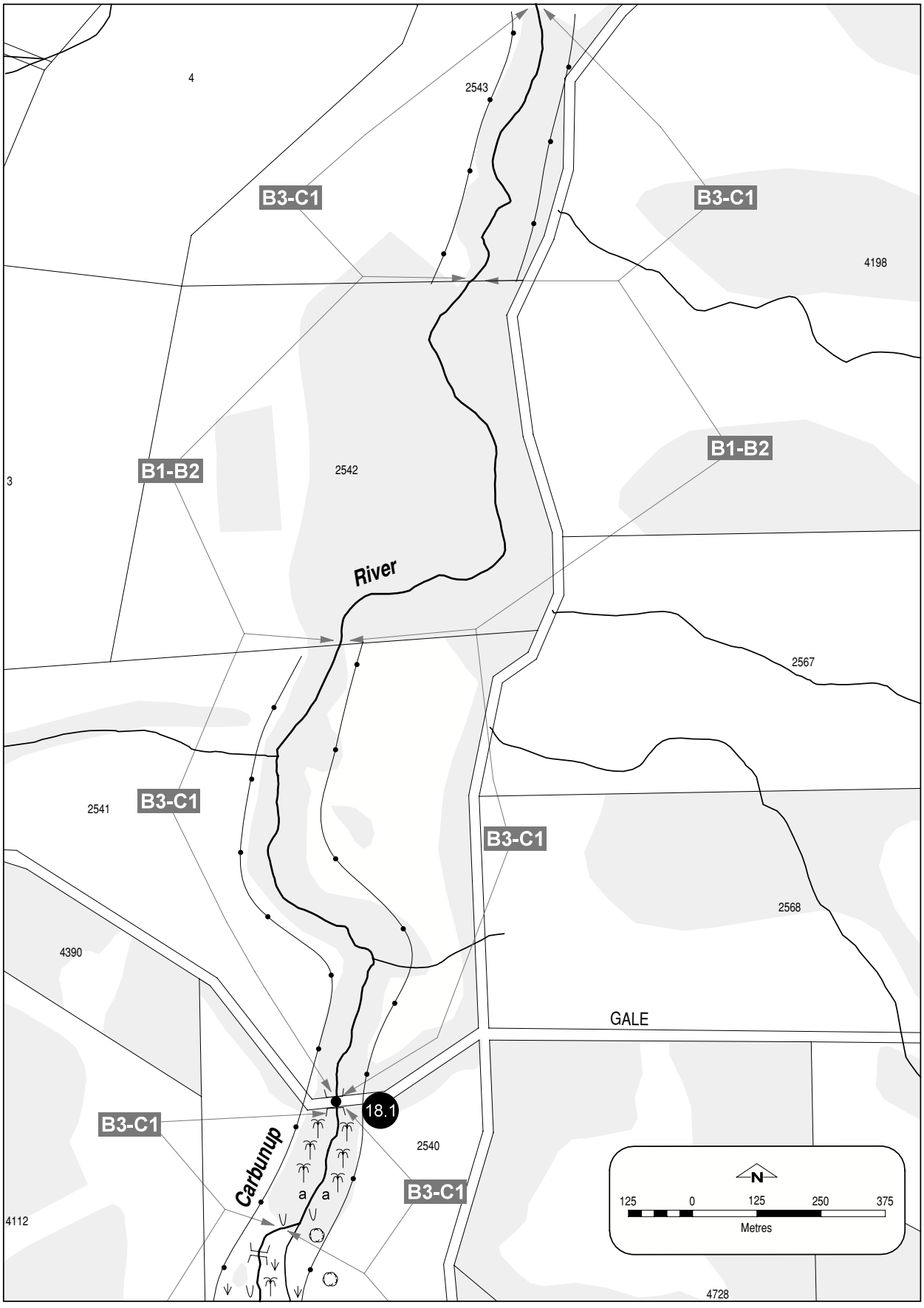
Map 1d

The river moves from the Treeton Hills land system into the Yelverton land system south of Gale Road. Several tributaries join as it meanders northwards towards Geographe Bay.

Summary Information

Distances from river mouth (approx.)	16 - 18 km
Loc./lot numbers of adjacent properties	2543; 2542; 2541; 2540
Date surveyed	1997 & 1999
Foreshore condition rating	B 32% B3-C1 63% C 5%
Vegetation cover	A significant stand of original medium jarrah-marri forest exists mid-way through this section. A narrow band of fringing tea tree in the southern part is supported by steep embankments.
Land use	Grazing, forestry and horticulture.

Issues	Management Advice
Vegetation	Where the foreshore retains some native vegetation, spot control of pasture grasses and infilling with native seedlings will begin to shade out the weeds. Where stock access is prevented, areas that currently support tea tree (*Agonis linearifolia*) will show some self-regeneration.
Weeds	Continued weed control will be necessary to reduce fire risk, especially whilst native species are being established. Weeds likely to be found through this section can be identified in Appendix 3.
Erosion and stock access	Undercutting has occurred and parts of the bank are vulnerable to collapse. Controlling stock access will allow for revegetation of the foreshore, resulting in more stable banks and greater soil cohesion. Stock may be watered from troughs or on the inside of meander bends where soil deposition naturally occurs. Stabilised crossings may be established where exposed ironstone occurs through this section. Stock access should be limited in the north and south of this section where grazing occurs. Preventing stock access to the existing tea tree surrounding the bridge at Gale Road will help to protect this bridge.



Carbunup River Map 1d

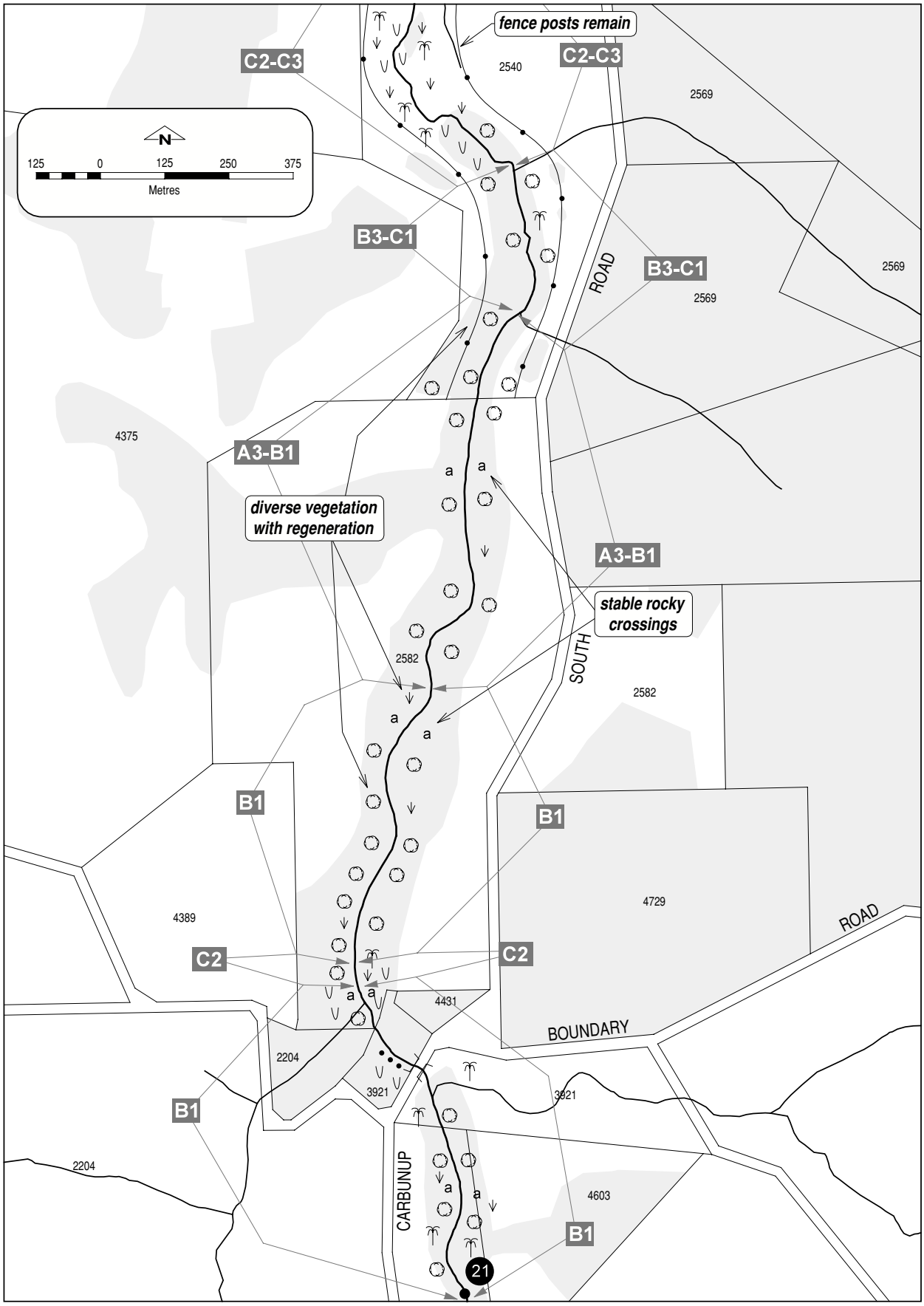
Map 1e

The river meanders northwards through the Treeton Hills land system to the west of Carbunup South Road.

