



River Action Plan for the Cape Naturaliste Streams



2006



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Jingarmup Brook, Meelup Brook,
Dolugup Brook, Dandatup Brook
and Dugulup Brook

2006

Prepared for the Geographe Catchment Council

by

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through the South West Catchments Council



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How to use this river action plan

This River Action Plan (RAP) was prepared for the Geographe Catchment Council (GeoCatch); landholders within the catchments of the study area; and organisations or community groups involved in managing these stream foreshores. It contains a detailed description of the current health of the waterways, provides information on current management issues, and recommends strategies to address these issues.

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

For landholders

Landholders should turn to the relevant map in Chapter 7 and read the associated management issues and recommendations. They should then read Chapter 5 to determine why these issues are considered to be a priority for remediation, and Chapter 6 to determine the most appropriate actions to address the issues. Information on the general study area, methodology used to develop this action plan and background information about stream ecology can be found in Chapters 1, 2 and 3.

For the Geographe Catchment Council

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

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

- Native vegetation species found on each stream foreshore.
- Common weeds that were found.
- Advice for planning projects.
- Useful contacts for further information and assistance.

Acronyms

LCDC	Land Conservation District Committee
DEC	Department of Environment and Conservation
GeoCatch	Geographe Catchment Council
DoW	Department of Water
DAFWA	Department of Agriculture & Food
RAP	River Action Plan
SoB	Shire of Busselton
UCL	Unallocated Crown Land

Disclaimer

GeoCatch is proudly supported by the Department of Water. However, this publication does not necessarily represent the views of the Department of Water or the State Government.

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Summary

This river action plan provides advice about the current health and management needs of the Jingarmup, Meelup, Dolugup, Dandatup and Dugulup Brooks flowing from Cape Naturaliste into Geographe Bay.

The Pen-Scott Foreshore Condition Assessment Method (Pen & Scott, 1995) was used to undertake assessments of the foreshore of these waterways with local landholders and community members between September and December 2005. A summary of the foreshore condition ratings of each brook is presented in Table 1 below.

Key issues identified

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

- Invasion by weeds, especially garden escapees on all waterways;
- Incremental clearing or degradation of fringing vegetation on all waterways except the Dolugup Brook;
- Removal of large woody debris from the stream channel, particularly on the upper north branch of the Dandatup Brook;
- Erosion and sedimentation of the waterways, especially the upper reaches of the Jingarmup and Dandatup Brooks;
- The absence of foreshore fencing on all except one location where stock currently have access to the foreshore. Stock management is needed on the Jingarmup and upper Dandatup Brooks and part of the Meelup Brook;
- The prevalence of dams and the need to effectively manage flows from these structures;
- Water quality degradation, particularly on the Dugulup Brook.

Table 1: Summary of foreshore condition rating of Cape Naturaliste streams

Condition	Jingarmup		Meelup		Dolugup		Dandatup		Dugulup	
	Length	%	Length	%	Length	%	Length	%	Length	%
A (pristine)	-	-	8.5	30	1.2	95	1.4	10	0.85	15
B (weedy)	3.5	20	9.2	34	0.05	5	5.2	36	2.7	50
C (erosion prone)	7.9	45	10.2	36	-	-	5.2	36	1.9	35
D (ditch)	5.9	35	-	-	-	-	2.5	18	-	-

General recommendations to improve the health of the Cape Naturaliste streams

It is recommended that landholders and land managers consider the following:

1. Undertake control of weeds identified in this plan using the advice provided.
2. Ensure weed control is followed by replanting with local native species to prevent re-invasion.
3. Where controlled burns are undertaken near foreshore areas, ensure that these are followed by weed control and monitoring of weed invasion; and ensure that a sufficient period is allowed between burns to enable recovery and seed germination of native species. A minimum of four years is recommended though a longer period may be needed for some species.
4. Retain and protect the remaining riparian vegetation of the Cape Naturaliste streams, including along drains and tributaries.
5. Retain woody debris in the stream channel and use the advice provided to re-position (rather than remove) debris where needed.
6. Where stock are present fence the river to enable control of stock access.
7. Use available funding to defray the costs of fencing or rehabilitation projects.
8. Where there are bypass valves on dam walls, open them at first flows and keep them open during all low flow periods.
9. Where there are no bypass valves (for example on older dams), install a siphon system to allow environmental flows.
10. Plant vegetation corridors that support the movement of wildlife and re-create their habitat. This includes working with neighbours to provide continuous habitat for native fauna.
11. Revegetate dams and waterways with local native species, noting the specific advice about dam rehabilitation in this plan.
12. Implement management techniques that minimise soil erosion and nutrient loss to waterways such as: buffer strips, soil testing and fertiliser management plans and maximising vegetation cover on the soil.
13. Where deep sewerage facilities are available, connect your property as soon as possible to reduce your contribution of nutrients and bacteria to local waterways, groundwater and Geographe Bay.

It is recommended that GeoCatch consider the following:

1. As a key priority, work with the Shire of Busselton and the Department of Water to identify and implement methods of improving the long term protection of local riparian vegetation. Areas of good quality riparian vegetation are still being cleared or degraded and it is more cost effective to protect these areas now than to restore them later after further degradation has occurred.
2. Coordinate a weed control program that assists landholders to achieve control of priority weeds at the same time. This will vastly increase the efficiency and effectiveness of weed control measures in the catchment.
3. Provide targeted information to landholders of the Cape Naturaliste streams about garden plants with potential to become invasive weeds on waterways; and on more alternative landscaping plants including local native species.
4. Provide support to community groups working on river restoration projects in the catchment.
5. Provide support to landholders to undertake revegetation using a diverse suite of local native species (including trees, shrubs, sedges, rushes, herbs and native grasses).
6. Encourage and support community efforts to fence the rivers to restrict stock access.
7. Apply for further funding to continue to subsidise the cost of revegetation projects and fencing.
8. Work with landholders and engineers from the Department of Water to address erosion and sedimentation in the catchment.
9. Seek funding to undertake further surveys of native fish and freshwater crayfish in the Meelup Brook, since this waterway was only surveyed at its mouth.
10. Work with Ribbons of Blue and other community organisations to increase community awareness and knowledge of the Cape Naturaliste streams catchment, focusing on natural assets, values, and threats.
11. Work with the Department of Fisheries to eradicate the population of the introduced aquarium fish Rosy barb from the Jingarmup Brook. This is expected to be feasible since the population is currently confined to the lower reaches of the brook.

Funding assistance and technical advice to implement management recommendations is now available through GeoCatch. For more information, please contact GeoCatch on 9781 0111.

1. Introduction

Background

Since 1997 the Geographe Catchment Council (GeoCatch) has led an ongoing program of river restoration within the Geographe catchment in consultation with local Land Conservation District Committees and community groups. The program has focused on the development and subsequent implementation of River Action Plans for individual waterways, with extensive landholder and community involvement at all stages of the process. Waterway restoration has continued to be a priority area of action for GeoCatch over this time and to date there are nine River Action Plans undergoing implementation. These include plans for the Capel, Abba, Sabina, Ludlow, Vasse and Carburnup Rivers in addition to the Yallingup Brook, Gynudup Brook and Tren Creek.

In 2005 the Geographe Catchment Council received funding from the National Action Plan for Salinity and Water Quality (NAP) to develop this new River Action Plan for the streams flowing from Cape Naturaliste into Geographe Bay and to contribute to implementation of the above existing plans. NAP funding for this project was provided as part of a joint partnership between GeoCatch, Department of Environment, Cape to Cape Catchments Group, Leschenault Catchment Council and the Warren Catchment Council via the South West Catchments Council Regional Investment Plan for 2005-2006.

Study aims

The primary aims of this River Action Plan are:

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

2. Study area

The study area of the project included the primary channels of five waterways flowing from Cape Naturaliste into Geographe Bay. These were:

- The Jingarmup Brook, which meets the ocean at Eagle Bay;
- The Meelup Brook, which meets the ocean at Meelup Beach;
- The Dolugup Brook, which meets the ocean at Castle Rock Beach;
- The Dandatup Brook, which flows through the Dunsborough town site; and meets the ocean at Vincent Street.
- The Dugulup Brook, which also flows through the Dunsborough town site and meets the ocean near the intersection of Gifford Road and Geographe Bay Road.

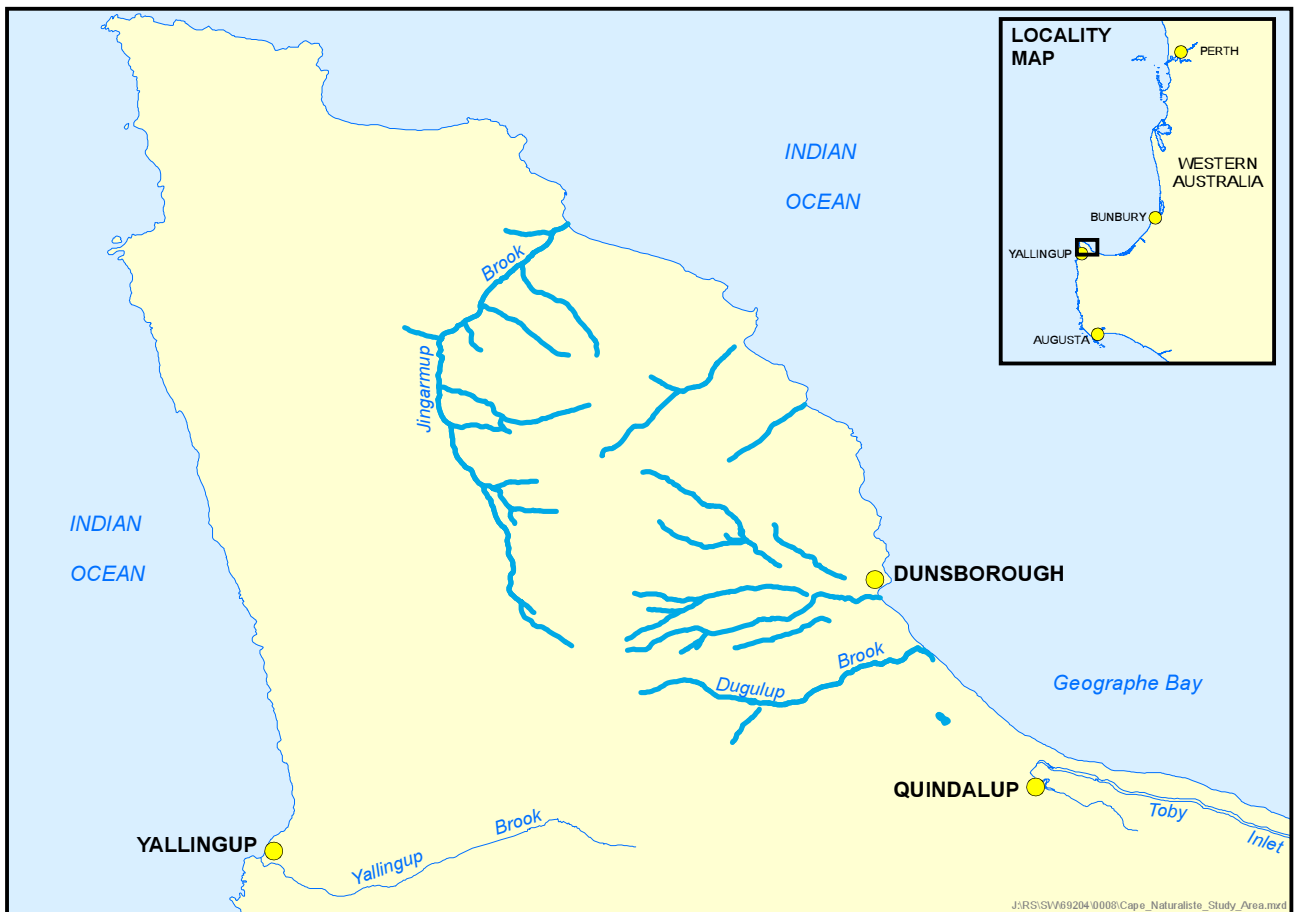


Figure 1: Study area

The waterway systems and catchments

Jingarmup Brook

The Jingarmup Brook is the longest creek system in the study area. The headwaters rise on farmland on the eastern slopes of the Leeuwin – Naturaliste ridge in proximity to Vidler Road. From this point the brook flows northwards with two main tributaries extending to the east before passing beneath Cape Naturaliste Road. It then continues through farmland in a north-easterly direction with one tributary to the north-west and three tributaries extending to the south-east before passing through the Eagle Bay town site where it meets the ocean near Fern Road.

The majority of the catchment and foreshore of this system has been extensively cleared for agricultural development, although the western portion of the catchment lies within the Leeuwin-Naturaliste National Park. Most of the Jingarmup Brook foreshore is grazed by sheep and/or cattle, yet stocking rates are relatively low. Clearing within the catchment of the brook has increased the velocity of water flow and accordingly the lower reaches have become incised over time.

Meelup Brook

The Meelup Brook rises on a small reserve that adjoins the eastern side of Cape Naturaliste Road near its intersection with Eagle Bay Road. From here the brook flows through farmland and a winery before passing through the Meelup Regional Park, a Class 'A' Shire reserve. There are a number of minor tributaries that join the brook from within the park.

Roughly half of the Meelup Brook catchment is contained within the Meelup Regional Park. Aside from a number of walk trails, firebreaks and old gravel extraction sites, Meelup Regional Park is completely vegetated. The vegetation is for the most part in excellent condition throughout and there is a high diversity of species including a number of rare plant species. Large areas of foreshore within park area are in excellent condition.

Dolugup Brook

The Dolugup Brook is the smallest of the waterways within the study area and lies entirely within the Meelup Regional Park. Its headwaters rise to the south

of Meelup Beach Road and flow alongside Castle Rock Road before entering the ocean at Castle Bay. Under normal circumstances the vegetation along this waterway is too dense to penetrate for the purposes of survey; however a recent control burn in the area provided the opportunity to include this waterway in the foreshore assessments. Existing disturbances to the foreshore and catchment of Dolugup Brook are minimal. These include an old gravel pit within its catchments, and recreational use of the area around the mouth of the brook. The Dolugup Brook provides a useful reference site to compare the condition of other waterways in the study area that are associated with more extensive human disturbance such as agricultural and residential development.

Dandatup Brook

The Dandatup system has three main branches that join at Cape Naturaliste Road. The northerly branch rises south of Dandatup Place in the Meelup Hills rural residential development. This branch flows in a south-easterly direction through these 'lifestyle lots' with one tributary flowing into this branch from the west. The middle branch is known locally as 'Butterworth Springs'. This and the most southern branch both rise on farmland to the east of the Cape Rise residential development and flow eastward to join the north branch at Cape Naturaliste Road. From this point the brook flows through the Dunsborough town site behind Curtis Street then between Beach Road and Bushland Close before meeting the ocean at Vincent Street in old Dunsborough. An additional old tributary to the Dandatup Brook flows alongside Norfolk Street and Sayers St before entering a roadside drain at Beach Rd that flows into Geographe Bay. While this tributary no longer joins the Dandatup Brook, it was included within the study area, given that it was historically part of the overall system.

The majority of the upper Dandatup Brook has been cleared for agricultural development. Extensive development of the middle catchment has occurred for rural residential development, involving creation of two to three hectares 'lifestyle lots'. This type of development has also seen the construction of numerous on-stream dams. The lower reaches of the brook are surrounded by residential development and the hydrology of this section has been extensively modified by the creation of artificial drains; piped

sections of the waterway; and increased flow velocity resulting from the extensive areas of hard pavement that come with residential areas. Despite these modifications, there are still some small sections of public foreshore that are in surprisingly good condition on the Dandatup, given their location within the centre of a town site.

Dugulup Brook

The Dugulup Brook rises on farmland to the east of Vidler Road, about one kilometre north of Caves Road. From here it flows through private land, including the site of the old Banamah Wildlife Park, then through a number of small lifestyle lots where it is joined by a small tributary to the south flowing from Big Rock Reserve and surrounding properties. From here the brook continues east on private land and enters foreshore reserve between Caves Road and the Naturaliste Heights residential subdivision. From here it passes beneath Cape Naturaliste Road near the police station and flows behind the existing shopping centre car park. It then continues within foreshore reserve to its mouth near the intersection of Gifford Road and Geographe Bay Road.