Summary Information

Distances from river mouth (approx.)	18 km - 21 km
Loc./lot numbers of adjacent properties	2540; 2582; 4431; 3921; 4393
Date surveyed	1999
Foreshore condition rating	A 14% B 57% B3-C1 10% C 19%
Vegetation cover	Some healthy, diverse native vegetation that is managed with intermittent stock access. A good example of the original jarrah-marri forest. Excellent specimens of Western Australian blackbutt (*Eucalyptus patens*) can also be found.
Land use	Grazing with hay cutting and some hobby horticulture and apiary.

Issues	Management Advice
Vegetation	The practice of cutting hay in paddocks along the river is a good management technique for maintaining healthy foreshore vegetation. It would be a useful exercise to place markers in the ground at the line where pasture currently meets the native vegetation in order to determine, over time, whether the foreshore vegetation is increasing or retreating. Consolidating the vegetation in the southern part would provide more stable embankment Although some natural regeneration may occur where stock is controlled, direct planting would give more reliable results. Vegetation should be replaced where it has been removed from Loc.3921 in order to limit erosion and weed infestation.
Weeds	Weed control will be necessary where stock control occurs. It will also be required in some areas to allow for native vegetation to be successfully established.
Erosion and stock access	Controlling stock access in the southern part will help to reduce the level of erosion.



Carbunup River Map 1e

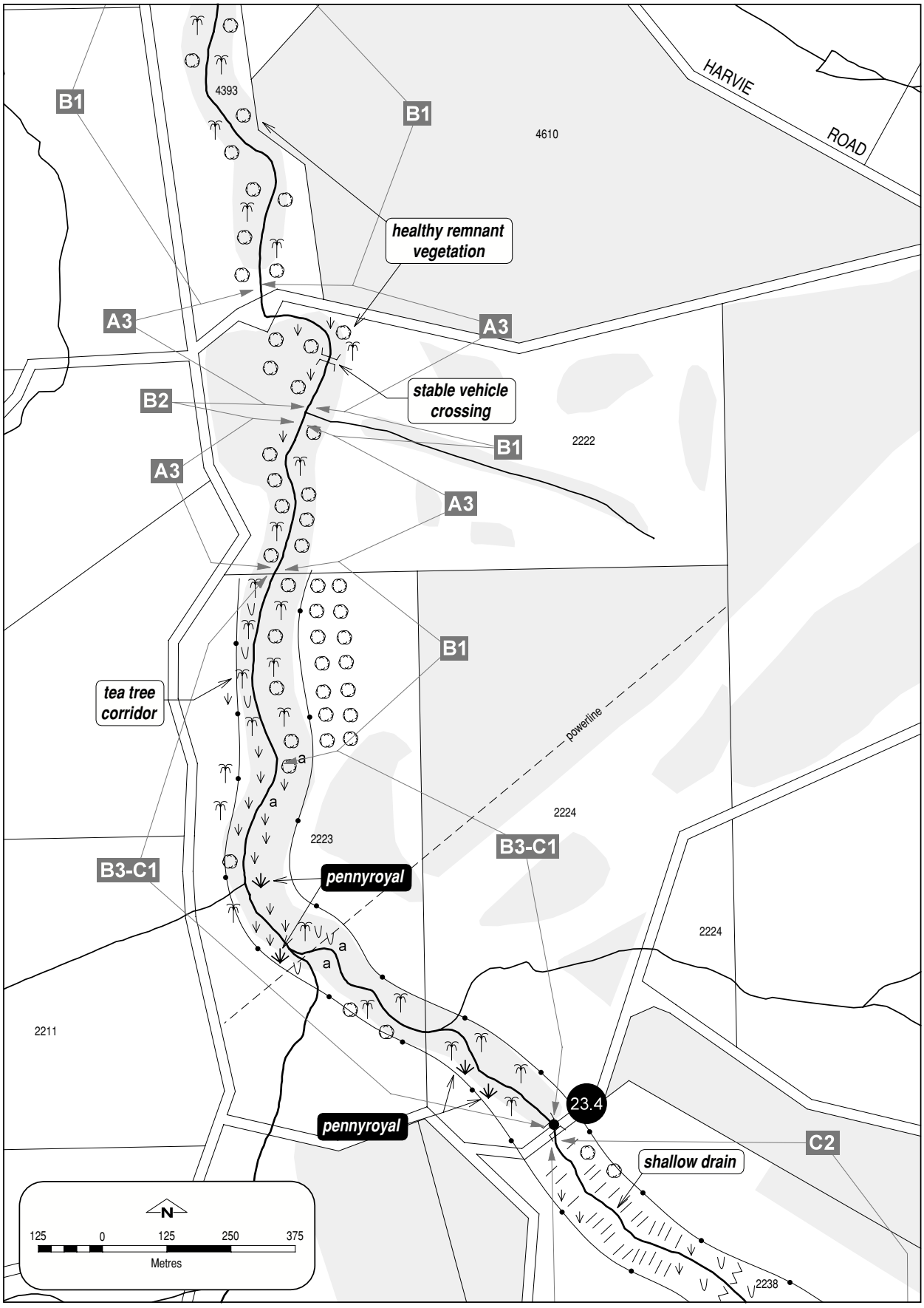
Map 1f

The river meanders across the Treeton Hills on the Blackwood Plateau. A number of permanent pools are present.

Summary Information

Distances from river mouth (approx.)	21 km - 23 km
Loc./lot numbers of adjacent properties	493; 2222; 2223; 2224; 2238
Date surveyed	1999
Foreshore condition rating	A 19% B 27% B3-C1 38% C 16%
Vegetation cover	The area of viticulture supports healthy fringing vegetation with large marri, jarrah and WA blackbutt trees. *Beaumea vaginalis* provides excellent cover of the banks in the middle and northern parts. A corridor of tea tree occurs about midway. Fringing vegetation has been completely lost from the northernmost part.
Land use	Grazing and viticulture.

Issues	Management Advice
Weeds	The most troublesome weeds through this section are pennyroyal and some *Juncus mircocephallus*. Control typically requires successive chemical treatments.
Erosion and stock access	In the middle and upper part the site characteristics allow for a relatively straight fence to be established. At several points exposed ironstone provides a stable crossing for stock. In the uppermost part, controlling stock access would allow for native vegetation to limit nutrient run-off and filter the water moving downstream.