Climate

Cape Naturaliste experiences a Mediterranean climate with hot, dry summers and mild, wet winters. The average rainfall is approximately 825 mm (Bureau of Meteorology, 2006). This average has declined over the past few decades. The *State Water Strategy* (Government of Western Australia, 2003) notes that 'Climate change has contributed to a 10-20 percent reduction in rainfall in the south-west of the State over the last 28 years, a subsequent 40-50 percent reduction in run-off into our dams and reduced recharge of groundwater'.

Landform and Soils

The Cape Naturaliste streams flow from and are predominantly contained within the Leeuwin Block geomorphic zone. The lower reaches of the Dugulup Brook extend into the southern margins of the Swan Coastal Plan. Two main land systems of the Leeuwin Block occur in the study area: the Cowaramup Uplands System and the Wilyabrup Valleys System. On the Swan Coastal Plain the Spearwood Land System occurs within the study area (Dept of Agriculture, 2003).

Within each land system there are a number of soil landscape subsystems. The channel and foreshore of the Meelup, Dolugup, and Dandatup Brooks, and the lower Jingarmup Brook lie within the Wilyabrup valleys soil subsystem. Upstream of Cape Naturaliste Road, the Jingarmup Brook soil subsystems are split between Cowaramup gentle slopes, Cowaramup vales and Cowaramup flats. The upper Dugulup Brook occupies the Metricup rocky valleys subsystem which is also part of the Cowaramup soil system. The lower reaches flow through the Yelverton deep sandy flats which is part of the Spearwood soil system of the Swan Coastal Plain. A description of the key soil types found within each of these soil subsystems as described by the Department of Agriculture (2003) *AgMaps Land Profiler* CDROM is presented below.

Wilyabrup Valleys Soil System

- Wilyabrup valleys: Loamy gravels, duplex sandy gravels, stony soils, brown deep loamy duplexes and friable red/brown and brown loamy earths.

Cowaramup Uplands System

- Cowaramup vales: Minor v-shaped valleys with loamy gravels and duplex sandy gravels.
- Cowaramup gentle slopes: Loamy gravels and duplex sandy gravels.
- Cowaramup flats: Loamy gravels, duplex sandy gravels, semi-wet soils and grey deep sandy duplexes.
- Metricup subsystem rocky valleys: Shallow gravels with loamy gravels and duplex sandy gravels.

Spearwood Land System

- Yelverton deep sandy flats: Pale deep sands, gravelly pale deep sands, and yellow deep sands and sandy earths.

Flora and Fauna

Vegetation complexes

Mapping of vegetation complexes shows that the dominant vegetation system occurring along the waterways of this plan is the Wilyabrup Ww2 vegetation complex, comprising a tall open forest of Marri (*Corymbia callophylla*) and Peppermint (*Agonis flexuosa*) on flats and valleys (Mattiske and Havel,

1998). This description matches much of the vegetation communities observed during the field surveys, although there were certainly variations to this on each waterway. For example the Jingarmup, Dandatup and Dugulup Brooks had extensive areas near the coast that were dominated by Stout paperbark (*Melaleuca preissiana*) and Freshwater paperbark (*Melaleuca raphiophylla*). The upper reaches of the Jingarmup Brook foreshore extends into the Cowaramup Cw2 complex, which is characterised by a woodland of Jarrah (*Eucalyptus marginata* subsp. *marginata*), Marri (*Corymbia callophylla*) on slopes and a low woodland of Stout paperbark (*Melaleuca preissiana*) – Swamp banksia (*Banksia littoralis*) on depressions (Mattiske and Havel, 1998). The Cw2 complex is a 'poorly represented' system, meaning that there is less than 30% remaining of its original pre-European settlement extent (Connell *et al.* 2000).

Flora

The study area supports a highly diverse range of flora species and many occurrences of declared rare flora, a number of which are orchids. These include critically endangered species such as the Dunsborough spider orchid (*Caladenia visidescens*). There are also a number of flora species that are endemic to Cape Naturaliste (i.e. they grow naturally only at this location) including the Shire of Busselton's floral emblem the bottlebrush *Calothamnus graniticus* subsp. *graniticus*. The high prevalence of rare and endemic flora in the Cape Naturaliste area emphasises the need to preserve remaining stands of intact vegetation communities, including those that occur along the foreshore of waterways.

Fauna

A wide range of native fauna species are known to occur in the Cape Naturaliste area and remnant riparian vegetation provides good habitat for many of these species. Riparian vegetation is particularly important where it has been retained on cleared land and in urban areas as these strips of vegetation frequently provide the only connecting corridors of habitat between larger areas of bushland. While certain native species such as the kangaroo can successfully move over large areas of cleared land, others are dependant on dense native

vegetation to provide shelter from predators such as foxes and feral cats in addition to raptors such as the wedge-tailed eagle. This is particularly true for small birds and for arboreal (tree dwelling) marsupials.

The endangered Western Ringtail Possum (*Pseudocheirus occidentale*) is dependant upon habitat provided by peppermint woodland, which is common along the streams of Cape Naturaliste. Other marsupials known to occur in the area include the Quenda or Southern Brown Bandicoot (*Isodon obesulus*), Brushtail Possum (*Trichosurus vulpecular*), Brush-tailed Phascogale or Wambenger (*Phascogale tapoatafa*) and of course the Western Grey Kangaroo (*Macropus fuliginosus*). There is anecdotal evidence of the presence of the native Water Rat (*Hydromys chrysogaster*) along these streams and it is possible that the Chuditch or Western Quoll (*Dasyurus geoffroii*) and the tiny Western Pygmy Possum (*Cercartetus concinnus*) could also occur in the general area.

A range of waterbirds were observed during the field assessments and these included Pacific Black Duck (*Anas superciliosa*), Maned Duck (*Chenonetta jubata*), Musk Duck (*Biziura lobata*), Black Swan (*Cygnus atratus*), Sacred Ibis (*Threskiornis spiniocollis*), Darter (*Anhinga melanogaster*) and the White-faced Heron (*Ardea novaehollandiae*).

A variety of frogs are known to exist in the area, with their presence noted by their distinctive calls. These include the Western Banjo Frog (*Limnodynastes dorsalis*), Moaning Frog (*Heleioporus eyrei*), Motorbike Frog (*Litoria moorei*), and Slender Tree Frog (*Litoria adelaidensis*). A recent survey of the freshwater fish and crustaceans in the Cape Naturaliste streams found that the native freshwater Marron (*Cherax cainii*) occurred only in the Meelup Brook, but Gilgies (*Cherax quinquecarinatus*) were found in all of streams except the Meelup Brook, which was only sampled at the mouth (Beattie, Morgan, Mitchell and Jury, 2006). The same survey found no native freshwater fish, but a population of the introduced aquarium species Rosy Barb (*Puntius conchonius*) was located on the Jingarmup Brook (Eagle Bay town site). This is the first known wild population of the Rosy Barb to be found in Western Australian and is highly likely to be a result of the deliberate release of aquarium fish (Beattie, Morgan, Mitchell and Jury, 2006).

Heritage

Indigenous heritage

Prior to European settlement, Cape Naturaliste was inhabited and used extensively by Aboriginal people. The Aborigines of the South West Region formed a socio-cultural group collectively known as Nyungar (O'Connor *et al.*, 1995). The group of Nyungar people that occupied the coastal areas of the Geographe Bay Catchment were known as the Wardandi people, 'the people that lived by the ocean and followed the forest paths' (Collard, 1994). This group of people used local waterways as a key food resource in summer, catching fish, turtles and frogs from the rivers and streams and collecting edible plants from the foreshore (O'Connor *et al.*, 1995).

The Wardandi people gave many local places on the Cape the names that are still used today. For example 'Meelup' means 'place of the moon' and 'Quedjinup' means 'place of the quenda' (bandicoot) (Collard, 1994). Wardandi people used the name Quedjinup to refer to the location occupied by the Dunsborough town site and this term is still in general use today to refer to the hills that rise to the south-west of the town. Other place names have been replaced by European names, for example Cape Naturaliste was known to the Wardandi people as 'Kwirree Jeenungup' meaning place of beautiful scenery (Collard, 1994).

Fifteen Aboriginal sites registered with the Department of Indigenous Affairs occur within the Cape Naturaliste streams catchment area. These include artifacts scatters, middens, scarred trees, camps, mythological and ceremonial sites. A large number of sites are also registered from Bunker Bay and Yallingup as well as a range of locations south of the catchment area. Clearly the Cape Naturaliste area was used by the Wardandi people over a long period of time and is of importance to remaining community members. Waterways in general have particular spiritual importance to Aboriginal people, and accordingly consultation with Aboriginal community representatives is required prior to undertaking any activities that may disturb the bed or banks of waterways.

European history and heritage

The following summary of European historical events has been based on information from the report: 'From Quedjinup to Dunsborough': A Brief History Compiled by Claire Guinness (1979). Information about the Bannamah Wildlife Park was drawn from newspaper records held by the Dunsborough Library; unfortunately reference details for these clippings had not been recorded.

The first recorded European visitors to Cape Naturaliste were French explorers aboard the ships '*Naturaliste*' and '*Geographe*' in 1801 and Point Piquet was named during this visit. When in 1830 Governor Stirling and John Septimus Roe visited the area in search of land suitable for settlement, they anchored in Eagle Bay and named this location after their 108 ton schooner 'Eagle'. American whalers frequented the Geographe Bay coast regularly, using the sheltered waters for repairs and replenishment. There were many hundreds of these ships whaling off the coast of Geographe Bay during the 1830s. European settlers took up land in the area in the mid 1930s after settlers in Augusta experienced hardship. George and Henry Chapman walked overland to Vasse and then took up land at Bunker Bay for cattle grazing. American whaling gave way to local whaling operations following a ban on American fishing within three miles of the Geographe Bay coast in 1844. William Seymour started the Castle Bay whaling station in 1846 and this continued until 1872. Remnants of the whaling station are still present at Castle Bay near the banks of the Dolugup Brook. The Seymour's homestead in Dunsborough was also used as a staging house for the coach service to Caves House, then the only accommodation for visitors to Ngilgi Cave in Yallingup. Passengers would be served tea and scones while fresh horses were harnessed, thus signifying the commencement of tourism in Dunsborough.

The Dunsborough town site was officially gazetted in 1879, but land there had been set aside for this purpose since the 1830s. It is believed that Dunsborough (originally spelt 'Dunnsbro'), together with Dunn Bay and Point Dalling, are named after Captain Richard Dalling Dunn, under whom Stirling served on the '*Hibernia 120*'. The local population did not increase significantly until 1957 when Henry Yelverton started a timber mill in Quindalup.

In 1970 Aubrey and Cath Chugg opened the Banamah Wildlife Park on the banks of the Dugulup Brook; at one stage the largest private wildlife park in Western Australia. The park housed more than 40 species of animals including kangaroos, wallabies, quendas, quokkas, eagles, owls, a variety of small birds as well as tammars, deer, fox, camel, guinea pigs, possums and donkeys. One such resident of the park was a large wedge tailed eagle named 'Tom' who became famous as the subject of a petition of 27,000 people to save his life from vermin protectors in Albany. The petition was successful in preventing his destruction and while Tom was not granted complete freedom, he lived for the rest of his days in the park. The park has since closed and the only commercial use of the property is a garden nursery occupying a small corner.

Population dynamics and land use change

Population within the Cape Naturaliste area is increasing rapidly in line with the remainder of the Shire of Busselton. At the last census of 2001 the Shire had an average annual growth rate of 5.1% (Shire of Busselton, 2005). The Dunsborough town site is the key growth area on the Cape and is continuing to expand on its southern and western margins. Some of this expansion is in close proximity to or immediately adjoining the Dugulup and Dandatup Brooks. Land use change in the area is continuing to intensify and in some cases this led to removal of riparian vegetation as part of development of dams, access tracks, and service infrastructure; or simply in order to improve views to the waterways. Such disturbance and fragmentation of habitat poses a significant threat to the health of the Cape Naturaliste streams.

The Cape Naturaliste area is a popular holiday destination and many of the dwellings in the area are used for holiday accommodation. The recent increase in land prices has also made property in Cape Naturaliste an attractive investment option. Excluding urban residents of the Dunsborough town site, over fifty percent of the landholders on the Cape Naturaliste streams do not live in the local area. The high proportion of 'absentee' landholders creates a management challenge since many of the landholders have limited time available for activities such as weed control as they may not visit their property regularly throughout the year.

Community action

There is already a strong and active community involved in the management of the Cape Naturaliste streams and this indicates a bright future for the health of these waterways, providing the management issues identified in this action plan can be addressed by all partners.

A range of Eagle Bay residents and landholders involved with the Residents of Eagle Bay Association (REBA) are actively involved in the restoration of the Jingarmup Brook. A number of initiatives within the town site such as weed mapping, weed control and dune rehabilitation have already been commenced by this group. REBA is also involved in commenting on development proposals that have potential to impact on the health of the Jingarmup Brook.

Meelup Regional Park, containing both the Meelup and Dolugup Brooks, is managed by the Meelup Regional Park Management Committee (MRPMC). This comprises local community members and Shire Council representatives. The MRPMC have already implemented extensive management works throughout the park including rehabilitation; weed control; dieback mapping and management; trail construction; and access management. A detailed restoration program to address erosion on the Meelup Brook is currently underway in response to the draft recommendations of this plan.

The Dunsborough and Districts Coast and Land Care group (DCALC) have achieved extensive rehabilitation works on the Dugulup and Dandatup Brooks within the Dunsborough town site. These works have included re-contouring of deeply incised banks and construction of rock – riffle – pool sequences to arrest erosion problems; replanting of the foreshore with local native species; and weed control programs both prior to and following replanting projects. The Dugulup Brook foreshore downstream of Naturaliste Terrace has been a focus area and detailed planning is in progress to achieve restoration and improved community access from this point upstream to Cape Naturaliste Road. Re-planting and weed control works have also been undertaken by this group on the Dandatup Brook.

3. Stream ecology

To increase understanding of the values, stream function and condition of the Cape Naturaliste streams some information about stream habitats is provided below. This section has been based on a summary prepared by Genevieve Hanran-Smith for the Margaret River Action Plan (2003) and is drawn from *Managing Our Rivers* by Dr Luke Pen (Pen, 1999).

Habitats

There are a great diversity of habitat zones and elements in a natural stream. This variety of habitats supports a diverse range of plants and animals. River and stream fauna of the south-west is illustrated in Figure 2. Flora of the Cape Naturaliste streams is listed in Appendix 1.

Habitat zones

Stream pools

In many years there are very few stream pools on the Cape Naturaliste streams since these are ephemeral (seasonal) waterways. Over the summer any water remaining occurs in deep stream pools, usually confined to the lower reaches of these streams. The pools provide an essential summer drought refuge for many stream fauna, including waterbirds, turtles, water rats, fish, crayfish and shrimp, and are integral to the survival of many aquatic animals. Undisturbed stream pools are usually surrounded by dense fringing vegetation and are well shaded and provided with snags and woody debris along their edges.

Riffles, rapids and cascades

These habitats occur where water flows swiftly over an irregular stream bed, over and between rocks and from one rocky terrace to another. As well as providing habitat for particular macroinvertebrates they have two very important functions. They help to oxygenate the water and the sound they make enables some species to find their preferred habitat.

Runs and low flow channels

Long reaches of unobstructed stream flow, where the flowing water has a flat surface, are often called runs. In the south-west they are the low flow channels that wind their way across the floodplains between pools. The low flow channels are often well supported and overhung by fringing and in-stream native vegetation.

Floodplains and backwaters

In terms of habitats, floodplains are generally broad areas of low flat land adjacent to the main floodway of the river. Each year floodplains are inundated to some degree by floodwater, creating a seasonal habitat which may be used for feeding and breeding by a variety of animals such as tiny crustaceans, birds, frogs and fish. Floodplains may also be part of broader wetland systems which in winter become very swampy through groundwater rise or the build up of rainwater over a clay layer. Floodplains are an integral part of the stream ecosystem. There is an exchange of water, nutrients, and living creatures between the stream and its floodplain, which is essential to the proper functioning of a healthy stream ecosystem.

When secondary channels become disused and form pools they are referred to as backwaters. The still or slow flowing water in the backwater is often the preferred habitat of species that are unable to cope with fast flow.

Habitat elements

Habitat elements are found within the zones outlined above in differing combinations to provide a large variety of habitats.

Riparian vegetation

In regard to habitat, fringing native vegetation is important as it contributes hard tannin-rich leaves to fuel the food web, and provides shade throughout the year helping to keep water temperature low.

Snags and woody debris

Snags are fallen trees and large branches lying in the stream channel. They are important to the ecology of the stream systems. Apart from generally helping to slow the flow of water, woody debris alters its flow, creating eddies and small isolated zones of turbulence or still water which provides 'microhabitats' for a range of tiny animals and plants. Furthermore, tree trunks and branches add a huge surface area to a stream environment, creating a woody habitat for certain species to use for all or part of their life cycle. Tree trunks lying close to or on the stream bed provide cover or a sturdy roof for burrowing animals such as marron and gilgies.

Shade

Shade provides an essential refuge for aquatic animals to escape the heat of the sun, as well as generally keeping the water temperature down.

Aquatic vegetation

Aquatic vegetation includes plants that are found submerged in, floating on or emerging from water. It provides a specialist habitat for certain animals, such as fish and hunting spiders, as well as cover for fish, shrimps and crayfish, and valuable breeding and nursery habitat for fish during spring.

Leaf litter

Leaves and twigs collect in pools or in areas of still or slightly flowing water and form an important microhabitat for a large range of aquatic organisms. These range from large crayfish to microscopic bacteria and fungi which break down organic material and initiate the natural food web. Piles of leaves and twigs can also provide cover for certain fish species, aquatic insect larvae and juvenile crayfish, but only if there is a slight flow of water through the material to maintain well oxygenated conditions.

Rocks and stones

Although vegetation dominates stream habitats in the south-west, rock and stone are important habitat elements. Rocks create a myriad of microhabitat elements in which a broad range of animals and plants can find a home. Rock also limits the growth of trees and shrubs over water and creates sunlit habitat. Finally, the water flow over rocky stream beds helps to oxygenate the water, improving the quality of habitats downstream.

Useful references on stream and river ecology

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

Water and Rivers Commission (2000) *Stream Ecology*. Water and Rivers Commission River Restoration Report No. RR7.

Water and Rivers Commission Water Note 8, *Habitat of Rivers and Creeks*.

Water and Rivers Commission Water Note 9, *The Value of Large Woody Debris (Snags)*.

Water and Rivers Commission Water Note 12, *The Values of Riparian Zones*.

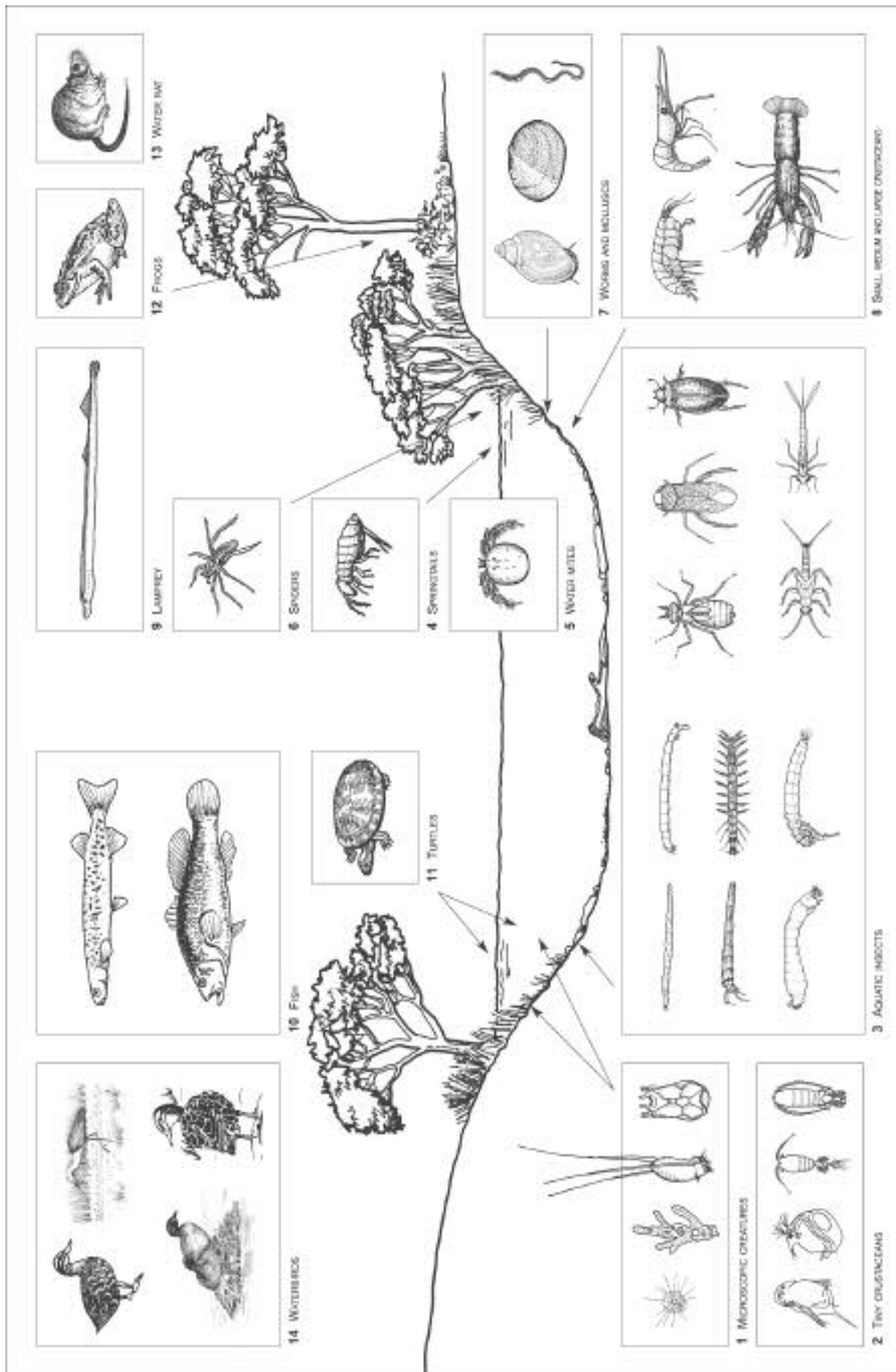


Figure 2: Stream fauna of south-western Western Australia.

4. Study Methodology

Community involvement

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

Many of the foreshore assessments were undertaken with landholders or land managers, and they were able to provide important background information about the streamlines and associated catchments. They were also able to identify issues of concern to them relating to the health and management of the waterways.

Other consultation processes included individual phone calls, articles in local and regional newspapers, and community workshops. Once the foreshore assessments were completed, a community meeting was held to present initial findings and to seek feedback about the project and management recommendations from the community.

River foreshore condition assessment

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

A grade foreshore

A1: Pristine

The river embankments and/or channel are entirely vegetated with native species and there is no evidence of human presence or livestock damage. This category, if it exists at all, would be found only in the middle of large conservation reserves where the impact of human activities has been negligible.

A2: Near pristine

Native vegetation dominates but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species. Otherwise there is no human impact. A river valley in this condition is about as good as can be found today.

A3: Slightly disturbed

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

B grade foreshore

B1: Degraded - weed infested

In this stage, weeds have become a significant component of the understorey vegetation. Although native species remain dominant, a few have probably been replaced or are being replaced by weeds.

B2: Degraded - 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.

B3: Degraded - weed dominated

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

C grade foreshore

C1: Erosion prone

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

C2: Soil exposed

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

C3: Eroded

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

D grade foreshore

D1: Ditch - eroding

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

D2: Ditch - freely eroding

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

D3: Drain - weed dominated

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

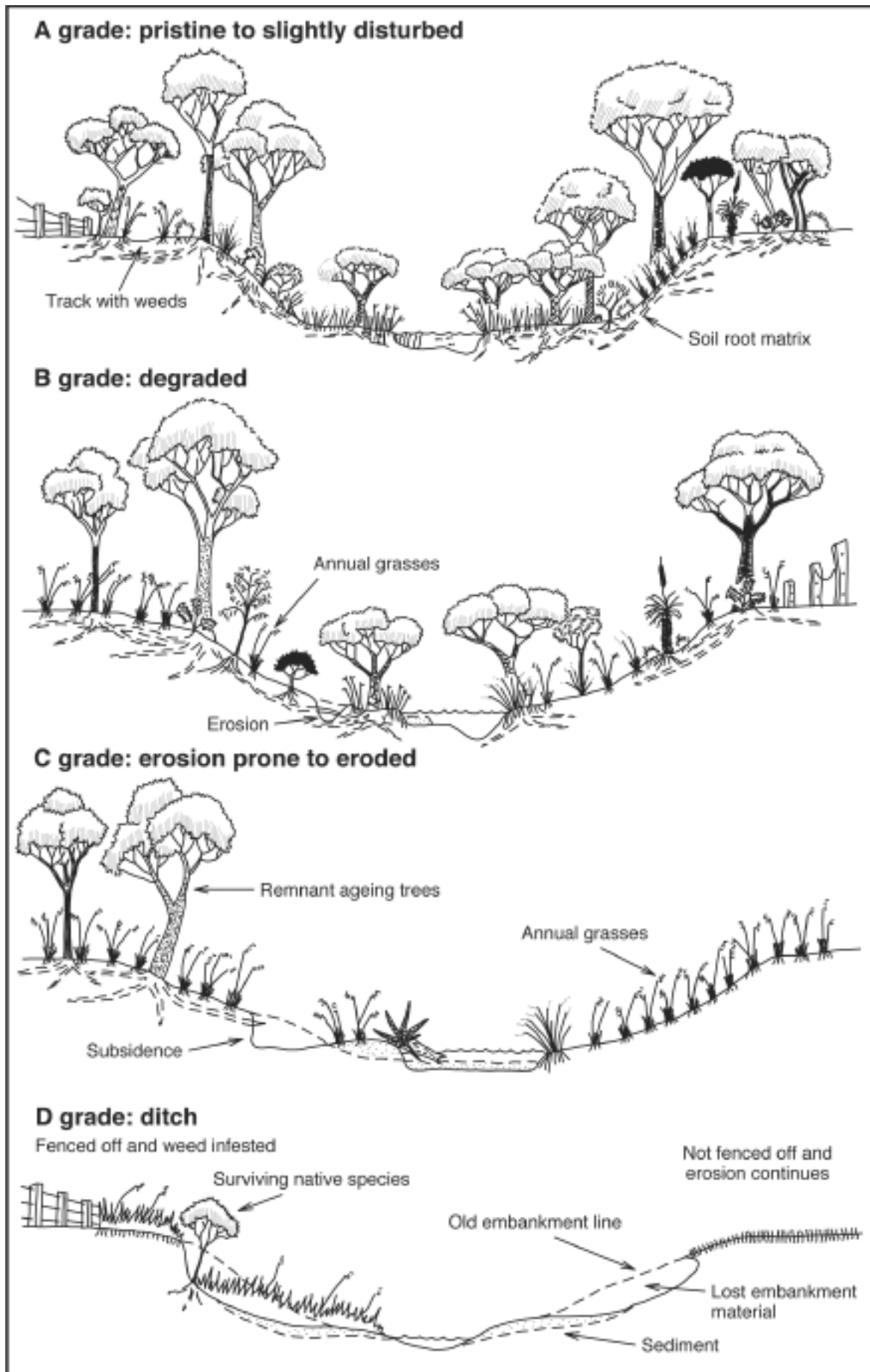


Figure 3: The four grades of river foreshore condition - (A) pristine to ditch (D).



A) A1 – A2 grade foreshore on the Meelup Brook within Meelup Regional Park showing all of habitat zones in tact and undisturbed (Photo by Don Hanran-Smith).



B) A2 Grade foreshore on the Meelup Brook. Fringing vegetation provides back support, shade and leaf litter while a riffle oxygenates the water (Photo by Don Hanran-Smith).



C) A Grade foreshore on the Dandatup Brook. Rushes and sedges provide important bank support and there is a wide band of adjoining healthy vegetation.



D) B1 Foreshore on the Dandatup Brook. The Melaleucas and native rushes and sedges remain dominant but arum lilies have invaded the understorey.



E) B2 – B3 Foreshore on the Dandatup Brook.
Weeds dominate the understorey.



F) C1 Foreshore on the Dugulup Brook.
Grasses dominate the foreshore and while there are a few trees, there is no sign of regeneration.



G) C2 Grade foreshore on the Dugulup Brook.
There are very few native species and soil is exposed. The processes of erosion have commenced.



H) C3 grade foreshore on the Dandatup Brook.
Native vegetation is absent and erosion is active with a head shown here migrating upstream.

5. Management issues

The relative importance of these issues to each brook varied, though there were a number of common themes across all of the systems. The main issues needing management attention on the Cape Naturaliste streams are outlined below. An explanation is provided regarding the specific waterways affected by each issue.

Weed invasion

The number one priority issue on the Cape Naturaliste streams was invasion of exotic plant species (weeds). There were over 60 different species of invasive weeds recorded from these waterways. Weed invasion is particularly severe on the Dugulup and Dandatup Brooks, which had over 40 species each. Weeds displace native species by out-competing them thereby reducing habitat value; they make rehabilitation difficult; they can change a diverse ecosystem into a simple one with only a few dominant species; they reduce food availability to native fauna; and can increase fire hazard. Weeds are a major threat to biodiversity values throughout the south-west region.

Weeds of particular concern included arum lily, blackberry, dolichos pea, tree ferns, Tangier pea, wavy gladioli, sweet pittosporum, edible fig, Myrtle leaved milkwort, Japanese honeysuckle and the exotic rushes *Juncus microcephalus* and *Isolepis prolifera*. A complete list of weeds found on each waterway is presented in Appendix 2. Specific locations of weeds on each waterway are identified on the maps in Chapter 7.

Many landholders were unaware of the presence of invasive species on their properties, indicating that some of the problem species are not being recognised as weeds. The majority of weeds identified were common garden plants that have 'escaped' from the backyards of people living in close proximity to the waterways. Many of these species are still commonly planted in gardens today and therefore continue to invade bushland and waterways. In some cases birds spread the seeds of weed species from locations far removed from the foreshore area. In the case of tree ferns, spores from the plant are transported by water and they travel downstream where they lodge in the bank to start a new cycle of infestation.

Some of the weeds identified in this plan were viewed by some landholders as holding particular aesthetic values. This is particularly the case for both arum lily and tree ferns. Unfortunately both of these species were found

to be highly invasive and have the ability to spread rapidly. Both species are dominating the foreshore vegetation where they are found; are displacing native plant species; and provide no food resources or habitat value for native fauna. There are many local native flora species that can be planted on stream foreshores that both look fantastic and will not harm the riparian ecosystem.

Clearing of streamline vegetation

As with all of the streams flowing into Geographe Bay the stream foreshore vegetation plays an important role in reducing sediment and nutrient loads into Geographe Bay by filtering fine sediment and by reducing bank erosion. Protection of stream foreshore areas is a priority everywhere in the Geographe Catchment for this reason. The streams are important ecosystems in themselves and provide valuable habitat when the foreshore vegetation is intact. Habitat is important for aquatic animals such as gilgies and frogs but also for small marsupials and birds that might use these areas. This is particularly important on cleared land or in urban areas where the stream corridors might be the only links between larger areas of bushland.

There are some excellent areas of foreshore remaining on the Cape Naturaliste streams, however incremental clearing of the riparian zone on the Cape Naturaliste streams is continuing to occur as a result of land use change or from clearing to obtain better views of the waterways. This is a particular problem on the Dugulup and Dandatup Brook where large areas of the foreshore are retained in the private ownership of many small landholders. Extensive removal of riparian vegetation has already occurred in the area as part of the development of numerous small dams and from historical agricultural clearing. Continued removal of riparian vegetation is seriously fragmenting the habitat of these waterways. Clearing of the riparian zone also leads to erosion and sedimentation as a result of bank disturbance.

Removal of large woody debris

There were a number of sites, mainly on the Dandatup Brook, where extensive removal of large woody debris from the stream channel has occurred. Removal of large woody debris is sometimes undertaken by landholders trying to address minor erosion problems or to improve

the flow of water through their properties. Unfortunately, the removal of large woody debris can often exacerbate erosion problems since the absence of debris in the channel accelerates water velocity. Large woody debris provides important habitat for in-stream fauna such as gilgies, native freshwater fish, frogs and a variety of macro-invertebrates. The loss of habitat for such fauna ultimately leads to the loss of these species from the stream ecosystem. Macro-invertebrates play an important role in breaking down organic matter from within the stream and grazing on algal growth, accordingly they can help to maintain better water quality. Also a number of macro-invertebrate species feed directly on the larvae of insects such as mosquitoes. Overall, a healthy waterway is much more pleasant to live next to, so there are many advantages to retaining the streamline habitat in a natural form.