Carbunup River Map 1f

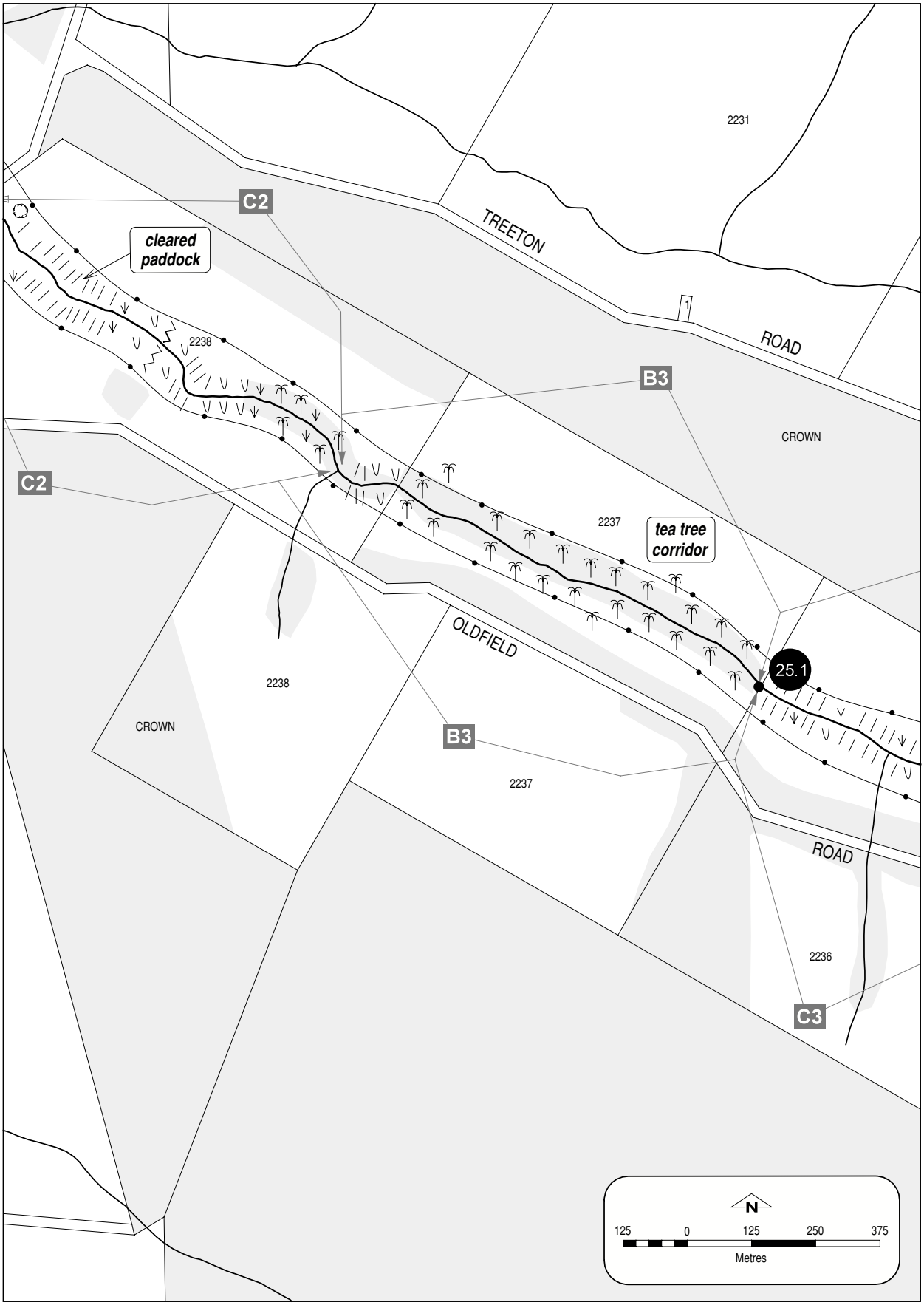
Map 1g

The river travels in a northwesterly direction between Oldfield Road and Treeton Road. This section through the Treeton Hills has a broad U-shaped channel with a swampy floor.

Summary Information

Distances from river mouth (approx.)	23 -25 km
Loc./lot numbers of adjacent properties	2238; 2237; 2236
Date surveyed	1999
Foreshore condition rating	B 44% C 56%
Vegetation cover	Most of the land has been cleared for grazing but original jarrah-marri stands occur on the upper valley slopes. In the middle, strong growth of tea tree has formed a corridor along the river channel. There are a few isolated trees (jarrah,marri, WA blackbutt).
Land use	Cattle grazing

Issues	Management Advice
Vegetation	Revegetation of cleared areas with native vegetation would increase the potential for filtering of nutrients from paddock run-off. Ripping and mounding parallel to the river channel would allow for the effective establishment of vegetation. Including some shading overstorey (jarrah, marri, WA blackbutt) in areas of revegetation would provide additional shade and shelter for stock. Revegetation species can be seen in Appendix 1, site 7.
Weeds	Weed control will be necessary in order to establish vegetation. The shade subsequently produced by the native overstorey could be expected to limit the growth of *Juncus microcephallus.* If the length of the river is fenced, monitoring of weed growth for fire risk prevention should be undertaken. It is likely that the regrowth of tea tree will out-compete pasture grasses in the long term where stock access is limited.
Erosion and stock access	Extending the cover of the existing tea tree to cleared areas would assist in binding the soil and limiting erosion. Controlling stock access to stabilised crossing points would further limit erosion and reduce the level of nutrient entering the waterway. The land managers have discussed consolidating crossing points in this section.



Carbunup River Map 1g

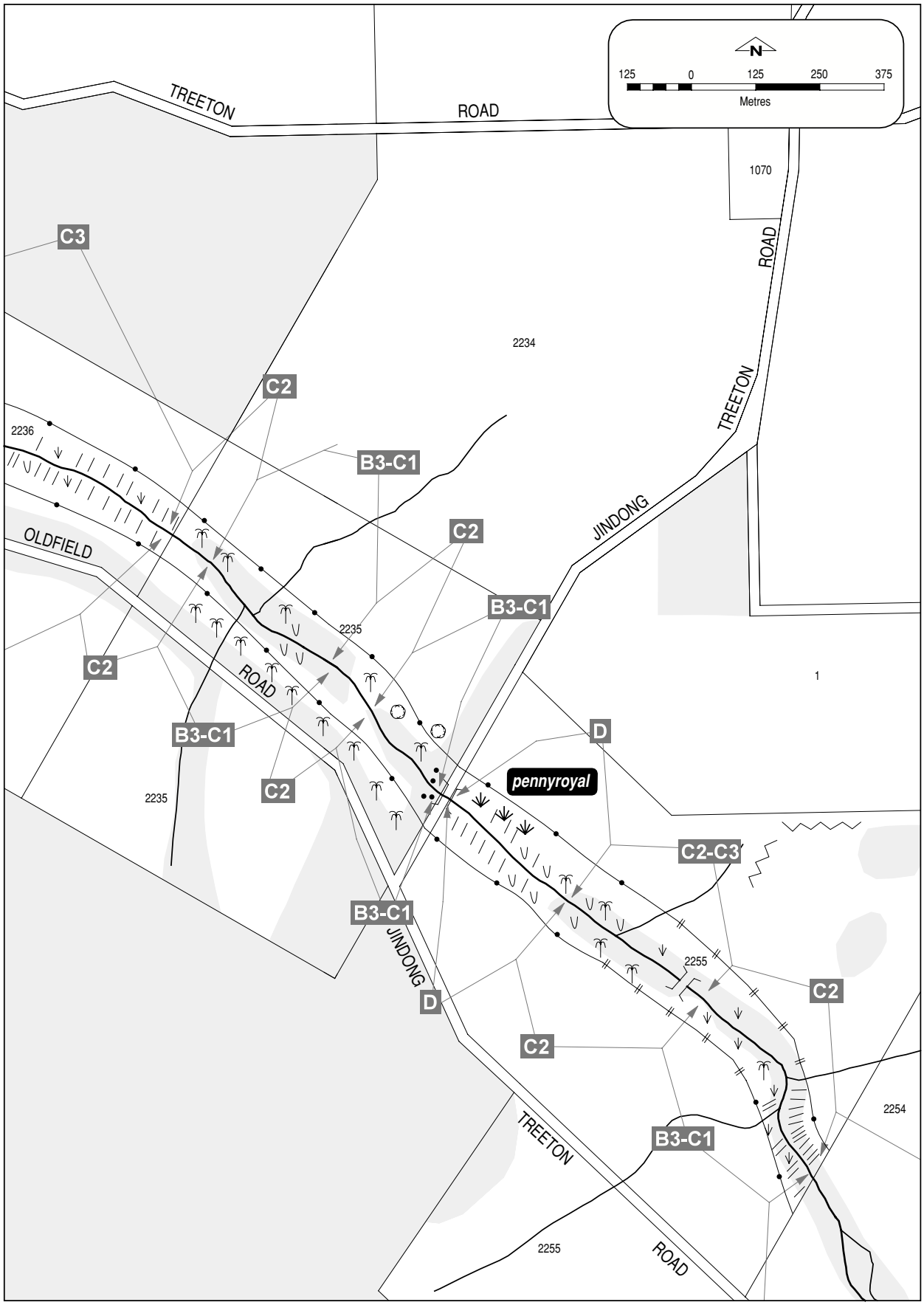
Map 1h

The river crosses Jindong-Treeton Road and flows on the northern side of Oldfield Road.

Summary Information

Distances from river mouth (approx.)	25 km - 27 km
Loc./lot numbers of adjacent properties	2236; 2235; 2255
Date surveyed	1999
Foreshore condition rating	B3-C1 30% C 56% D 14%
Vegetation cover	This section is interspersed with tea tree cover and a cleared channel. Some isolated overstorey vegetation is also present on the foreshore west of Jindong-Treeton Road. Loss of vegetation has reduced the effect of shade and soil cohesion along the banks so that growth of rushes has proliferated and erosion is present in parts.
Land use	Dairying and cattle grazing.

Issues	Management Advice
Vegetation	Native rushes, *Juncus pallidus* and *J.pauciflorus*, provide excellent soil cohesion and should be maintained along the foreshore. Land managers report that traditional treatment limits the spread of these rushes into pasture. Revegetation species can be seen in Appendix 1, site 7.
Weeds	Pasture grasses and pennyroyal occur through this section and should be controlled, The planting of shade trees will assist this.
Erosion and stock control	In parts the existing tea tree is being undermined by incision. Further erosion and bank collapse is likely to occur without protection of the remaining vegetation. Consolidating the existing belt of tea tree and preventing stock access will assist. Establishing some native vegetation along the cleared channel will limit erosion and reduce infestation of the channel by pasture and weeds. Revegetation will also contribute to nutrient bio-filtering of paddock run-off, provide a continuation of the natural river corridor and provide shade and shelter for stock. Where there is erosion from a gravel raceway, the water can be slowed down by placement of rocks or it could be diverted across the paddock or through an area planted with rushes and sedges.



Carbunup River Map 1h

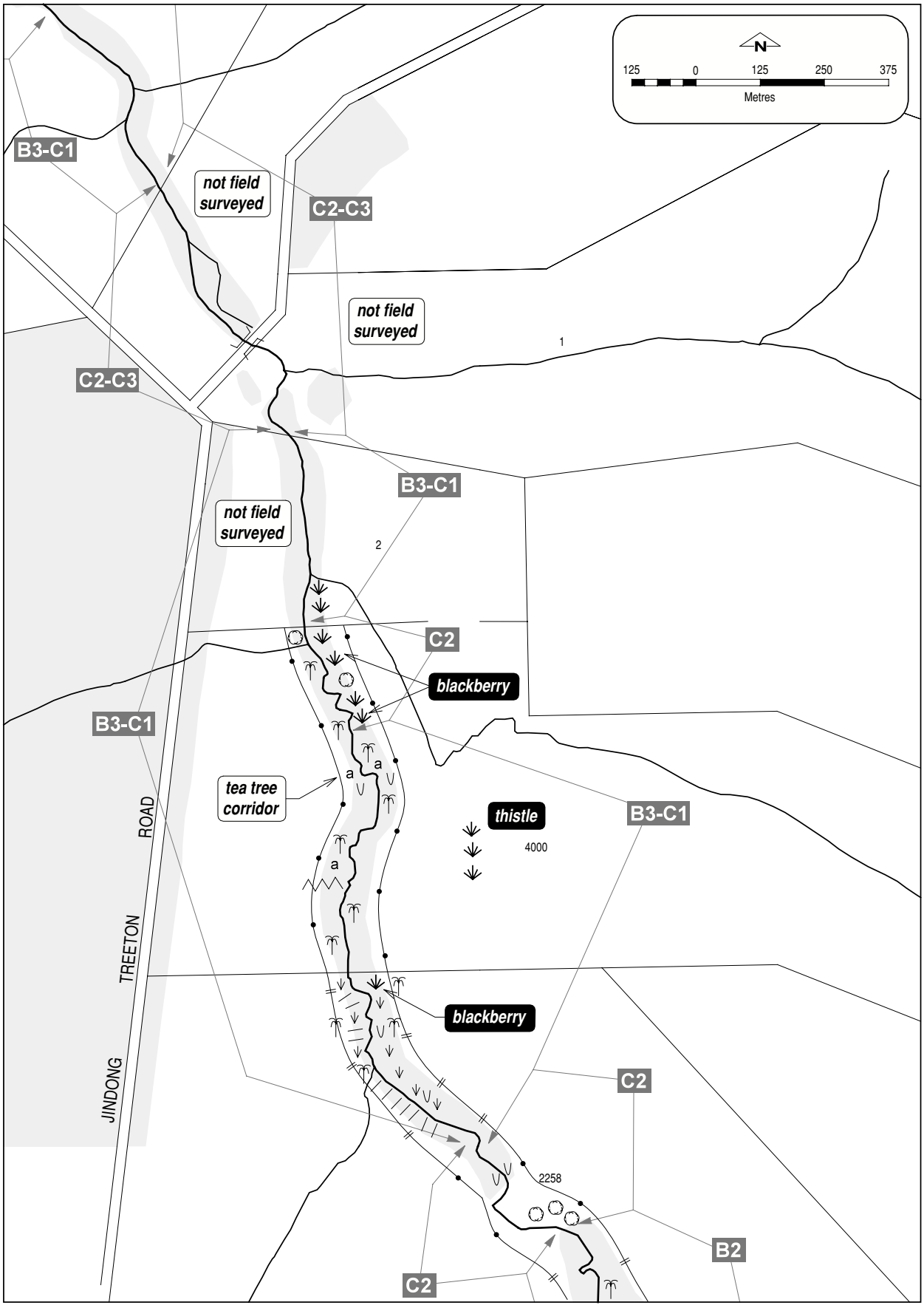
Map 1i

The river travels northwards from the uppermost private property along its length (east of Jindong-Treeton Road) and crosses Hubert Road. The lower reaches were not field surveyed. Remote observation and examination of aerial photographs were used for a condition rating. The management advice does not apply to the lower reaches.

Summary Information

Distances from river mouth (approx.)	28 km - 33 km
Loc./lot numbers of adjacent properties	2254; 1;2; 4000; 2258
Date surveyed	1999
Foreshore condition rating	B 7% B3-C1 61% C 32%
Vegetation cover	A tea tree corridor covers most of this section Some overstorey vegetation of jarrah, marri, WA blackbutt occurs in the lower parts. A timber belt has been established in the upper part as a means of protecting the river channel and providing income from an alternative crop.
Land use	Cattle grazing and intensive livestock raising.

Issues	Management Advice
Vegetation	Appendix 1, site 7 provides a good reference list for suitable rehabilitation species. The tea tree corridor does not show significant regeneration and new recruits are needed. Establishing some tall shading species would contribute to the protection of the banks as well as providing shade and shelter for stock
Weeds	Control and eradication of weeds including blackberry and thistle should be continued. Chemical control may be the most effective treatment of *Juncus microcephallus.*
Erosion and stock access	Controlling stock access will increase vegetation health and cover as well as limiting erosion and assisting in filtering nutrient run-off from paddocks. Crossing points should continue to be utilised and maintained.



Carbunup River Map 1i

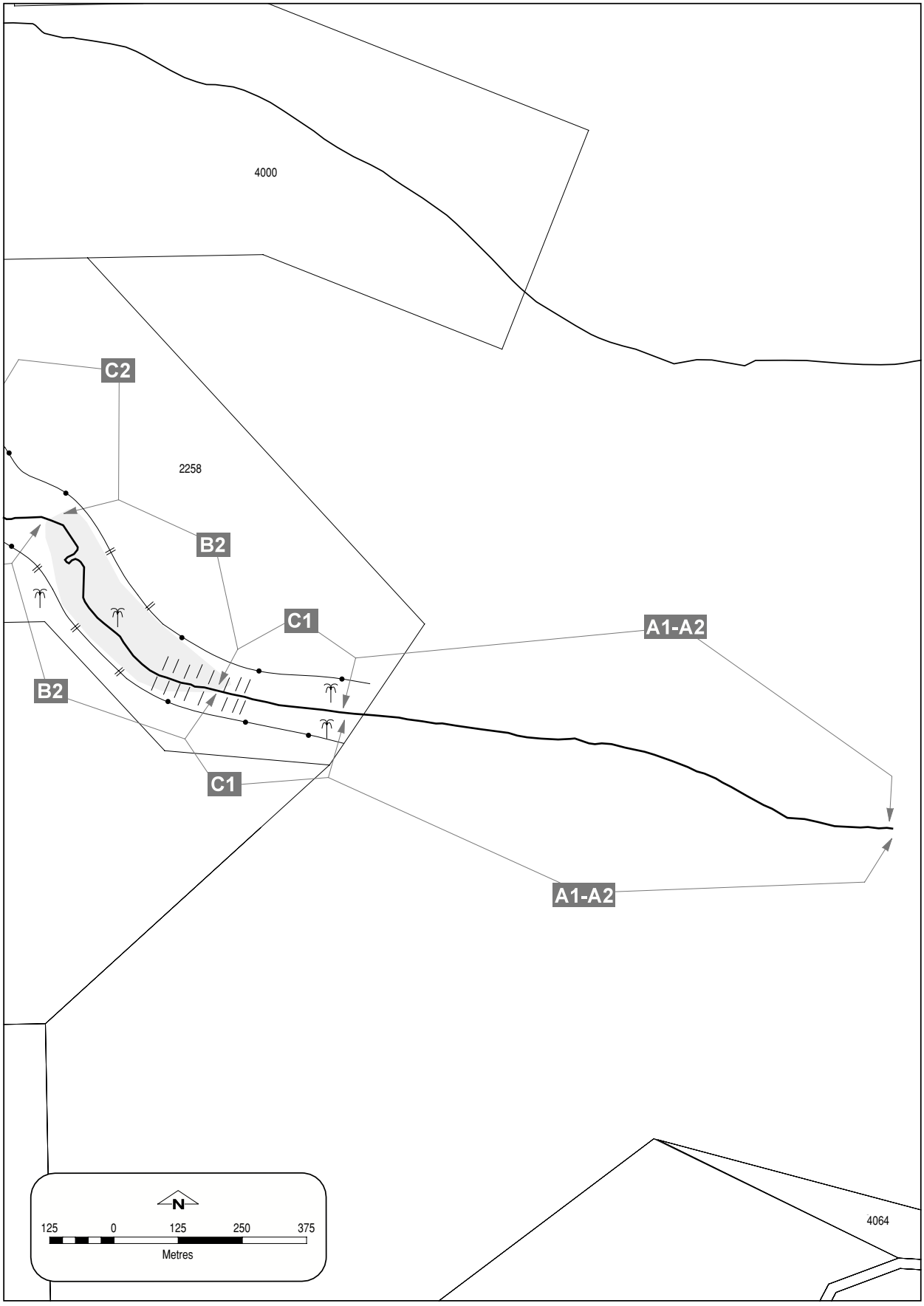
Map 1j

The Carbunup River originates in this section, with its headwater streams located in the Treeton State Forest, in the Treeton Hills. Where the river is located in the State Forest, the foreshore and surrounding area is in excellent condition.