Erosion

Erosion in the form of channel incision and the formation of head cuts was identified in a number of locations during the foreshore assessments. These problems were particularly common on the Dandatup Brook, which has possibly been the most extensively modified of all of the streams in the study area. This type of erosion occurs when the stream velocity increases, usually as a result of catchment clearing. The loss of riparian vegetation and large woody debris has also contributed to localised areas of bank slumping.

The upper reaches of the Dandatup and Jingarmup Brooks show signs of severe gully erosion. While these areas were only assessed from aerial photos, gully erosion could be seen clearly in a number of locations. The absence of streamline vegetation and fencing to manage stock access at these locations is likely to make the task of addressing these erosion problems difficult. It should, however, be noted that the landholder has advised that works are underway to manage sites of severe erosion on the upper Dandatup Brook.

Erosion causes a number of problems including:

- sedimentation of the waterways further downstream, which can result in loss of deep pools that provide important habitat for marron and gilgies;
- loss of these deep pools also reduces the flood attenuation capacity of the stream channel, which

causes water to overtop the floodway in high rainfall events;

- increasing the channel width; and
- loss of valuable agricultural land and top soil. In severe cases the loss of fencing infrastructure and riparian vegetation can also occur.

Stock control

As part of existing agricultural use of the area, cattle and sheep currently have access to the foreshores of the Jingarmup Brook upstream of the Eagle Bay town site, and the upper reaches of the south branch of the Dandatup Brook. There is also a section on the upper Meelup Brook where cattle have access to the foreshore. In total this represents a large proportion of the study area that is currently grazed without foreshore fences in place to manage stock access. Unrestricted stock access contributes to nutrient enrichment and erosion of waterways in addition to leading to loss of riparian vegetation through trampling. Stock can also spread weeds and cause soil compaction problems on the foreshore, making it difficult for native plants to regenerate. As discussed above, it is very difficult to arrest existing erosion problems while stock still have access to the problem area.

Dams and their management

Dams have been constructed on all of the waterways within the study area except the Dolugup Brook, which is located entirely within the Meelup Regional Park. The Dandatup Brook in particular had a high prevalence of dams constructed within the Meelup Hills rural residential development. A number of landholders expressed concern about an observed decrease in flow on the waterways and believe that this is related to the size and number of on-stream dams constructed. In the absence of long term flow data from these streams it is not possible to ascertain whether such reductions have occurred as a result of reduced rainfall or increased water use/water retention, yet the most likely scenario is that both have contributed to some extent.

Ideally the construction of gully wall or on-stream dams should be minimised where possible since they usually result in removal of riparian vegetation and may also block the passage of native freshwater fish on their

annual migration upstream to spawn. Once these dams are in place it is vital that flows from the outlet are managed appropriately. In the majority of cases the construction of a dam requires approval from the Shire of Busselton so it is important to contact the Shire prior to planning a new dam. All gully-wall dams approved by the Shire are required to have an under wall bypass pipe installed that should be open during all periods of low flow. The management of these pipes is discussed further in the following chapter.

Water quality

There is little long term monitoring data available for the Cape Naturaliste streams, however recent sampling of the Dugulup Brook by the Shire of Busselton identified high levels of faecal coliform bacteria that exceeded the criteria for safe recreational use of waterways (Barbour, pers. comm., 2005). Given the relative absence of stock on the Dugulup Brook it is highly likely that septic systems from adjoining residential and light industrial development have contributed to these levels.

The Dunsborough municipal waste management facility is near the headwaters of the Jingarmup Brook. Some landholders along this brook expressed concern about the potential for water contamination from the facility. Advice from the Shire of Busselton is that regular monitoring of groundwater bores around the landfill have not shown any levels of nutrient, chemical or heavy metal contamination above the recommended guidelines (ANZECC,2003); a deep layer of high phosphorous retention clay separates the groundwater layer from the base of the facility thereby providing an effective barrier to groundwater pollution (Barbour, pers. Comm., 2005). Results from monitoring are provided annually to the Department of Environment and have also previously been provided to concerned landholders on special request.

6. Management advice

The information in this chapter is largely taken from *River Action Plan for the Sabina, Abba and Ludlow Rivers* (GeoCatch, 2002) by Genevieve Hanran-Smith.

Where to start

The main principles for riparian management are:

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

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

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

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

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

Stock control

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

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

'Ideally, fences should be placed above the river valley (Figure 4). Depending on the steepness of the embankment, the fence should be placed 5 m to 20 m back from the edge of the river valley (Figure 4 A). Five metres is sufficient for a shallow valley a couple of metres deep but a broader zone, greater than ten metres, is required for valleys deeper than five metres. The purpose of fencing off the shoulders of the river is to enable trees on the upper part of the embankment and those above the river valley to anchor the adjacent land, and thereby prevent subsidence.

In the case of shallow river valleys, there is little chance that embankments will subside. Nevertheless, fence-lines should be located above the river valley (Figure 4 B). This is because fences and firebreaks located within the river valley will be damaged and eroded by floodwaters. When they occur, firebreak washouts can be severe and contribute large quantities of sediment to the river system.

If the river valley is particularly broad and floodplains have been cleared for grazing, fencing them off may mean sacrificing good farmland. In this case it is necessary that only those areas that are prone to water erosion or stock damage, such as embankments and secondary river channels which only flow strongly at times of flood, need to be fenced off (Figure 4 C). Some of these fence-lines will be prone to flood damage, but this can be minimised if fences run, as much as possible, parallel to the direction of floodwaters.

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

Fencing may be used to exclude stock entirely from the stream foreshore, or to allow restricted grazing. Once native species have regenerated or been re-established it may be appropriate to allow careful grazing for short periods to control weeds. Grazing may also be used to control weeds prior to planting. Heavy grazing that would degrade the riparian zone and ultimately eliminate native plant species should be avoided. Total

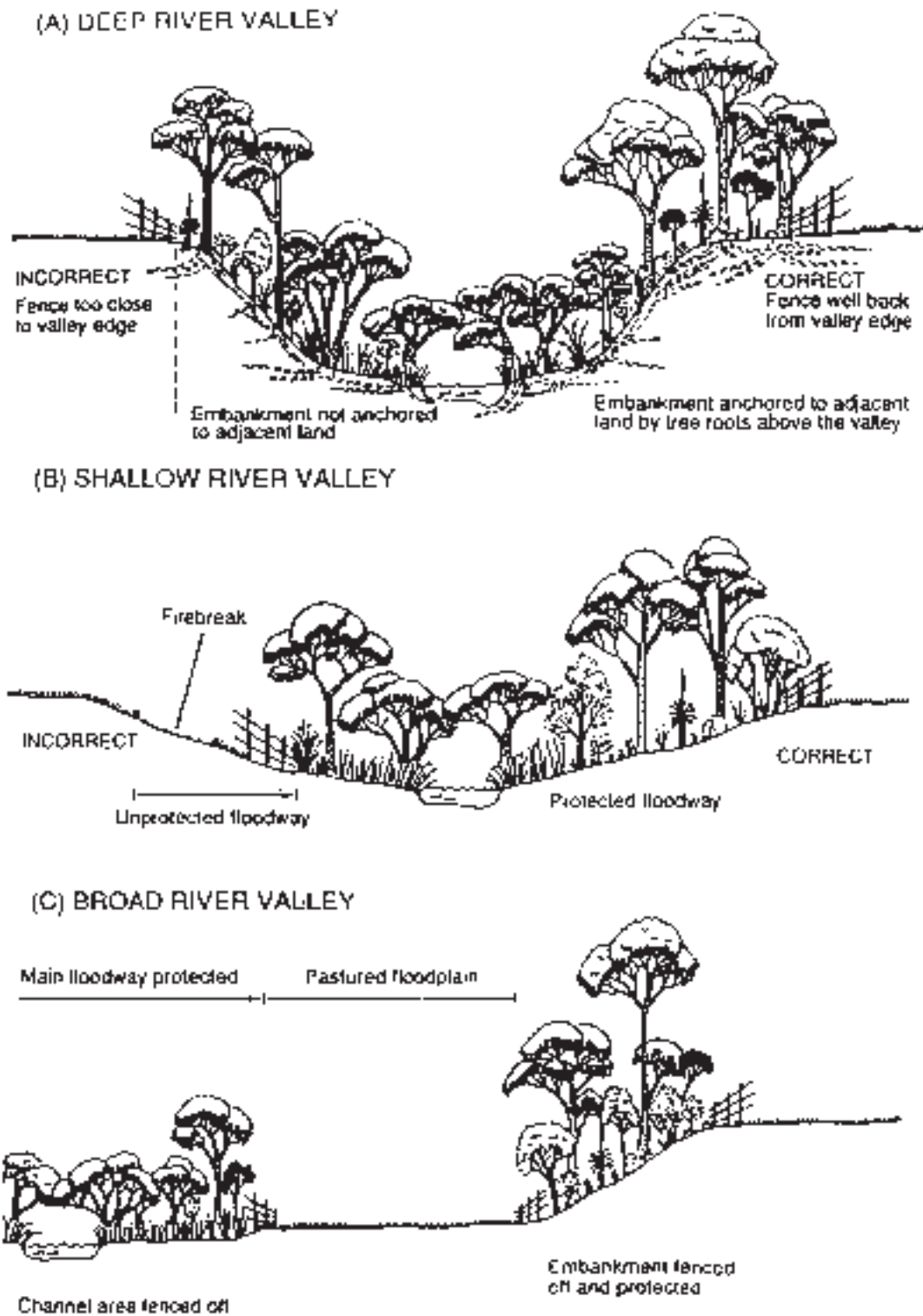


Figure 4: The correct placement of fences in relation to the river valley: (A) the deep river valley, (B) the shallow river valley and (C) the broad river valley with broad floodplain (APACE Green Skills & Pen, 1995).

exclusion of stock will be necessary where the bank is steep and sandy, or prone to collapse, or where the objective is to maintain high quality riparian habitat. A longterm weed management and revegetation plan needs to be developed prior to fencing off riparian land.

In areas where stock are not present, there is no need to fence. However on properties where stock are present, even for only part of the time, it is important to restrict stock access to the banks. GeoCatch now has funds available to landholders to restrict stock access to waterways. These funds may be used to erect fencing, provide alternate watering points and construct stock and vehicle crossings. For more information, please contact GeoCatch.

Useful references on stock control

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

Water quality

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

Vegetated dams

Dams and constructed soaks can become a healthy and vibrant ecosystem if they have fringing vegetation, as in a natural creek system. Not only will riparian vegetation clean the water and provide habitat to aquatic organisms such as marron and native fish, it may add considerable value to the property as vegetated dams are aesthetically pleasing.

Dam walls should not be planted with trees as their roots may undermine the structural integrity. They can be safely planted however with a variety of rushes, sedges, groundcovers and shrubs. The same species should be planted on the edges and dam entry point, with the addition of local native trees. If stock are present on the property, the dam should be fenced to prevent them damaging the vegetation, and a corner of the dam be left open for their access.

Vegetative buffers

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

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

Farming practices (from Kingdon, 2000)

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

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

Cultivation along the contours, rather than at right angles to them, will slow the rate at which water flows across the land, reducing soil erosion by as much as 50% (Pen, 1999).

Soil testing and fertiliser use

Fertiliser is generally applied according to traditional practice, usually some time before the winter/spring growing season. Today, we know that after a number of years of fertiliser application, many soils are rich in nutrients but may be deficient in a few trace elements (Pen, 1999). Soil should be tested to determine fertiliser requirements and avoid excess application of nutrients, a portion of which will find their way into waterways. GeoCatch has a project called 'Nutrient Smart' which is designed to assist landholders to better manage their fertiliser use through soil testing. A paddock-scale fertiliser plan will be produced, allowing landholders to better target soil deficiencies and improve yields. For more information, please contact GeoCatch.

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

Useful references for protecting water quality through farming practices

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

Managing dam flows

A gully-wall dam on an ephemeral (seasonal) stream can have significant impacts upon the timing and amount of flow downstream of it. One way to address this issue is the low-flow or bypass valve. This is a valve at the bottom of a dam wall that can be used to let flows through to the creek at any time. In the past valves have primarily been used to flush out saline water or sediment that has collected in the dam, however they can easily be used to negate the environmental impact of a gully-wall dam and they are a requirement of all dams approved for construction in the Busselton Shire. The valve should be opened at the start of the season (as soon as water is flowing into the dam). The dam will still fill over the winter months and, once it is full to overflowing, the bypass valve can be closed. This ensures that the riparian ecosystem downstream of the dam receives water when it is meant to. The rest of the flows will safely dilute any salt or sediment that has built up in the dam over summer.

If an existing dam does not have a bypass valve installed, it is possible to set up a simple siphon system where a length of piping is laid over the top of the dam wall and extends into the deepest part of the dam (and is secured via a weight) and down the dam wall past the level of lowest water depth. A tap can be placed at the end of the pipe and it can be turned on and off as required. If the tap is turned off (but the pipe left in place) once the dam has overflowed, water will be retained in the pipe and there will be no need to prime the siphon in subsequent years. Retrofitting a bypass valve to a dam is likely to be a very difficult and costly exercise.

Erosion control

Erosion is an issue requiring attention in parts of the Cape Naturaliste streams, with areas showing signs of severe incision, undercutting and bank slumpage.

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

to commencing any form of physical modification to the river channel. GeoCatch and engineers from the Department of Environment can assist with providing technical support.

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

Point bars

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

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



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

Undercutting

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

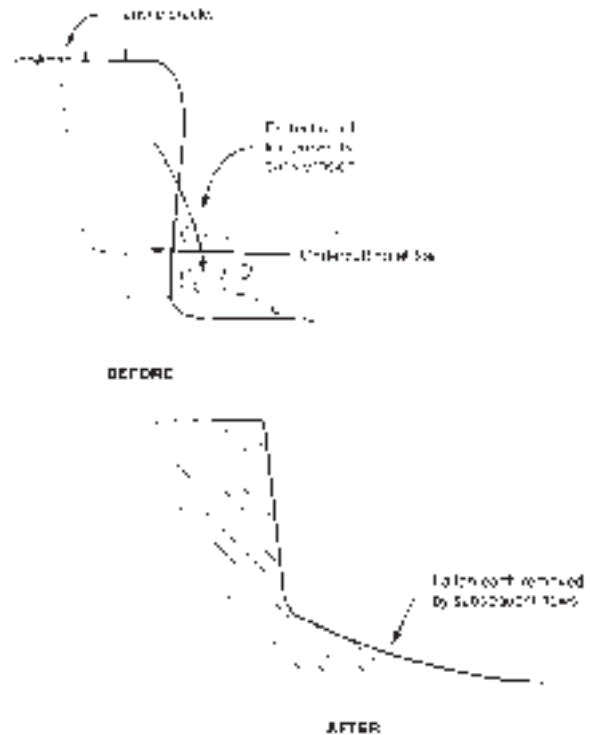


Figure 6: The use of structural works, such as a rock toe, will prevent the process of undercutting (adapted from Raine & Gardiner, 1995).

Bank slumping

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

revegetate the foreshore with suitable species. Raine and Gardiner (1995) provide the following advice on this process:

- Replant the toe with species that can withstand high flow velocities (e.g. native sedges). This replanting should be dense with spaces between plantings of less than 1 metre;
- Replant the middle to upper bank areas with fast growing, deep rooted trees and large shrubs. These will hold the bank together, enhance drainage and remove excess moisture through transpiration;
- Vary the species that are planted to ensure differing root structures; and
- Extend plantings from the toe to the floodplain. If a narrow band of trees is planted, this may serve only to add to the weight of the bank without providing the necessary network of root support.