Summary Information

Distances from river mouth (approx.)	33 km -35 km (the headwaters extend a bit further south making the total length of the river approximately 38 km.
Loc./lot numbers of adjacent properties	2258; Treeton State Forest
Date surveyed	1999
Foreshore condition rating	A 55% B 29% C 16%
Vegetation cover	The original vegetation cover is jarrah-marri forest with pockets of bullich (*E. megacarpa*) and WA blackbutt (*E. patens*) in the depressions.
Land use	Cattle grazing and State Forest production.

Issues	Management Advice
Vegetation	Further regrowth in areas infested with weeds including *Juncus microcephallus* and pasture grasses would be encouraged by planting tall shading trees. Establishing some fringing vegetation along the uppermost part of the river channel would provide improved nutrient and sediment filtration of paddock run-off.
Weeds	Short-term control by chemical means may be necessary to establish seedlings.
Erosion and stock access	The land manager will control a small area of erosion through a soil stabilisation technique (tyres or logs buried into the soil profile).



Carbunup River Map 1j

5.2 Summary of findings

The survey produced the following overall assessment of the foreshore conditions along the river. The ratings along the east and west bank have been averaged.

Condition Rating	Description	Total length km	Total %
A	pristine to slightly disturbed	4.5	13
B	moderately degraded, weeds present, soil disturbance	22	61
C	poor, soil exposed, little foreshore vegetation	8	24
D	drain	1	2

Table 4: Overall condition rating of the foreshore.

Summary information of the condition rating along the Carbunup River shows that 61% of the river is B grade foreshore. Land managers are in a fortunate position to protect and enhance the river's health for the long term. Acting to consolidate areas with vegetation loss and decline will greatly improve the overall condition of the river and the quality of water travelling through its system. Protection and maintenance at this stage of health will reduce management impositions in the future.

The foreshore is not in pristine condition; it has limited degradation caused by loss of vegetation and weed infestation. Protection and enhancement of native vegetation may often be a case of controlling stock access, encouraging regeneration of existing bush and keeping weeds in check.

Where the detailed maps 1a to 1j show B3 - C1 grade foreshore, this indicates that more vegetation has been lost and erosion occurs in parts. Often the vegetation that remains on the foreshore is limited to a corridor of tea tree without the tall shading trees such as jarrah and marri, of the original vegetation cover.

C grade foreshore is recorded along 24% of the Carbunup River. Here the foreshore has incurred significant loss of vegetation cover and the soil has often been exposed and is prone to sheet and gully erosion. Stock access usually prevents the regeneration of native tea tree. Where this grade of foreshore occurs, the nutrient filtering capacity of native vegetation has been largely lost and there are significant breaks in the natural corridor along the river. Controlling stock access and replacing some fringing vegetation will improve the condition of this foreshore.

D grade foreshore was recorded for only 2% of the Carbunup River. Fortunately, complete loss of vegetation cover is limited to small areas and often the heavy nature of the soils prevents more significant erosion from becoming widespread. Controlling stock access and replacing native vegetation will limit erosion, increase the filtering of nutrient from paddock run-off and consolidate the corridor along the river.

The ratings accorded to sections of the river covered by the individual maps shown earlier in this section are displayed in Table 5.

	A grade %	B grade%	B3-C1 grade %	C grade %	D grade %
Map 1a	25	43	12	20	
Map 1b	14	27	32	27	
Map 1c		39	24	31	6
Map 1d		32	63	5	
Map 1e	14	57	10	19	
Map1f	19	27	38	16	
Map 1g		44		56	
Map 1h			30	56	14
Map 1i		7	61	32	
Map 1j	55	29		16	
Total %	11 %	32 %	28 %	27 %	2 %
Total km	4 km	12 km	10 km	10 km	1 km

Table 5: Detailed section ratings along the Carbunup River.

The occurrence and vigour of the native tea tree (*Agonis linearifolia*) continues to provide beneficial cover of the Carbunup River. It is important to ensure that regeneration of the tea tree occurs in order for this cover to be maintained. Without regeneration, the existing vegetation may decline and may not be replaced. Taller shading trees can provide excellent stabilisation of areas of tea tree as well as providing shade and shelter for crops and stock.

The requirement for control of stock access along the foreshore of the Carbunup River is shown in Table 6. Approximately 15 km along the Carbunup River could benefit from the control of stock access.

Access should be controlled in a way that is appropriate to the land use and site characteristics. It is recommended that land managers obtain advice from the Water and Rivers Commission regarding the dynamics of stream flow, when considering fencing.

Condition rating	WEST BANK recommend control access (m)	EAST BANK recommend control access (m)
A	-	654
B	2389	2057
C	5070	5159
D	465	329
B3-C1	8062	6173
Total	15 586 (42%)	14 372 (38 %)

Table 6: Requirements for control of stock access along the river.

Table 7 indicates the scale of degradation in areas requiring rehabilitation work along the Carbunup River. Three levels of degradation are distinguished:

1. Areas exhibiting severe erosion and/or bank damage which threatens to get worse in the short term. Area exhibiting major weed infestation.

2. Areas showing either limited erosion or the first signs of erosion, or which are prone to erosion due to the absence of fringing vegetation, or areas having infestations of declared weeds (eg. arum lilies).

3. Areas that retain substantial fringing vegetation that is becoming progressively degraded by livestock or significant weed infestations (eg.flat weed).

Map Number	Weed control	Erosion Control	Stock control	Revegetation
Map 1a	3	1	3	2/3
Map 1b	3	1	2	2/3
Map1c	3	1	2	2/3
Map1d	3	1	2	2/3
Map1e	1	3	2	2/3
Map1f	1	2	2	2/3
Map1g	2	1/2	1/2	2/3
Map1h	1	2	2	2/3
Map1I	1	2	2/3	2/3
Map1j	3	3	3	2/3

Table 7: Scale of degradation along the Carbunup River.

1 = exhibiting severe degradation
2 = moderate degradation
3 = limited degradation

6. Rehabilitation techniques

As indicated at the beginning of the previous chapter, the problems of riverine rehabilitation and the solutions to them can be complex and interrelated.

It is recommended that staff at GeoCatch or Water and Rivers Commission be contacted for specific technical support and advice.

However, the following general rehabilitation techniques may be considered.

6.1 Controlling stock access

Controlling the movement of stock in riparian land and managing grazing pressure is a key element of protecting waterways.

Fencing to permanently exclude stock is one option. Others include temporary electric fencing, permanent fencing for intermittent grazing, or adjusting the land use to reduce pressure, such as cutting for hay adjacent to the river.

Fencing enables the land manager to control the duration, number and season when stock are in the riparian area. It also allows use of the riparian land for alternative activities such as timber production and forage production.

In some regions, land managers have chosen to use fences as a means to control, rather than exclude grazing altogether. Limited grazing is periodically permitted without interfering with regeneration.

Types of fencing

The type and placement of fencing used should be influenced by the land use and site specific characteristics such as landform. Fences are ideally placed set back from the top edge of the stream bank or valley slope (Figure 10). The greater the distance, the more effective the buffer. A setback will allow the establishment of perennial vegetation to assist in soil stabilisation and nutrient filtering.

Placing fences too close to the channel may allow the bank to be undermined. It is important to consider the potential impacts of flooding when erecting fencing.

Hanging fences

These are usually built across the stream to prevent stock from straying into the riparian area during low flow conditions. Hanging fences have drop panels that are lifted by the water flow and hang down when there is no flow. The greater the flexibility in panel movement, the less likely they will be damaged by debris travelling downstream.

Electric fences

Electric fences can be used across streams or alongside streams. They can be permanent or portable and generally require less maintenance than traditional fences.

Drop fences

Drop fences are designed to be manually or automatically lowered flush to the ground to allow access (or in expectation of a flood).

Electronic fences

Electronic fences are an alternative to traditional fencing and are reported to be cheaper (LWRRDC, 1996). Stock wear a receiver ear tag and transmitter boxes are located to form an internal boundary. The transmitters initially emit an audio signal and then an electric impulse if the boundary is crossed.