Large woody debris

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

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

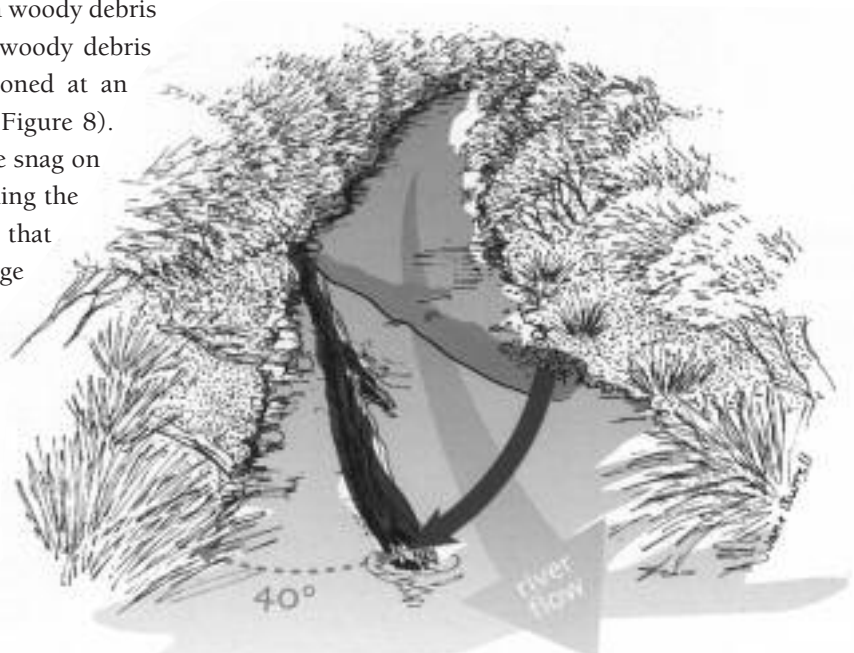


Figure 8: Repositioning large woody debris (Gippel et al., 1998).

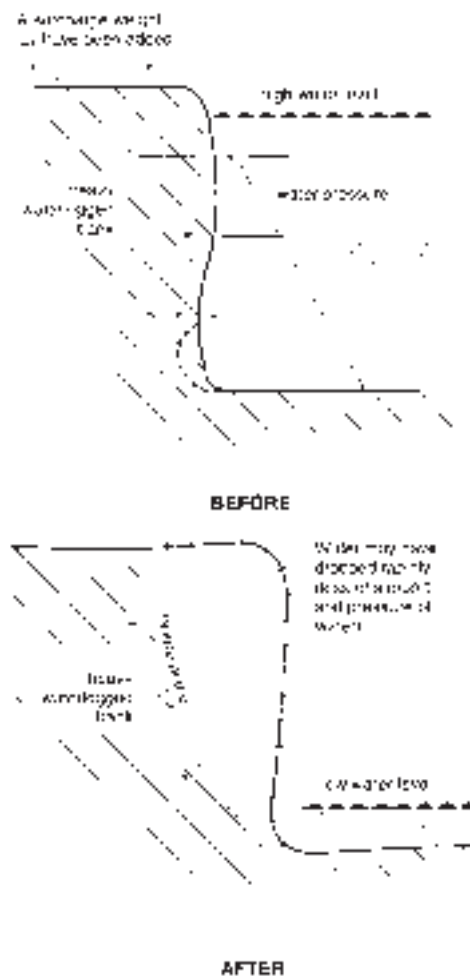


Figure 7: The process of bank slumping caused by excessive weight and lack of support (adapted from Raine & Gardiner, 1995).

Useful references on erosion control

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

Regeneration and revegetation

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

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

found in the area. Species for revegetation projects in the catchment should be selected from this list. GeoCatch can assist with species selection.

Revegetation techniques

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

Direct seeding

Direct seeding involves placing seeds directly on or into the soil on the site, either by hand or with machinery. For individual farm sized projects a mix of local seeds can be prepared in clean (weed free) sand and sown into lightly cultivated or raked soil. For an increased cost but higher success rate, tree bags can be placed over these areas to protect seedlings from dehydration, wind and predation. These bags will also help to identify and protect plants during follow-up spot spraying for weeds over the coming seasons. Several areas in the catchment have been identified as having good potential for the collection of local provenance³ seed. More information on seed collection and propagation is available from GeoCatch.

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

- it is less time consuming and requires less labour than planting tube stock;
- a mixture of trees, shrubs, sedges and groundcovers can be planted at the same time, resulting in a plant community with a more natural look, and better resilience due to increased diversity and synergy;
- seeds will germinate over several years, giving a range of ages and growth forms, resulting in a more natural look;

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

- it is less expensive than using tube stock; and
- the natural root development of seedlings grown from seed usually results in plants developing deeper taproots, requiring less follow-up care.

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

Planting

Planting is an appropriate technique for embankment and in-stream revegetation, and where direct seeding is difficult due to insufficient seed, excessive weed competition, or other factors. In these cases, nursery tube stock is ideally supplied from local provenance seed. A rule of thumb guide for planting densities is 3-4 rushes per 1 m², 1 shrub per 1 m², and 1 tree every 3 m². When selecting plants and designing the revegetation of an area, it is also important to take into account the budget for follow-up management; the availability of water over summer; the range of species available; existing vegetation cover such as tree canopy; soil types; and the intended weed management approach.

Rushes and sedges should be planted in spring, when the water table is beginning to fall and the soil is still moist. Other seedlings should be planted when the surrounding soil is moist and follow-up rain is likely (usually between May and July). Care should be taken to ensure that specimens are not root bound, and that minimal damage to the roots occurs when removing from pots. Planting requires significant prior planning, as local seed can be collected and given to the community nursery to raise in time for planting in the following wet season. Seedlings can also be purchased from the Geographe Community Nursery in Busselton which specialises in growing local native plants for revegetation purposes. For more information, contact GeoCatch.

Brushing

Brushing is an excellent technique for all zones apart from the channel bed. This technique can be used to

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

Pre-seeded matting

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

Division and transplanting of rushes and sedges

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

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

Useful references on natural regeneration and revegetation

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

Weed control

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

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

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

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

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

Specific notes on certain weeds

A number of declared weeds (under the *Agricultural and Related Resources Protection Act 1976*) were found in the study area. They are: arum lily, blackberry, and

pennyroyal. According to legislation, declared plants need to be controlled or contained depending on their status, and reported to the local Agricultural Protection Officer. More information on the requirements for control and treatment is available from the Department of Agriculture & Food. Weeds of concern in the catchment are listed below, with suggested control methods.

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

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

Agapanthus *Agapanthus praecox*

A succulent strap leaved garden escapee from South Africa, agapanthus is a perennial with similar ecological requirements to arum lily. It is a weed of national significance. It seeds freely and the clumps can exclude all other vegetation. It has the potential to become a very serious weed in south-west Western Australia (R. Randal, pers. comm., 2003). Prevent seed set yearly, and dig out clumps ensuring no root fragments are left behind. The most successful chemical control is likely to be Chlorsulfuron or Metsulfuron Methyl.

Arum lily *Zantedeschia aethiopica*

A tufting perennial with dark green, shiny leaves arising from a tuberous root. Easily recognised by large white 'flower' with a central yellow column of minute male and female flowers. Toxic to stock and introduced as a garden plant. Berries are spread by birds and along watercourses. A serious threat to riparian vegetation. Slashing, if undertaken regularly (at least three times per season) over a long period, may be effective but is very time and labour intensive. Chemical control with low rates (0.5 grams per 10 L of water) of Chlorsulfuron

or Metsulfuron as flowers start to wither is most effective. Little effect will be noticeable immediately, however the following year very few plants will come up. Glyphosate is not an effective control. Blanket or hockey stick wipers should be used near waterways to prevent spray drift or runoff. In areas with very dense infestations, multiple applications will be required to ensure any new seedlings are controlled.

Blackberry *Rubus* spp.

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

Blue periwinkle *Vinca major*

A sprawling groundcover with dark green opposite leaves with a shiny surface and singular blue flowers with a white throat. Blue periwinkle is native to the Mediterranean region and is a common garden plant in Australia. The plant spreads rapidly by producing new roots where the stems have contact with the ground. Effective control can be achieved in early to late spring by first raking the vine to lift it off the ground, and mowing or cutting the vine then spraying the regrowth with Glyphosate or Dicamba. Several applications every three months are required. The last remnants will need to be removed manually or by spot spraying as these will start a new infestation. Some control is achieved with hot fires and solarisation.

Bridal creeper *Asparagus asparagoides*

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

available for release. Contact GeoCatch for more information and release locations.

The rust appears to be spreading well, and was found on most bridal creeper infestations. In many places where previously bridal creeper was extremely thick, the rust has worked very well. However care must be taken not to become complacent about bridal creeper. Due to the nature of biological controls, the rust will never eradicate bridal creeper, it will just make it manageable. Now is the time to implement other control methods such as wiping individual stems with a 1:2 Glyphosate solution as they emerge.

Budding club rush (*Isolepis prolifera*) and *Juncus microcephalus*

These are two introduced rushes from South Africa. Both inhabit damp soil or shallow, slow moving water. *Isolepis prolifera* is a pale green fleshy short (to 50 cm) perennial that often reproduces by forming new plants (budding) at the end of a stem. *Juncus microcephalus* is a robust rush to 1.2 m with flowers in dense upright clusters and leaves divided by transverse (horizontal) partitions. Both thrive in disturbed damp areas and can become a problem, restricting flow and causing sedimentation. Manual control (removal) is best. Herbicides are not generally suitable unless the plants grow in areas that dry up over summer.

Bulrush *Typha orientalis*

A perennial emergent aquatic plant, native to the Eastern States and Asia, up to 4 metres tall. There is also a native bulrush (*T. domingensis*) that is easily confused with *T. orientalis*, with the two readily hybridising. Both species were found during the foreshore assessments. Manual control through slashing in late summer and then drowning can be very effective, as can cutting the stem 15 cm below the waterline 2-3 times a year, including at flowering. Chemical control needs to be very carefully executed as the potential for runoff or drift into the water is very high. Glyphosate with a modified surfactant (such as Roundup® Biactive) could be used in late spring to summer.

Dolichos pea *Dipogon lignosus*

A robust perennial climber with alternate leaves divided into 3 broadly triangular leaflets each 2-7 cm long. Dolichos pea has numerous large pea flowers that are white or pink to purple, 8-15 mm long. Manual removal is difficult since the root system may re-sprout when damaged. While small plants can be hand pulled, the larger ones tend to re-sprout. Slashing is not effective. Burning encourages germination of seed, and although a hot fire can kill the plant re-shooting may occur after a moderate fire. Chemical control is likely to reduce infestations to levels that can then be controlled by hand removal. Most effective chemical control options will damage native plants. Wipers should be used near waterways to prevent spray drift or runoff. Tordon, Lontrel and Metsulphuron have all provided effective control, but none of these are suitable for selective control in bushland.

Easter lily *Amaryllis belladonna*

A perennial herb, dying back to a large bulb. Leafless when flowering. Large pink to white flowers in autumn. Leaves are green and strappy. A garden escapee native to South Africa and common around old settlements. Spraying with a 1:100 solution of Glyphosate after flowering as new leaves emerge is the most effective control. Manual removal of bulb results in significant soil disturbance and further weed invasion.

Edible fig *Ficus carica*

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

Kikuyu (*Pennisetum clandestinium*), buffalo grass (*Stenotaphrum secundatum*), couch (*Cynodon dactylon*) and water couch (*Paspalum distichum*)

These perennial introduced grasses all spread from runners or rhizomes and are invasive in damp situations. Manual control (except large scale scalping) is not effective, and care must then be taken to minimise

erosion. A spray-burn-spray regime using Glyphosate appears to work well in areas where water levels recede, allowing the use of herbicides and fire.

Myrtle-leaved milkwort *Polygala myrtifolia*

A garden escapee originally native to South Africa and now invading coastal bushland areas. This is a shrub, about 2.5m high with light green elliptic leaves and clusters of pea-like pink to purple flowers. Remove seedlings and small plants by hand. Larger plants can simply be cut off at the base and tend not to re-grow. Burning can kill adult plants if hot enough but will result in larger infestations if there is not follow-up control as the seeds will germinate. Glyphosate can also be used for effective control.

Pennyroyal *Mentha pulegium*

A slightly succulent rhizomatous perennial that favours damp conditions such as along paddock drains and creeklines. Has a strong mint-like smell when crushed. Chemical control using Glyphosate when actively growing is effective. Caution should be used when applying Glyphosate near waterways. Spray only when flows have receded or stopped.

Deciduous trees, tree ferns and other woody weeds

Woody weeds such as deciduous species like Willows (*Salix* sp.) and Poplars (*Populus* sp.) can be controlled using stem injection or cut and paint with undiluted Glyphosate ('cut-stump' method). The tree ferns found along the Dandatur Brook can be controlled with the cut-stump method. To stem inject, holes should be drilled around the trunk and spaced no more than 5 cm apart into the sapwood (just beyond the bark, but not into the heartwood) and herbicide injected immediately. The tree may take up to 3 months to die and can then be felled or left as habitat. To cut and paint, the tree should be felled with a chainsaw as close to the ground as possible and painted immediately with undiluted herbicide. All material must be removed and monitoring for suckers should occur for at least 2 years after control.

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

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

More information on weed identification and control is available from the Department of Agriculture & Food and GeoCatch.

Useful references on weed identification and method of control

- Brown, K. & Brooks, K. (2002) *Bushland Weeds: A Practical Guide to their Management with Case Studies from the Swan Coastal Plain and Beyond*. Environmental Weeds Action Network, Greenwood, Western Australia.
- Department of Agriculture (1999) *Wetlands not Weedlands*. Weed Note No. 1/99, Department of Agriculture, Perth, Western Australia.
- Department of Agriculture (2002) *Declared Plants Handbook: Recommendations for the Control of Declared Plants in Western Australia*.
- Dixon, B. & Keighery, G. (1995) 'Suggested methods to control weeds'. In: *Managing Perth's Bushlands*, Scheltema, M. & Harris, J. (eds). Greening Western Australia, Perth, WA.
- Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. & Lloyd, S.G. (1997) *Western Weeds: A Guide to the Weeds of Western Australia*. Plant Protection Society of Western Australia, Victoria Park, Western Australia.
- Hussey, B.M.J. & Wallace, K.J. (1993) *Managing Your Bushland*. Department of Conservation and Land Management, Como, Western Australia.

- Moore, J. and Wheeler, J. (2002) *Southern Weeds and their Control*. Department of Agriculture, Bulletin No. 4558. Perth, Western Australia.
- Water and Rivers Commission (1999) *Revegetation: Revegetating Riparian Zones in South-west Western Australia*.
- Water and Rivers Commission River Restoration Report No. RR4.
- Water and Rivers Commission Water Note 22, *Herbicide Use in Wetlands*.
- Water and Rivers Commission Water Note 15, *Weeds in Waterways*.
- Water and Rivers Commission Water Note 25, *Effects and Management of Deciduous Trees on Waterways*.

Feral animal control

Rabbits were evident in parts of the catchment. Rabbits severely damage native vegetation, hindering

regeneration and revegetation. Landholders and managers are encouraged to control rabbits through baiting, shooting, fumigation and destruction of warrens.

The value to native fauna of vegetated corridors along the rivers is undermined by the presence of foxes and feral cats. Large numbers of landholders were concerned that foxes and feral cats preyed on native fauna which has limited habitat options in the area. Baiting and shooting can control foxes. Feral cats are more difficult to control, although some success has been had with wire cages baited with sardines. Cages are available from rangers at the Shire of Busselton. The effectiveness of fox and feral cat control is greatly improved if undertaken on a large scale, involving as many landholders as possible. Further advice and assistance is available from GeoCatch and the Shire of Busselton.

7. Stream foreshore condition and recommendations for management

Using the maps

The following pages provide an index for the individual maps, and an overview of the condition of Cape Naturaliste Streams. For a summary of the condition rating and percentage of Cape Naturaliste Streams that is fenced to exclude stock, please see Table 1 and Table 2 in the Summary.

Maps 1 to 11 show the entire Cape Naturaliste Streams catchment, the main channel and tributaries, and adjoining land titles.

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

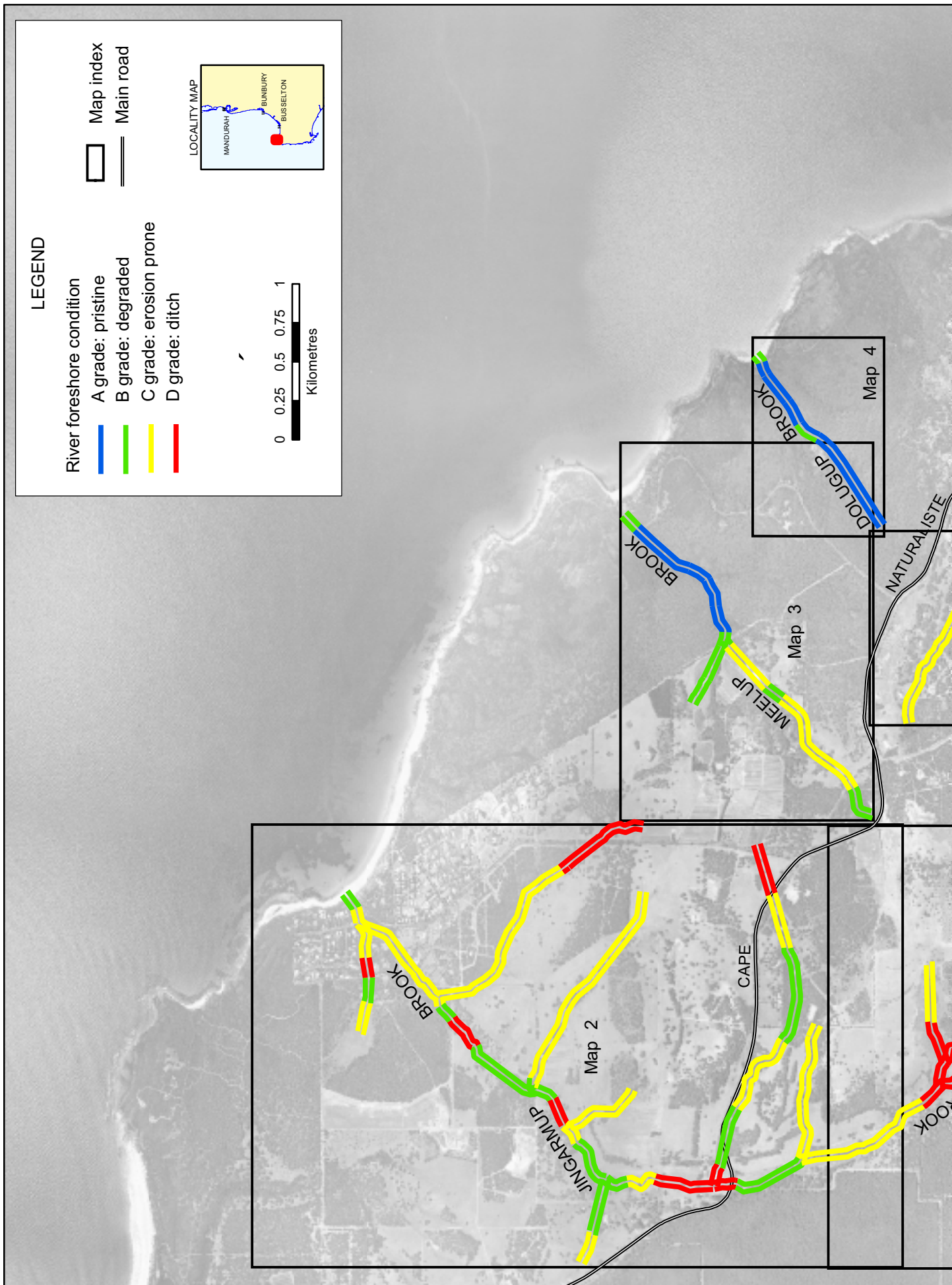
The background aerial photos of the maps were taken in 2003 and are available from the Department of Land Information www.dli.wa.gov.au.

Management recommendations

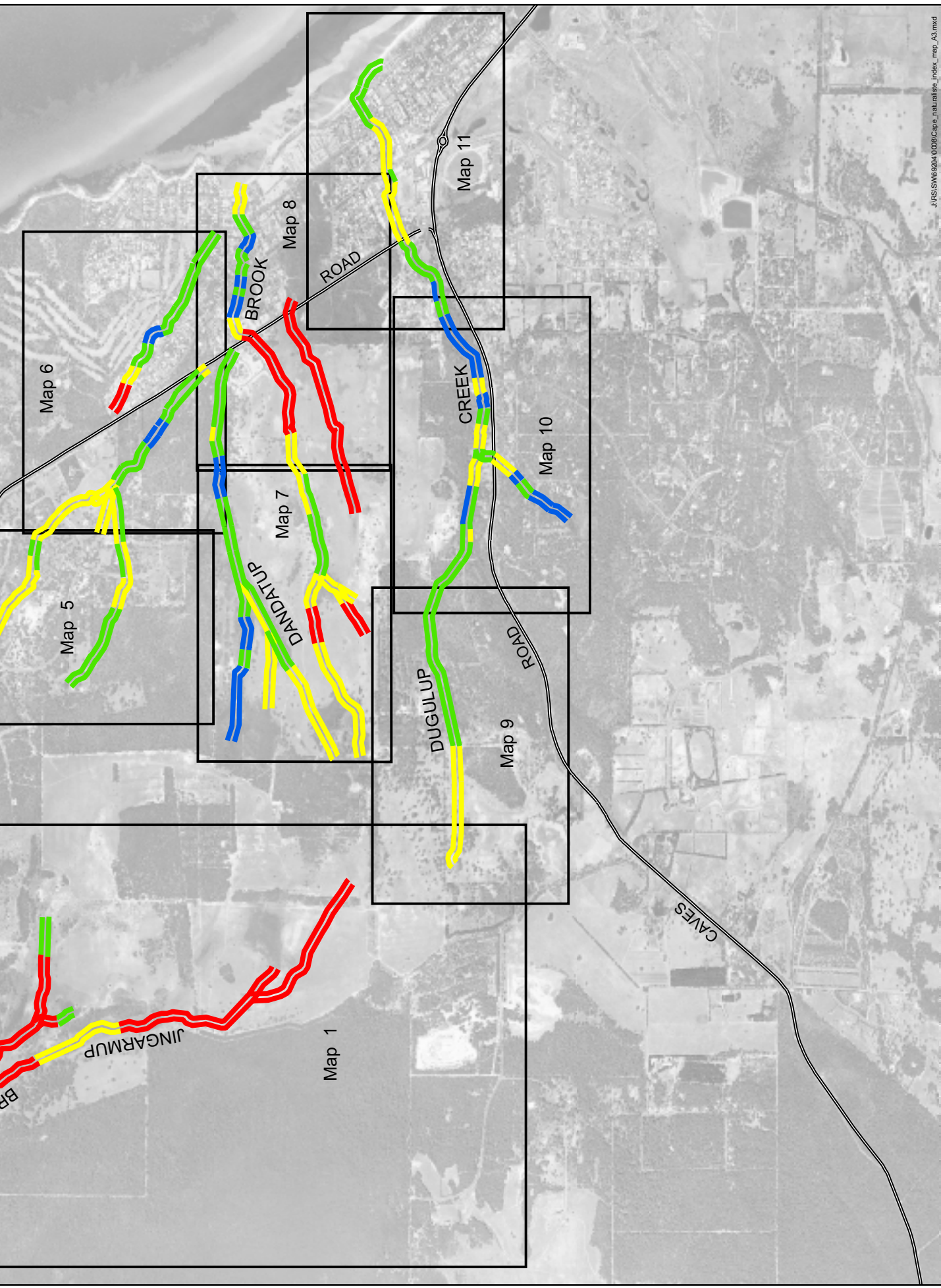
The notes accompanying each map contain background information and management recommendations.

A recommended set of catchment-wide priority actions is provided in Chapter 7.

These priority actions should be considered alongside the specific recommendations listed for each map. Prior to actions being undertaken, consultation should occur with stakeholders and relevant agencies, such as GeoCatch, the Department of Water and the Shire of Busselton.



Index map



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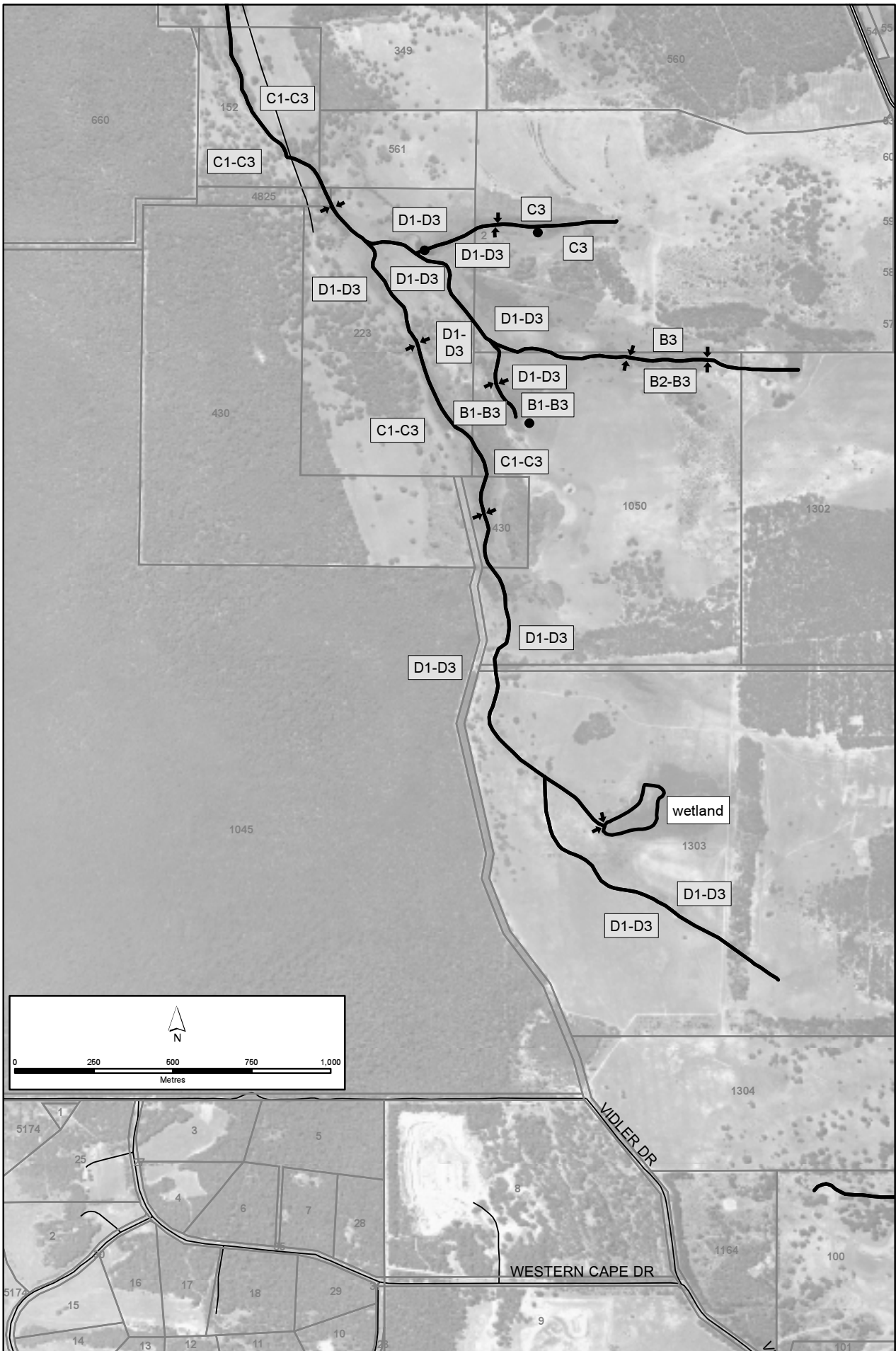
Map 1 Jingarmup Brook

Map 1 shows the southern half of the Jingarmup Brook catchment with a number of minor tributaries running east. The whole of this catchment area was assessed from aerial photos since access to this part of the brook for an on-ground assessment was not possible at the time of the survey.

Issues	Comments
Land use and fencing	While under separate titles, this part of the Jingarmup Brook is owned and managed by one landholder and is used for sheep grazing, though with low stocking rates. There is no foreshore fencing on any of these locations.
Landform, soils and erosion	Gully erosion is present where riparian vegetation is absent. This is visible on the aerial photograph of Lots 1303, 1050 and 223. Soils are part of the Cowaramup Uplands Soil System comprising loamy gravels, duplex sandy gravels, semi-wet soils and grey deep sandy duplexes. The presence of duplex soils is likely to have made this area more susceptible to gully erosion.
Native vegetation	A survey of existing vegetation was not possible for this section of the brook. Regional vegetation mapping indicates that foreshore vegetation is comprises of the Cowaramup Cw2 complex, or a woodland of Jarrah (<i>Eucalyptus marginata</i> subsp. <i>marginata</i>), Marri (<i>Corymbia calophylla</i>) on slopes and a low woodland of Stout paperbark (<i>Melaleuca preissiana</i>) – Swamp banksia (<i>Banksia littoralis</i>). This is a poorly represented vegetation complex.
Weeds	Arum lily is present along the creek line on this property and the landholder currently undertakes annual control of this weed. The incidence of other weed species is not known as a survey was not undertaken on the ground.
Other comments, special features	There is a small, partially vegetated wetland or damp land area near the headwaters of the brook on Lot 1303. There are very few intact wetlands remaining within the Cape Naturaliste area and accordingly this area should also be given a priority for fencing from stock. The presence of poorly represented vegetation on this section of foreshore emphasises the need for fencing.

Map 1: Management recommendations and advice

- Implement a staged fencing program on all locations to restrict stock access, including construction of stable stock crossings and provision of stock watering points away from the brook to minimise bank damage and protect water quality. Since this would be a large fencing project, priority should be given to areas of the foreshore where riparian vegetation is still intact, i.e. preserve the areas of better quality foreshore first and work outwards from these points.
- Continue and expand the current weed control program for arum lily and monitor outbreaks of other invasive species described in this plan. Ensure arum lily control is undertaken when the plants are actively flowering for maximum effectiveness.
- Undertake targeted erosion control measures to reduce further sedimentation and channel incision. It may be necessary to construct pool and riffle sequences to manage current active erosion. Technical advice should be sought prior to undertaking control of severe erosion and should only be undertaken following implementation of stock control measures.
- Undertake targeted revegetation around the areas of better quality foreshore, which appears to be on Lot 223. Revegetation should also be undertaken wherever erosion control measures are implemented.



Jingarmup Brook Map 1

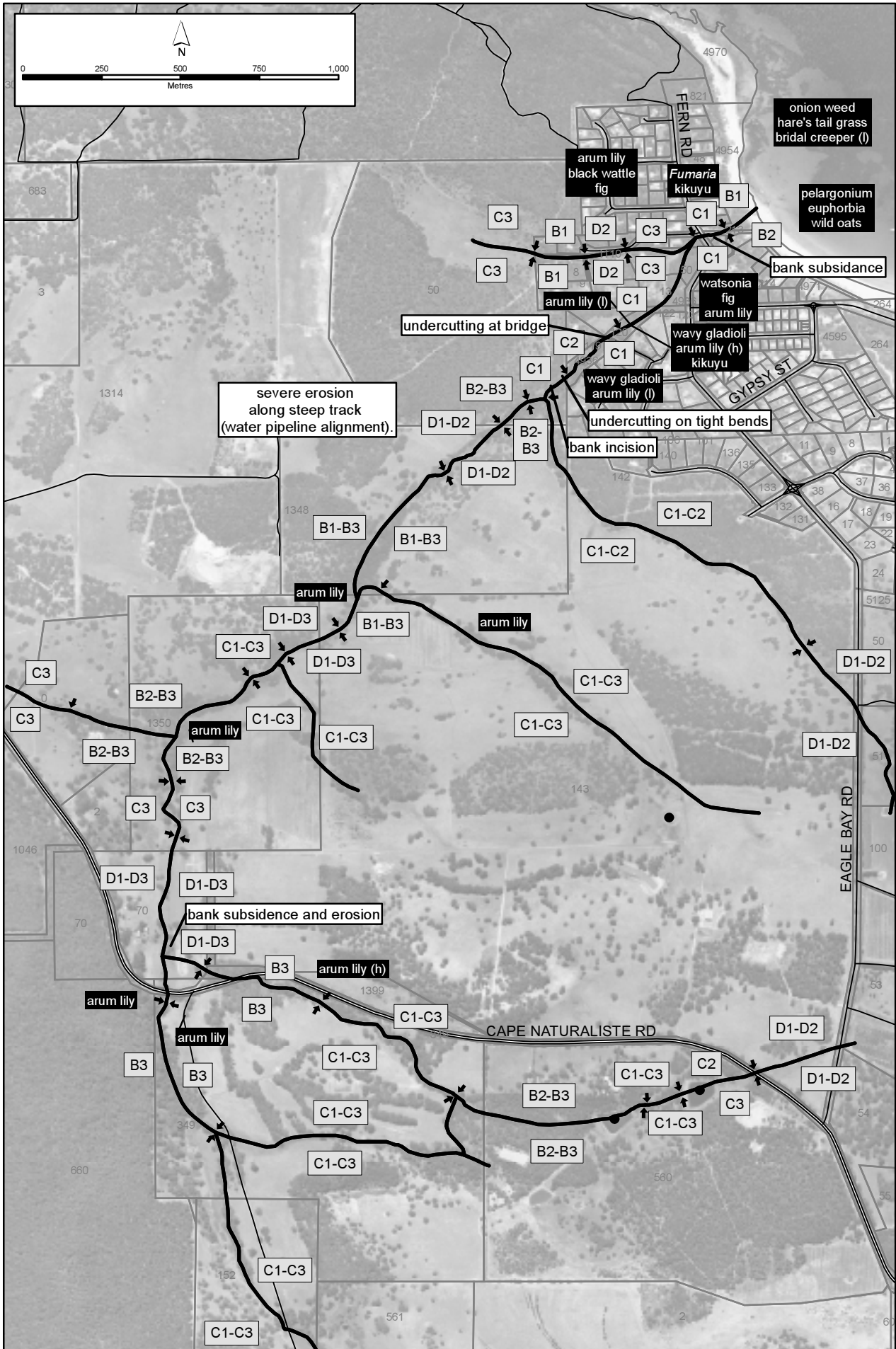
Map 2 Jingarmup Brook

Map 2 shows the northern half of the Jingarmup Brook catchment with a number of larger tributaries running east. The area between Lots 349 and 1348 inclusive were assessed from aerial photos since access to this part of the brook for an on-ground assessment was not possible at the time of the survey.