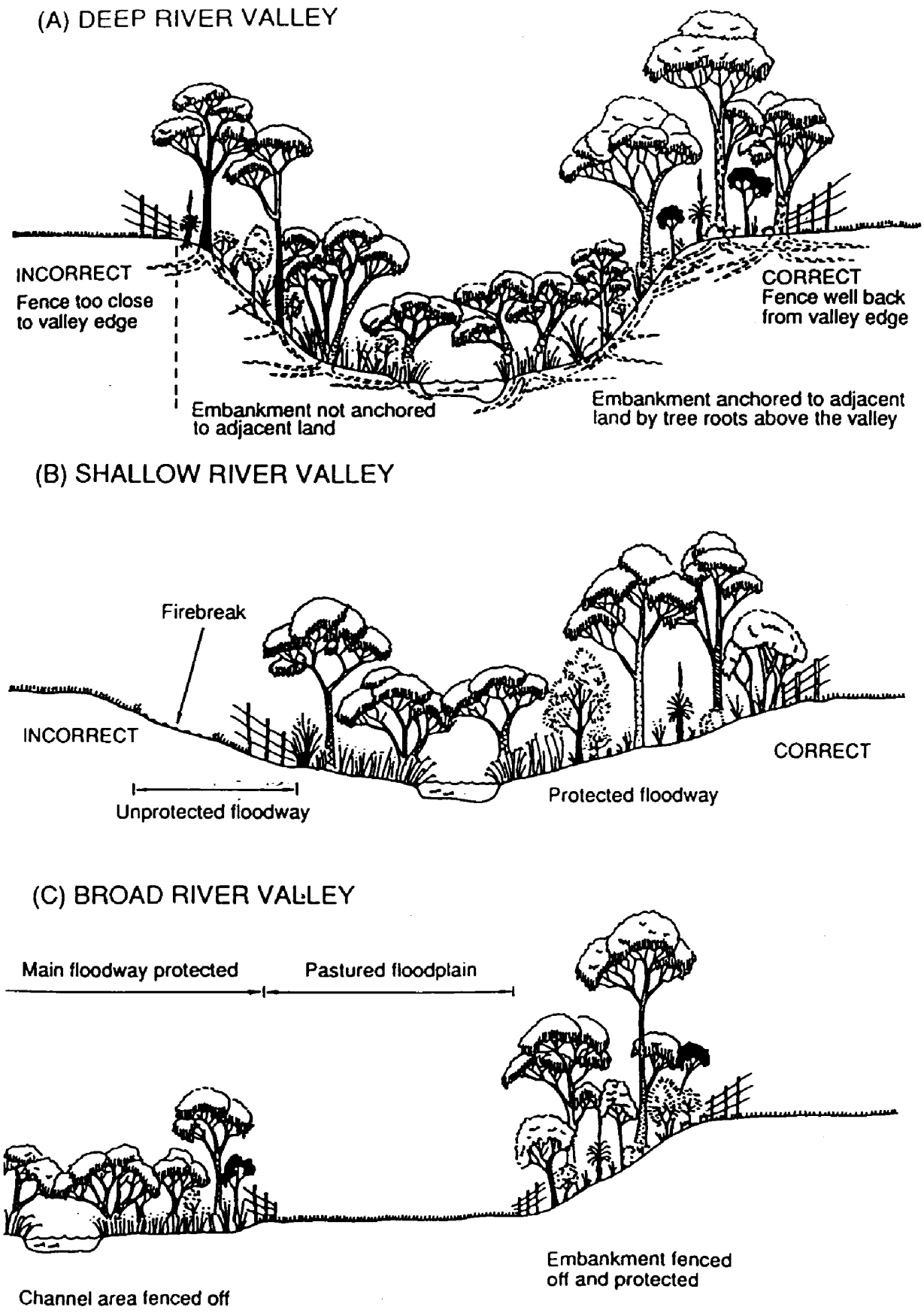


Figure 10: The correct placement of fences in relation to river form (APACE Green Skills & Pen, 1997).

6.2 Stock watering

Watering stock from streams is achieved through sound placement of access points.

It is ideal to utilise an area of exposed bedrock and these are commonly found along the Carbunup. The inside of a meander bend or a point bar is a preferred location. A walkway may be completed by compacting gravel, laying concrete or placing logs parallel to the stream.

Filling troughs from upslope dams is a cheap way to water stock. Alternatively, pumping from the river with the use of solar pumps is increasingly popular.

There is also considerable interest in the nose pump operated by cattle, which activate a piston and a diaphragm to pump water into a trough[4].

Stock watering from rivers and troughs has been compared. A series of field trials in Canada showed that the source of drinking water for stock could have a measurable impact on their performance. Trials in 1990 and 1991 demonstrated that 18-month-old steers that watered from troughs gained 23 % more weight over a 70-day period than stock that watered from dams (LWRRDC, 1996).

6.3 Erosion

Erosion is often best controlled by the establishment of native vegetation that anchors the bank and increases the soil root matrix to bind the soil. A combination of large powerful roots from overstorey trees and smaller fine roots from understorey vegetation creates ideal conditions for a stable bank. Preventing increased erosion through protecting riparian vegetation is often cheaper and easier than earthworks associated with repairing significantly eroded areas.

Erosion type, causes and treatment are highlighted below.

Erosion Type	Possible Cause	Ways to Fix
Undercutting	Lack of vegetation	Stabilising the toe of the bank with appropriate native vegetation, such as the sedges and rushes identified in Appendix 1
	Obstruction	Reposition obstruction
	Stock access	Limit stock access
Bank slumping	Undercutting	See above
	Weight of the bank (saturation)	Encourage drainage with appropriate understorey and plant trees away from the edge of the bank
	Lack of supporting vegetation	Revegetate with a range of native understorey and plant trees away from the edge of the bank
	Stock access	Limit stock access

[4] The Kondinin Farm Group completed a survey of different types of pumps that can be read in Farming Ahead, June 1996, No.54.

6.4 Snags or woody debris

Large woody debris (LWD) is an important component of a natural stream that can reduce the speed of flow and provide important refuge and habitat for aquatic fauna.

Woody debris in the channel would need to occupy at least 10 per cent of the cross-section of the channel before it significantly affected the flow velocity or caused flooding (LWRRDC, 1996).

It is recommended where appropriate to utilise the stabilising benefits of woody debris by aligning it with the flow and against the bank, on an angle of less than 45˚ (Figure 11).

This action will protect the bank by directing the flow of water away from the bank towards the centre of the channel.

The use of LWD is recommended on the outside of meander bends where the erosive power of stream flow can be great. Further detail can be found in Volume 7, *Riparian Management Series* (Askey-Doran, M.Hairsine *et al.*, 1998)

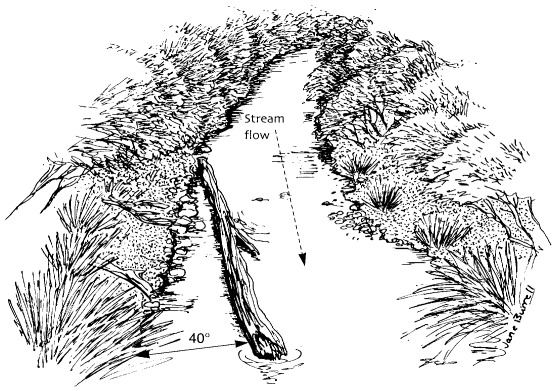


Figure 11: Positioning large woody debris can protect the banks from erosion.

Picture courtesy of Askey-Doran et al. (1998).

6.5 Revegetation

General advice on vegetation rehabilitation can be sought from the Regional Bushcare Facilitator or support staff and local members of the community such as the Busselton and Bunbury Naturalists' Clubs (see contact details in Appendix 3).

Detailed advice can also be obtained from a number of publications including those listed in Appendix 3.

The protection and establishment of vegetation along the foreshore is an effective management action that can provide a bio-filtering effect to improve water quality.

When revegetating for bank stability it is important to consider the following:

- The cause of the erosion is important, eg. direction of flow and existence of obstacles;
- Working with others along the river in a combined approach will have greater benefits than individual action.
- Surrounding land use should influence the area to be planted and the species selected.
- Commercial use of riparian vegetation may be an opportunity, eg., apiaries, timber.
- Vegetative buffers can serve a range of land management goals including intermittent grazing, fodder crops, windbreaks, conservation, nutrient filtering and erosion control.
- Revegetation should be started away from the edge of the bank if erosion is active. Moving down the bank is possible where active erosion is limited and the slope of the bank is moderate (this may require battering).
- Choosing a range of species for revegetation will increase the chances of success.
- Care should be taken with in-stream vegetation. If a lack of channel capacity has caused erosion or is known to be a problem, vegetation should not be established in the channel.

- Carefully consider woody debris.
- Young seedlings are particularly vulnerable to trampling and browsing.

Plant species for rehabilitation

The use of local plant species for revegetation can provide a hardy, low maintenance area. There is little opportunity for local species to become a weed management problem for the immediate or adjacent land. It is appropriate to select local species for revegetation in Reserves.