Issues	Comments
Land use and fencing	Boundary fencing of the foreshore reserve is in place either side of Reserve 213 at the mouth of the brook and at Reserve 4936. There is no foreshore fencing established on any other locations. Sheep grazing and cattle grazing occurs on Lots 349, 70, 1350, 143, 1348. Land use downstream of this area is rural residential and residential.
Landform, soils and erosion	Soils in this area are within the Wilyabrup slopes, Wilyabrup deep sandy slopes and Wilyabrup valleys land units all with gravely well drained soils. At the coast the brook passes through the Wilyabrup Wet Fertile Flats land unit, which has poorly drained deep alluvial soils. Gully erosion and channel incision is evident on Lots 51 and 70. At the lower end of the brook the channel is incised and showing signs of bank erosion as a result of increased flow velocity from catchment clearing.
Native vegetation	The upper catchment areas were not surveyed on the ground, though regional vegetation mapping shows this area as dominated by marri (<i>Corymbia calophylla</i>) and peppermint (<i>Agonis flexuosa</i>). Through the town of Eagle Bay, vegetation is dominated by flooded gum (<i>Eucalyptus rudis</i>), peppermint (<i>Agonis flexuosa</i>) and freshwater paperbark (<i>Melaleuca raphiophylla</i>). At the coast this changes to mainly peppermint with boobiala (<i>Myoporum insulare</i>) and golden wreath wattle (<i>Acacia saligna</i>).
Weeds	Arum lily is present throughout, though with varying densities depending on the level of control. Gladioli, watsonia and fig are problematic in the lower urban areas. There are occasional light infestations of bridal creeper in the lower foreshore reserves. Upstream and downstream of Fern Road there is a dense infestation of the introduced grass <i>Phalaris paradoxa</i> and black wattle is also present here. Other grasses such as kikuyu, blow fly grass, wild oats and couch are a problem in the lower reaches. At the coast sea spurge (<i>Euphorbia paralias</i>), dune onion weed (<i>Trachyandra divaricata</i>), rose pelargonium and hares tail grass have invaded the dune areas.
Other comments, special features	The introduced aquarium fish Rosy barb was found in Reserve 4396. This is the only known wild population of this feral fish in WA. A water and sewerage pipeline located along the boundary of lots 50 and 1348 is eroding and exacerbating sedimentation of the brook. The outlet of a dam located on the boundary of lot 1348 is also causing localised erosion. Arum lily control has been effective in some areas but is hampered by patchy landholder involvement.

Map 2: Management recommendations and advice

- Coordinate a community weed control program on public and private land involving all landowners and land managers (i.e. target weed control of species such as arum lily at the same time to maximise effectiveness). Remove existing populations of fig, black wattle and *Phalaris paradoxa* as a high priority and provide ongoing control of arum lily, watsonia and wavy gladioli. Ensure all minor outbreaks of bridal creeper are infested with the rust fungus to provide biological control.
- Implement a staged fencing program on Lots 349 to 1348 to restrict stock access, including construction of stable stock crossings and provision of stock watering points away from the brook to minimise bank damage and protect water quality. Since this would be a large fencing project, priority should be given to areas of the foreshore where riparian vegetation is still in-tact, i.e. preserve the areas of better quality foreshore first and work outwards from these points.
- Stabilise erosion of the water pipeline alignment and the outlet of the dam at the boundary of Lots 50 and 1348 to reduce further sedimentation of Jingarmup Brook.
- Undertake revegetation of rushes, sedges and understory species at reserve 4396 to improve bank stability.
- Work with the Department of Fisheries to eradicate the introduced fish Rosy barb from the Jingarmup Brook.



Jingarmup Brook Map 2

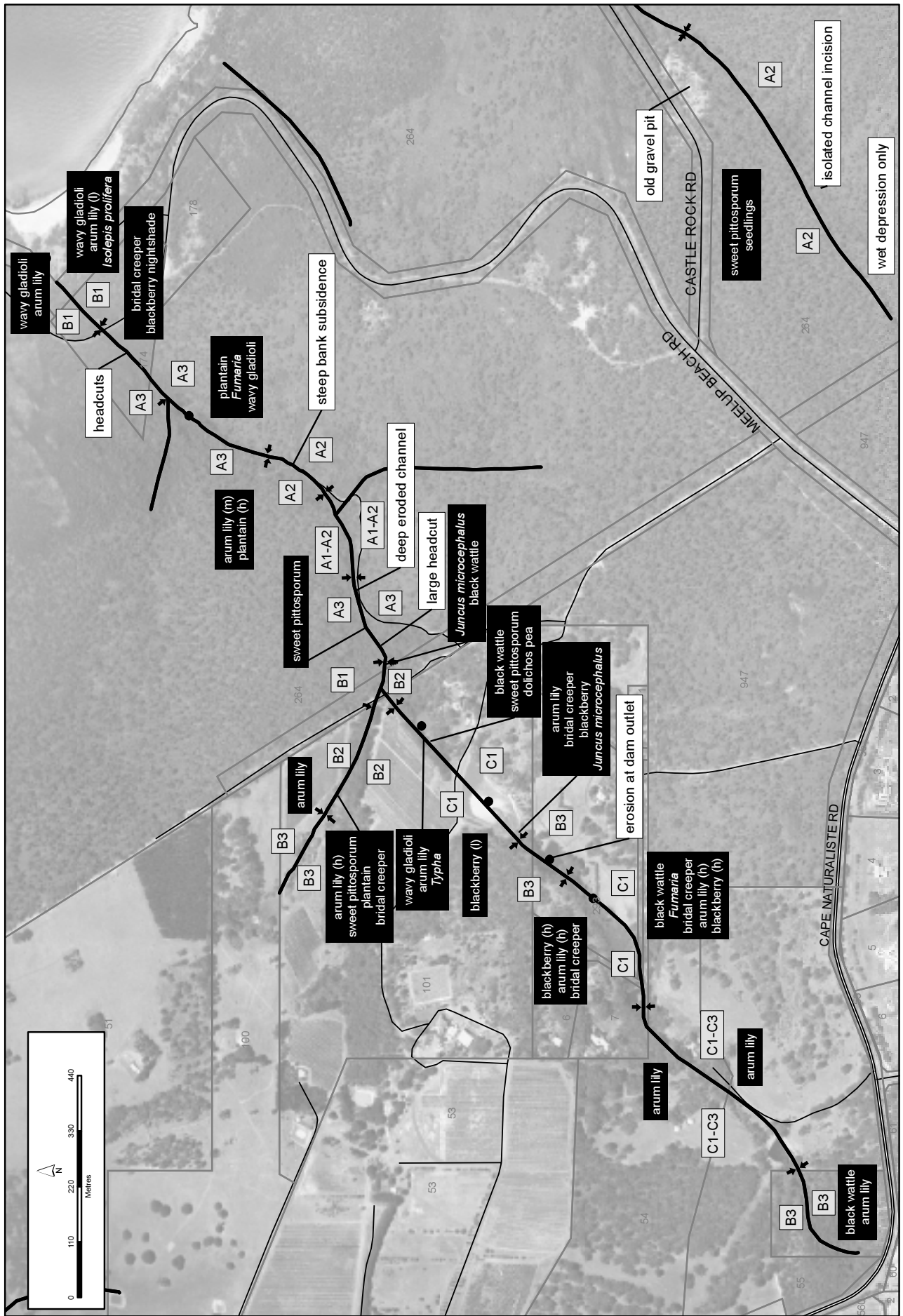
Map 3 Meelup Brook

Map 3 shows the Meelup Brook from its headwaters just east of Cape Naturaliste Road, to its mouth at Meelup Beach. Locations 55, 54 and 7 were assessed from aerial photos since access to this part of the brook for an on-ground assessment was not possible at the time of the survey.

Issues	Comments
Land use and fencing	Locations 55, 54, 7 and 293 are sheep grazing and lifestyle lots and these are unfenced. The foreshore has been fenced on location 101, which is used for viticulture and tourism though a small number of sheep are also present. Downstream the brook flows through the Meelup Regional Park, which is an 'A' class recreation and conservation reserve.
Landform, soils and erosion	Meelup Brook is located within the Wilyabrup valleys land unit and comprises typical gravelly soils on a steep 'V' shaped drainage depression. There are a number of head cuts within Meelup Regional Park, one over a hundred metres long in the upper reaches, though possibly now stabilising. There are also smaller head cuts and bank subsidence at the lower end. A number of disused water supply dams were noted in the park and water diversions around these have created some minor erosion problems. Minor erosion is present at the outlet of a dam on location 293.
Native vegetation	The upper catchment is dominated by peppermint (<i>Agonis flexuosa</i>) and some marri (<i>Corymbia calophylla</i>) though with limited understorey remaining. Where the brook flows through Meelup Regional Park the vegetation is in excellent condition huge diversity of species. Here the dominant overstorey is marri (<i>Corymbia calophylla</i>) with some jarrah (<i>Eucalyptus marginata</i>), and peppermint (<i>Agonis flexuosa</i>) more abundant towards the coast.
Weeds	Arum lily is present throughout and blackberry occurs on location 293 and spreading into location 101. A wide variety of other invasive environmental weeds also occur on location 101. These include black wattle, dolichos pea, sweet pittosporum, bridal creeper, typha and <i>Juncus microcephalus</i> . Weed invasion in Meelup Regional Park is worst near the boundary of location 101, where weeds common to both locations are found. At the lower end of the brook there is also wavy gladioli, bridal creeper and blackberry nightshade. Where the brook flows through the middle of the park, there are few weeds, though plantain, white fumitory and wavy gladioli could be found at most sites of minor disturbance.
Other comments, special features	There are some short sections of A1-A2 quality foreshore of exceptional quality within Meelup Regional Park and a high diversity of flora species in this area.

Map 3: Management recommendations and advice

- Undertake control of blackberry on locations 293 and 101 as a matter of high priority.
- Construct fencing on locations 55, 54, 7 and 293 to restrict stock access, including construction of stable stock crossings and provision of stock watering points away from the brook to minimise bank damage and protect water quality.
- Liaise with the property manager of location 101 and members of the Meelup Regional Park Management Committee to discuss the feasibility of a joint control program for weeds that are common to the boundary areas of both locations.
- Stabilise erosion at the outlet of the dam on location 293 using rock of small size and replanting of rushes and sedges below the outlet to dissipate flow energy.
- Undertake coordinated control of arum lily and remove sweet pittosporum and black wattle on all locations.
- Establish a small demonstration river restoration site at the lower end of the Meelup Brook on degraded areas near the boardwalk platform and the disused dam.
- Undertake annual weed control and checks for outbreaks of new weeds on the Meelup Brook within the Meelup Regional Park. This part of the brook is in the best condition and is therefore a priority for all weed and erosion control measures.



Meelup Brook Map 3

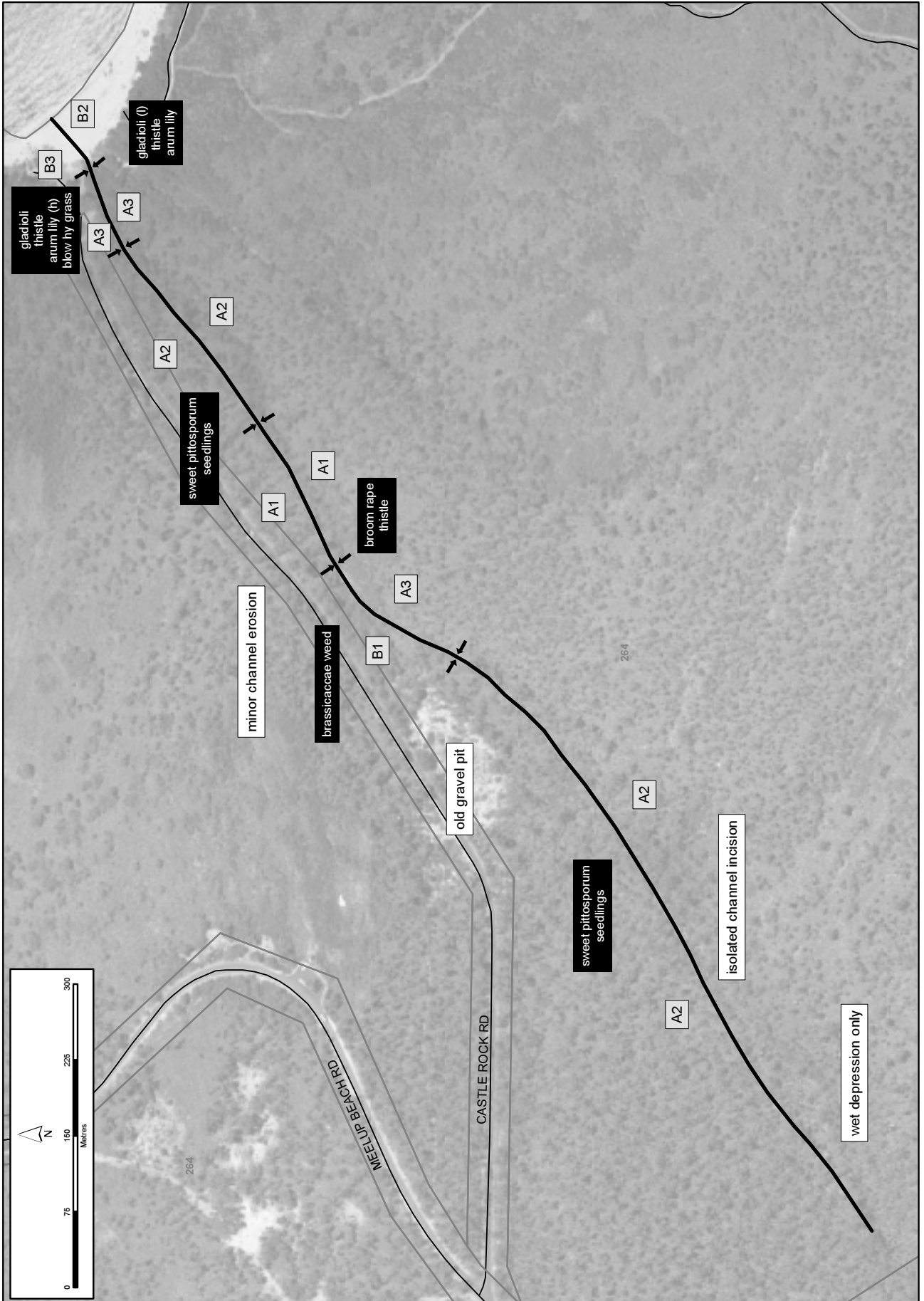
Map 4 Dolugup Brook

Map 4 shows the Dolugup Brook from its headwaters south of the intersection of Castle Rock Road and Meelup Beach Road, to its mouth at Castle Rock Beach.