Appendix 1 provides a list of local plant species that can be selected for revegetation. The list indicates whether the species is a tree, shrub or groundlayer plant. Local nurseries and native vegetation enthusiasts will be able to provide further advice on the growth habit of these species.

Planting in the riparian zone

A general recommendation for planting in the riparian zone is for the seedlings to be set back from the channel so as to avoid disturbance by flooding and erosion. It is recommended to begin planting away from the channel and continue closer to the channel, as the banks become more stable.

Where good foreshore vegetation exists, planting close to the channel with sedges or rushes which tolerate seasonal inundation and flooding can be successful. It is also possible to establish plants on newly deposited sediment if it has been stabilised.

Planting seedlings behind barriers such as logs can protect them from water flow. However, it is important to ensure that the flow does not go over the top of the barrier which will then create a scour on the downside.

Pest management may be necessary to control rabbit and grasshopper damage to seedlings.

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Allowing small patches of weeds to go unchecked may quickly result in a larger infestation. A relatively small amount of effort and funding applied early may limit or prevent future rehabilitation needs.

It is possible to measure whether weeds are advancing or retreating, compared to native riparian vegetation, by placing pegs in the ground along the current line of weeds. During subsequent seasons it will be possible to determine whether this line of weeds is advancing or whether the riparian vegetation is encroaching upon the weeds.

This simple technique allows a ready measurement of the gradual impact of changes to a grazing regime. For instance, removing stock or significantly contributing feed (hay) towards the end of summer when the stock are more likely to graze on native vegetation, should reduce the capacity for weed invasion

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Appendices

Appendix 1: Species list for vegetation rehabilitation

The following table lists the plant species identified at 7 sites along the Carbunup River:

1. Vasse-Yallingup Siding Rd
2. Bussell Hwy
3. Roy Rd
4. Gale Rd
5. Boundary Rd
6. Smith Rd (at property boundary)
7. Treeton State Forest (headwaters)

The list provides information to assist in the selection of species for rehabilitation including: the plants growth form (eg. tree, shrub); method of propagation (eg. seed, vegetatively); and an indication of the ease of propagation (ie. 1= easy, 2= moderate; 3 = difficult but can be done). Few sedges and rushes respond to vegetative dividing except when grown in containers.

Species Name	Form	1	2	3	4	5	6	7	Propagate	Ease	Common name
Acacia divergens	shrub				✗		✗	✗	seed	1	
A. extensa	shrub					✗			seed	1	wiry wattle
A. insolita	shrub						✗		seed	1	
A. myrtifolia	shrub					✗			seed	1	
A. pulchella	shrub	✗					✗		seed	1	prickly moses
Adenanthos barbigerus	shrub			✗					seed	3	
A. obovata	shrub				✗		✗	✗	seed	3	
Agonis linearifolia	shrub	✗	✗	✗	✗	✗	✗	✗	seed	1	tea tree
A. parviceps	shrub			✗	✗	✗	✗	✗	seed	1	tea tree
A. flexuosa	tree	✗	✗	✗		✗			seed	1	peppermint
Agrostocrinum scabrum	herb										blue grass lily
Allocasuarina fraseriana	tree							✗	seed	1	sheoak
A. humilis	shrub						✗	✗	seed	1	
Anarthria prolifera	sedge	✗	✗				✗	✗			
Anigozanthus flavidus	monocot	✗	✗	✗	✗	✗			seed	1	kangaroo paw
Arthropodium capillipes	monocot	✗									
Astartia fascicularis	shrub	✗	✗	✗	✗		✗	✗	seed	1	
Astroloma spp.	shrub						✗	✗			
Banksia. grandis	tree						✗	✗	seed	1	bull banksia
B. littoralis	tree						✗	✗	seed	1	swamp banksia
Baumea vaginalis	rush		✗	✗		✗			s/veg	2	sheath twigrush
Billardiera floribundum	creeper				✗	✗	✗				
Billardiera varfolia	creeper			✗					s/veg	3	
Bossiaea eriocarpa	shrub							✗	seed	1	common brown pea
B. linophylla	shrub		✗						seed	1	
B. ornata	shrub	✗						✗	seed	1	
Brachysema praemorsa	prostrate	✗							seed	1	
Calystachys lanceolata	shrub	✗							seed	1	wonnich
Cassytha racemosa	twiner		✗			✗					dodder laurel
Conostylis aculeata	monocot		✗	✗				✗	seed	2	prickly conost
C. breviscape	monocot							✗	seed	2	
C. setigera	monocot							✗	seed	2	bristly conostylis
Corymbia calophylla	tree	✗	✗	✗	✗	✗	✗	✗	seed	1	marri
Dampiera preisii	herb						✗	✗	s/veg	2	tall sedge

D. tetragona	herb	✗	✗	✗	✗	✗	✗	✗			
Dasypogon bromeliifolius	monocot						✗	✗		2	
D. hookeri	monocot						✗	✗		2	pineapple bush
Davesia longifolia	shrub	✗							seed	2	
Desmocladus flexuosus	rush			✗		✗					
Eucalyptus marginata	tree						✗	✗	seed	1	jarrah
E. megacarpa	tree				✗		✗	✗	seed	1	bullich
E. rudis	tree		✗						seed	1	flooded gum
E. patens	tree				✗	✗	✗	✗	seed	1	blackbutt
Gahnia decomposita	sedge				✗		✗	✗			saw sedge
Gompholobium capitatum	herb						✗	✗	seed	1	
Dampiera tetragona	herb	✗	✗	✗	✗	✗	✗	✗			
Grevillea diversifolia	shrub		✗						seed	1	valley grevillea
Haemodorum spicatum	monocot			✗					seed	2	
H. laxum	monocot			✗				✗	seed	2	
Hakea amplexicaulis	shrub						✗		seed	1	prickly hakea
H. lasianthoides	shrub				✗				seed	2	
H. varia	shrub				✗	✗			seed	1	variable –leafed hakea
H. lissocarpha	shrub	✗							seed	1	honey bush
Hibbertia hypericoides	shrub	✗					✗	✗			buttercup
H. cuneiformis	shrub							✗	veg		
Hovea trisperma	shrub							✗	seed	1	common hovea
H. elliptica	shrub							✗	seed	1	oval leafed hovea
H. chorizemifolia	shrub								seed	1	holly leafed hovea
Hypolaena exsulca	sedge							✗			rope rush
Hypocalymma	shrub								seed	2	pink myrtle
angustifolium											
H. cordifolium	shrub						✗		seed	2	
Isopogon sp.	shrub							✗	seed	2	drumstick
Juncus pallidus	rush								seed	1	pale rush
Lasiopetalum floribundum	shrub						✗	✗			
Leucopogon spp.	shrub			✗			✗	✗			
L. verticilata	shrub							✗			tassel flower
Lepidosperma tenue	sedge		✗	✗							
L. squamatum	sedge										
L. effusum	sedge	✗			✗	✗		✗	tissue culture		spreading sword-sedge
L. longitudinale	sedge		✗		✗						pithy sword-sedge
L. tetraquetrum	sedge			✗	✗		✗	✗			angle sword-sedge
L. diffusus	rush					✗		✗			tall mop rush
Lepyrodia glauca	rush							✗			
Macrozamia reidlii	monocot							✗	seed	3	
Meeboldina thysananthus	rush					✗		✗			
Meeboldina scariosa	rush		✗	✗		✗	✗	✗			velvet rush
Mesomelaena tetragona	sedge							✗			semaphore sedge
Mirbelia dilatata	shrub	✗	✗	✗	✗	✗		✗	seed	1	

Melaleuca incana	shrub								seed	1	
Patersonia occidentalis	monocot							✗	seed	3	purple flag
P. longifolia	shrub							✗			snotty gobble
Platysace compressa	herb						✗	✗			
Pultenea pinifolia	shrub	✗							seed	1	
Pimelia rosea	shrub						✗		seed	3	
Podocarpus drouynianus	shrub					✗		✗			emu bush
Scaevola pilosa	shrub	✗					✗				
Sollya heterophylla	creeper		✗						seed	3	bluebell
Stylidium spp.	herb						✗	✗			trigger plant
S. laciniatum	herb						✗	✗	seed	3	fringed trigger
Stypandra inbricata	monocot			✗				✗			
Synaphea sp.	shrub										
Taraxis grossa	rush		✗	✗							
Tetraria capillaris	sedge			✗				✗			
Thomasia spp.	shrub						✗	✗			
Turbastes glaucescens	rush		✗			✗		✗			rush
Viminaria juncea	shrub		✗						seed	1	swishbush
Xyris lacera	monocot		✗		✗				seed	3	
Xanthorrhoea preissii	shrub							✗	seed	3	balga
X. gracilis	monocot							✗	seed	3	

Appendix 2: Descriptions of weeds potentially found along the Carbunup River

The following descriptions are predominantly taken from Western Weeds (1997).

Acacia melanoxylon - blackwood wattle

A large Eastern States tree to 30 m with dark grey furrowed bark. Acacia melanoxylon has dark green phyllodes and cream flowers in spring. It is a popular timber tree with an aggressive regeneration habit, spreading by root suckers and seed.

Alisma lanceolatum[5]

A perennial emergent waterplant that is naturalised in Western Australia. Alisma lanceolatum has lanceolate leaf blades and pinkish white flowers above a slender branched stalk occurring in summer.

Alternathera pungens - khaki weed

A native American prostrate perennial found in moist habitats. It has long (50 cm) stems that root at the nodes, spiny fruits and pungent flowers. The leaves are broadly elliptical.

Angallis arvensis - pimpernel

A hairless, spreading annual with almost square stems and opposing ovate leaves. Small (1 cm) flowers are held on stalks above the leaves. There are two varieties, with scarlet or blue flowers.

Briza maxima - blowfly grass

A slender tufted annual to 60 cm with flat linear leaves. The inflorescence is a loose panicle of nodding spikelets (3-15) produced in spring.

Chamaecytisus palmensis - tagasaste

An upright bushy shrub or small tree (to 4 m) with drooping hairy branches and leaves with three leaflets. The winter/early spring flowers are scented and creamy-white. This Canary Island native has been widely planted for fodder and readily escaped into road verges and elsewhere. Acacia saligna (native) has more recently been favoured over this species for fodder and land rehabilitation.

Cirsium vulgare - spear thistle

A biennial to 1.5 m with spiny winged leaves continuing down the spiny winged stems. The purple flower heads (4 cm) have a flat-topped cluster of spiny bracts. It is a native of Europe and western Asia.

Cotula australis - carrot weed

A small hairy annual with fern-like leaves often found in lawns. In spring produces small white to pale yellow flowers on long slender stalks.

Cyperacea spp.

A tall (to 1.5 m) sedge forming clumps with cylindrical stems and umbrella-like inflorescences. A native of North Africa, it flowers in spring.

Hypochaeris radicata/glabra - flatweed

Annuals or short-lived perennials, with a basal rosette of leaves and yellow dandelion-like flowers which open in the morning and close in the afternoon. A native of Europe they can flower all year round but tend to flower most prolifically in spring.

[5] This plant was originally identified as Alisma platago-aquatica, however it is believed that this plant is now referred to throughout Western Australia as Alisma lanceolatum.

Solepis prolifera - budding club rush

A perennial (up to 60 cm) plant of waterways, it reproduces vegetatively at the shoot tips. A native of South Africa, it is a common weed in moist areas.

Juncus spp.

Juncus is a large genus with species that hybridise easily and are often difficult to tell apart. Along the Carbunup River in paddocks and where clearing has occurred, Juncus microcephallus is common. It is a native of South Africa of tufted appearance, with hollow cylindrical stems and red-brown capsules.

Juncus usitatus is a tufted rhizotomous leafless perennial with terete green stems to 70 cm. It has a loose open inflorescence and a stem with no strengthening bars across the pith.

Lactuca serriola - prickly lettuce

This native of Europe has prickly, deeply lobed leaves held vertically and prickly stems.
It is a summer growing annual with a basal rosette of leaves.

Lathyrus tingitanus - tangier pea

An annual climber with winged stems and spikes of pink or bright cerise flowers (3 cm). A native of Europe.

Lavendula spp. - garden lavender

A grey-green, many stemmed bushy shrub with crowded linear leaves that are very aromatic. Flowers are produced in winter and spring on a stalk from the shoot tip. A native of the Mediterranean region.

Mentha pulegium - pennyroyal

A rhizotomous perennial, native to Europe and western Asia. Stems are prostrate with relatively small, elliptical leaves, until elongating to produce the flowering stem. Mauve flowers in dense clusters along the upper stem in late spring and summer with a strongly mint-like aroma.

Paspalum dilitatum - paspalum

A tufted rhizotomous perennial to 1 m tall. The inflorescence is a panicle to 20 cm long. A native South American pasture grass.

Rumex crispus - dock

An erect perennial to 1.5 m with narrow, lanceolate leaves. The flowers are in dense erect, branched spikes. A native to Europe and Asia.

Penisetum clandestinum - kikuyu

A rhizotomous perennial which can form large colonies up to 2 m tall. Summer flowers are hidden amongst the leaves. A native to East Africa, it is a popular pasture grass and lawn species.

Rubus fruticosus - blackberry Declared Plant

A prickly perennial shrub, with sprawling stems which root on contact with the ground. Plants are spread by seed, have white flowers in late spring followed by red fruits that ripen to black.

Phalaris angusta - canary grass

A tufted annual to 1.5 m tall with an inflorescence as a dense cylindrical panicle of tightly packed spikelets (3-17 cm long). A summer flowering pasture grass, native to South America.

Polygala myrtifolia - milkweed/butterfly bush

Bushy shrubs to 2 m with oval leaves and pale purple flowers; it is a garden ornamental.

Emex australis - doublegee

A hairless annual, usually prostrate with ovate leaves and green flowers in clusters in winter. The woody fruit has three rigid spines. This South African native was introduced as a salad vegetable and probably in hay.

Tryfolium spp - clover

A large genus introduced for pasture grasses, with at least 28 species naturalised in Western Australia

Raphanus raphanistrum - wild radish

An annual herb up to 1m tall, with bristly leaves. Yellow petals are approximately 5-10 mm long. A native to Europe.

Solanum nigrum - nightshade

A sprawling or erect annual to 60 cm with oval dark green leaves and small star-shaped white flowers. Blackberry nightshade has a dull black berry and is native to Europe.

Sonchus asper - prickly sowthistle

An annual from Eurasia and North Africa with yellow flowers opening in the morning and closing in the evening. A stout upright annual to 1.5 m with hollow stems and large leathery leaves with prickly margins.

Vellereophyton dealbatum - white cudweed

A white woolly annual found in undisturbed moist areas. A native of Europe.

Zantedeschia aethiopica - arum lily Declared Plant

A robust dark green succulent herb with smooth leaves in an elongated heart shape. White tubular flowers occur predominantly in spring.

Appendix 3: Useful contacts

- Sussex LCDC
  Chair - Neil MacDonald
  9755 4123

- GeoCatch - Geographe Catchment Council
  62 Kent Street Busselton, WA 6280
  Tel: 9754 4331

- Ribbons of Blue
  Tel: 9754 4331

- Busselton Naturalists' Club
  Bernie Masters
  Tel 9727 2474

- Water and Rivers Commission
  Rivercare Officer
  Tel: 9721 0666

- Bunbury Naturalists' Club
  Gordon Paine
  9797 0673

- AGWEST, Busselton
  1 Queen St Busselton, WA 6280
  Tel: 9752 1688

- CALM, Busselton
  14 Queen St Busselton, WA 6280
  Tel: 9752 1677

- Coastcare Facilitator - South West
  Tel: 9725 4300

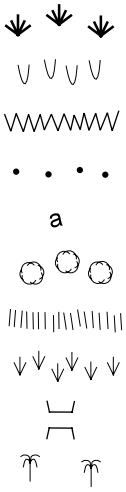
- Bushcare Facilitator - South West
  Tel: 9725 4300

- Streamlining Project Officer
  Tel: 9757 3727

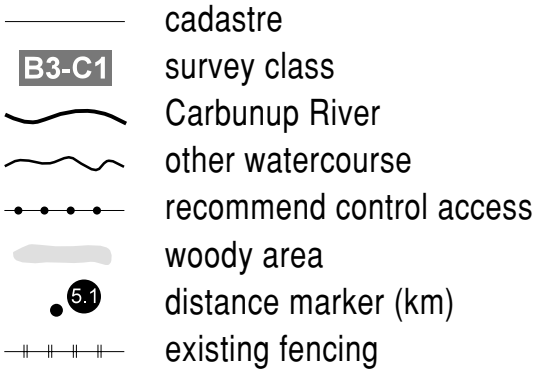
- Land for Wildlife, Off Reserve Conservation Officer
  Tel: 9752 1677

Notes

LEGEND : CARBUNUP RIVER MAPS



weed infestation
sheet erosion
gully erosion
bared streambank
access point
planted trees or remnant trees
herbaceous and lawn
dense rush / sedge growth
bridge
tea tree



cadastre
survey class
Carbunup River
other watercourse
recommend control access
woody area
distance marker (km)
existing fencing

CONDITION RATING

A grade foreshore	A1	pristine
	A2	near pristine
	A3	slightly disturbed
B grade foreshore	B1	degraded / weed infested / isolated erosion
	B2	degraded / heavily weed infested / isolated erosion
	B3	degraded / weed dominated / isolated erosion
C grade foreshore	C1	erosion prone / little foreshore vegetation / weeds
	C2	soil exposed / eroded / weeds
	C3	eroded and subsiding / weeds
D grade foreshore	D1	ditch eroding
	D2	drain / weed dominated

Cadastral data supplied by the Department of Land Administration

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