Issues	Comments
Land use and fencing	Dolugup Brook lies entirely within the boundaries of the Meelup Regional Park.
Landform, soils and erosion	Dolugup Brook is also located on gravelly soils on the WilyabrupValleys soil subsystem with loamy gravels dominant. Despite its small size there are some spectacular pools and small waterfall features since it flows through some steep terrain. Some minor channel erosion is evident in a few places, and this is likely to have occurred following exposure of soil after the fire. Signs of regeneration were vigorous however and it is likely that these areas will stabilise on their own.
Native vegetation	Overstorey is peppermint (<i>Agonis flexuosa</i>) dominated with occasional marri (<i>Corymbia calophylla</i>) and a diverse understorey that includes cutleaf hibbertia (<i>Hibbertia cunififormis</i>); two species of grass trees – the graceful grass tree (<i>Xanthorrhoea gracilis</i>) and balga <i>Xanthorrhoea preissii</i> ; and <i>Bossea linophylla</i> among many others. There are also some excellent areas of square sedge (<i>Lepidosperma tetraquetum</i>) on this brook.
Weeds	The mouth of the brook flows very close to the edge of the beach car park and access track and is quite disturbed in this area. Arum lily is dense here and there is also gladioli, blow fly grass and thistle. Upstream of the small footbridge a number of small sweet pittosporum seedlings are germinating following a recent fire, though there were no signs of adult plants. These are scattered for some distance throughout the upstream stretches. Where the brook flows close to Castle Rock Road, there are also outbreaks of various Brassicacea weeds.
Other comments, special features	The Dolugup Brook is largely in excellent condition aside from two areas of minor disturbance where it flows close to the road and car park. While a recent burn allowed assessment of the brook to be undertaken, access is usually limited by dense vegetation, which may have contributed to its preservation and predominant lack of weeds. Areas of algal growth in the water column are likely to be a short term outcome of the control burn, which has increased sun penetration to the water by removal of canopy shade and would probably have also provided a shock nutrient load to the brook through increased runoff and ash content.

Map 4: Management recommendations and advice

- Undertake hand pulling of the sweet pittosporum seedlings along the brook as a high priority. This should ideally be undertaken while the seedlings are still small and before regenerating vegetation blocks access along the brook.
- Undertake coordinated control of arum lily, gladioli and thistle at the mouth of the brook.
- Establish a small demonstration river restoration site from the footbridge to the mouth of the brook to re-establish fringing vegetation and prevent weeds from re-invading this area.
- Undertake annual weed control and checks for outbreaks of new weeds on the Dolugup Brook.



Dolugup Brook Map 4

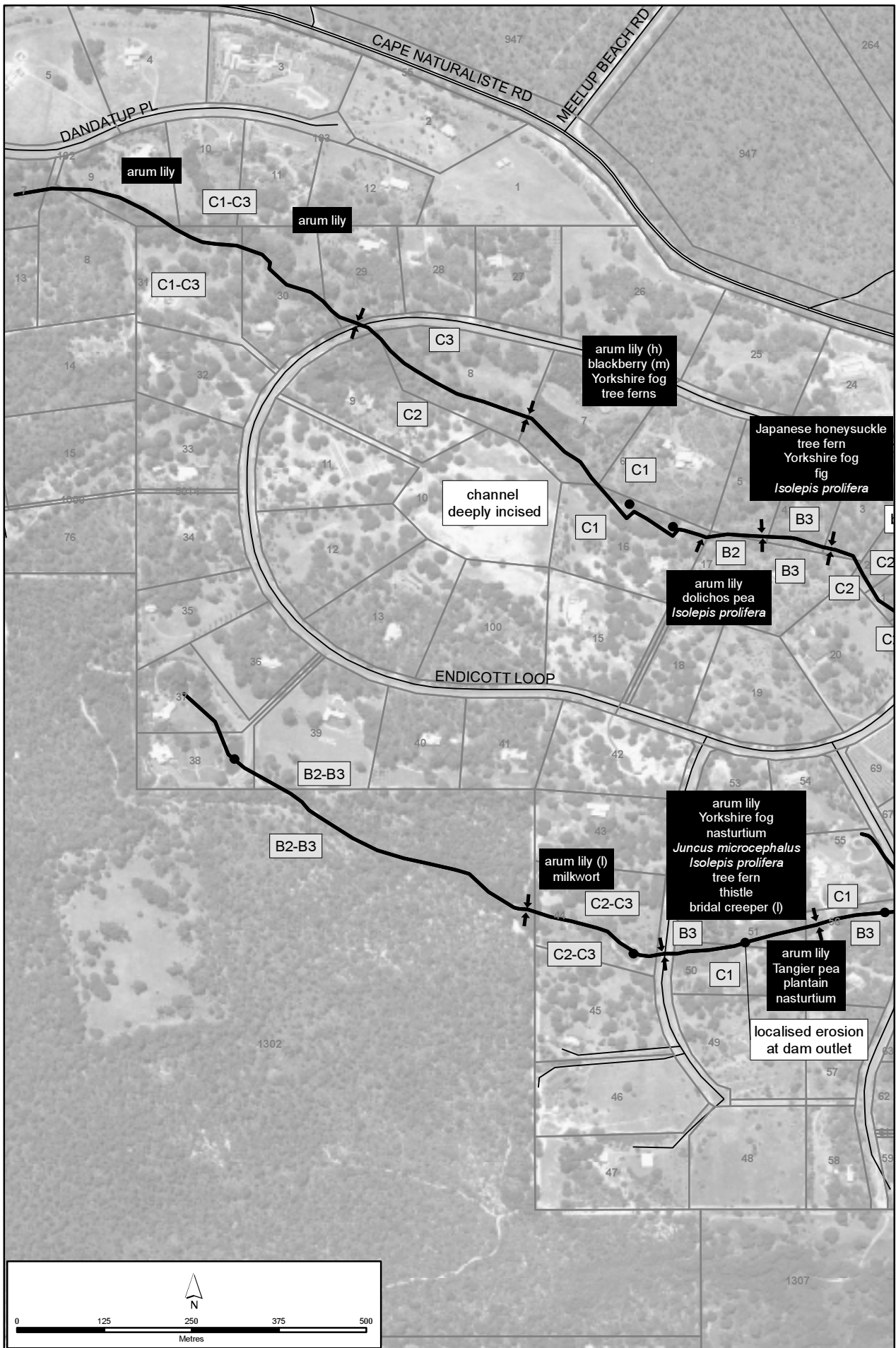
Map 5 Dandatup Brook

Map 5 shows the Dandatup Brook from the headwaters of its northern tributary south of Dandatup Place to the centre of the rural residential development bounded by Endicott Loop. A second tributary also extends from the south-west of this area.

Issues	Comments
Land use and fencing	Land use within this area is entirely rural residential lifestyle lots, with the exception of location 1302 which is a vegetated rural lot. Fencing and livestock are not present.
Landform, soils and erosion	The channel is deeply incised throughout most of the extent of the main tributary. Some minor erosion is present at the dam outlet on location 51. Soils are part of the Wilyabrup Valleys soil system and these range from loamy gravels, duplex sandy gravels, stony soils, brown deep loamy duplexes to friable red/brown and brown loamy earths.
Native vegetation	Peppermint (<i>Agonis flexuosa</i>) and marri (<i>Corymbia calophylla</i>) dominate the overstorey in the main channel, with swamp peppermint (<i>Agonis linearifolia</i>) on the tributaries.
Weeds	Arum lily is present throughout this area of the brook, and some control is undertaken by landholders, though this is patchy. <i>Juncus microcephalis</i> , <i>Isolepis prolifera</i> and tree ferns are common, though the latter is popular with many landholders as an aesthetic feature. Blackberry is present on location 7 Endicott Loop. There are also patchy outbreaks of milkwort, thistle, bridal creeper, dolichos pea and the introduced grass Yorkshire fog.
Other comments, special features	There are numerous dams in this area. Removal of large woody debris from the brook has reduced habitat values and increased channel incision in some areas. Fire management measures on some lots have resulted in increased invasion of weeds as a result of regular burning.

Map 5: Management recommendations and advice

- Undertake control of blackberry on lot 7 as a matter of priority.
- Establish a coordinated weed control program to encourage landholders to undertake weed management at the same time each year to maximise effectiveness and participation.
- Ensure weed control is followed by replanting with local native species to prevent re-invasion.
- Plant local native rushes and sedges to improve stream habitat values and reduce erosion of the stream bank.
- Undertake erosion control measures at the outlet of the dams on location 51 using a rock riffle sequence and replanting of the banks with rushes and sedges to dissipate flow energy.
- Implement erosion control measures such as a rock riffle sequence where the channel is deeply incised at locations 7 and 8 Endicott Loop.
- Liaise with the Shire of Busselton and the Department of Water to ensure that dams are managed appropriately with the use of low flow bypass pipes, and that the outlets do not erode the stream bank or channel.
- Ensure weed control and monitoring of weed invasion is undertaken following control burns near foreshore areas, and ensure that a sufficient period is allowed between burns to enable recovery and seed germination of native species. A minimum of four years is recommended though a longer period may be needed for some species.



Dandatup Brook Map 5

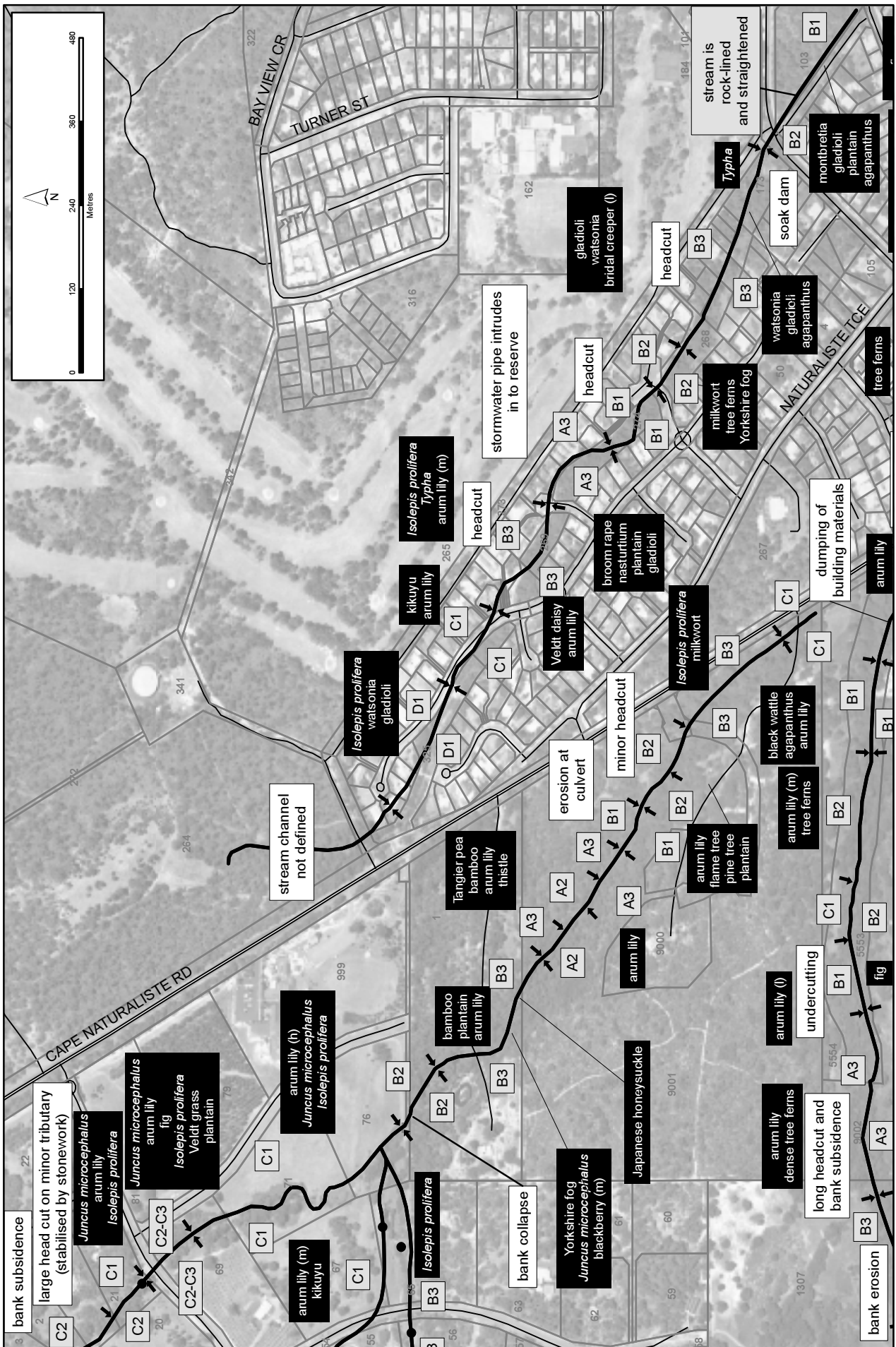
Map 6 Dandatup Brook

Map 6 shows the Dandatup Brook northern tributary connecting from map Da1 to Cape Naturaliste Road where it flows into a roadside drain before passing into the foreshore reserve behind Curtis Street. A separate tributary passes alongside Norfolk St and terminates at Sayers St, from which point it is diverted away from the main system via a drain to an outlet at the foreshore near the end of Beach Road.

Issues	Comments
Land use and fencing	This section commences in rural residential lots before flowing through lots 1 and 296 Cape Naturaliste Rd, which are soon to be developed for residential housing and will include establishment of a foreshore reserve. The tributary that flows behind Norfolk Street is located within a foreshore reserve and is bounded by residential development. Locations 5 and 173 Chapman Street are private land. There is no foreshore fencing in these areas and no livestock.
Landform, soils and erosion	Soils are gravelly loams and deep brown loamy duplexes. The channel is incised through the upper northern tributary and bank collapse is evident where fringing and instream vegetation has been lost. A severe head cut on Lot 2 Endicott Loop appears to have been stabilised with stone work. A number of small head cuts are still active within the foreshore reserve behind Norfolk Street.
Native vegetation	Peppermint (<i>Agonis flexuosa</i>) and Marri (<i>Corymbia calophylla</i>) woodland is dominant with Stout paperbark (<i>Melaleuca preissiana</i>) and occasional peppermint on the tributaries and coastal reaches.
Weeds	Weed infestation is severe throughout this section with the exception of the upper parts of lot 296 Cape Naturaliste Rd, which are in excellent condition. Arum lily, gladioli and <i>Isolepis prolifera</i> are present in most sections. Of particular concern is blackberry and Japanese honeysuckle on Lot 1 Cape Naturaliste Rd. Others invasive species include fig, tangier pea, milkwort, bamboo, agapanthus, nasturtium, and veldt daisy, which are all common garden plants still in use today. They are almost certainly present as a result of the close proximity of surrounding residential development.
Other comments, special features	There is a small section of excellent quality foreshore and surrounding bushland on Location 296 Cape Naturaliste Road. Where the brook flows alongside Sayers St it has been rock lined. The adjoining bushland reserve 'Blythe Reserve' contains high conservation value flora.

Map 6: Management recommendations and advice

- Undertake control of blackberry and Japanese honeysuckle on lot 1 Cape Naturaliste Road as a high priority.
- Liaise with the Shire of Busselton to ensure minimal disturbance is made to the foreshore areas of Lots 1 and 296 Cape Naturaliste Road when development of these subdivisions commences. Particular care should be taken not to disturb the area of 'A' class foreshore located on lot 296.
- Stabilise erosion in the Norfolk St foreshore reserve using rock riffle sequences and revegetation with rushes and sedges.
- Establish a coordinated weed control program to encourage landholders in the rural residential areas to undertake weed management at the same time each year to maximise effectiveness and participation.
- Ensure weed control is followed by replanting with local native species to prevent re-invasion.
- Plant local native rushes and sedges to improve stream habitat values and reduce erosion of the stream bank.
- Provide targeted and regular information to town residents adjoining the foreshore reserve regarding garden plants with potential to become invasive weeds, and the benefits of landscaping with local native species.
- Encourage the development of a local friends group to assist with long term rehabilitation and management of the Norfolk St foreshore reserve.



Dandatup Brook Map 6

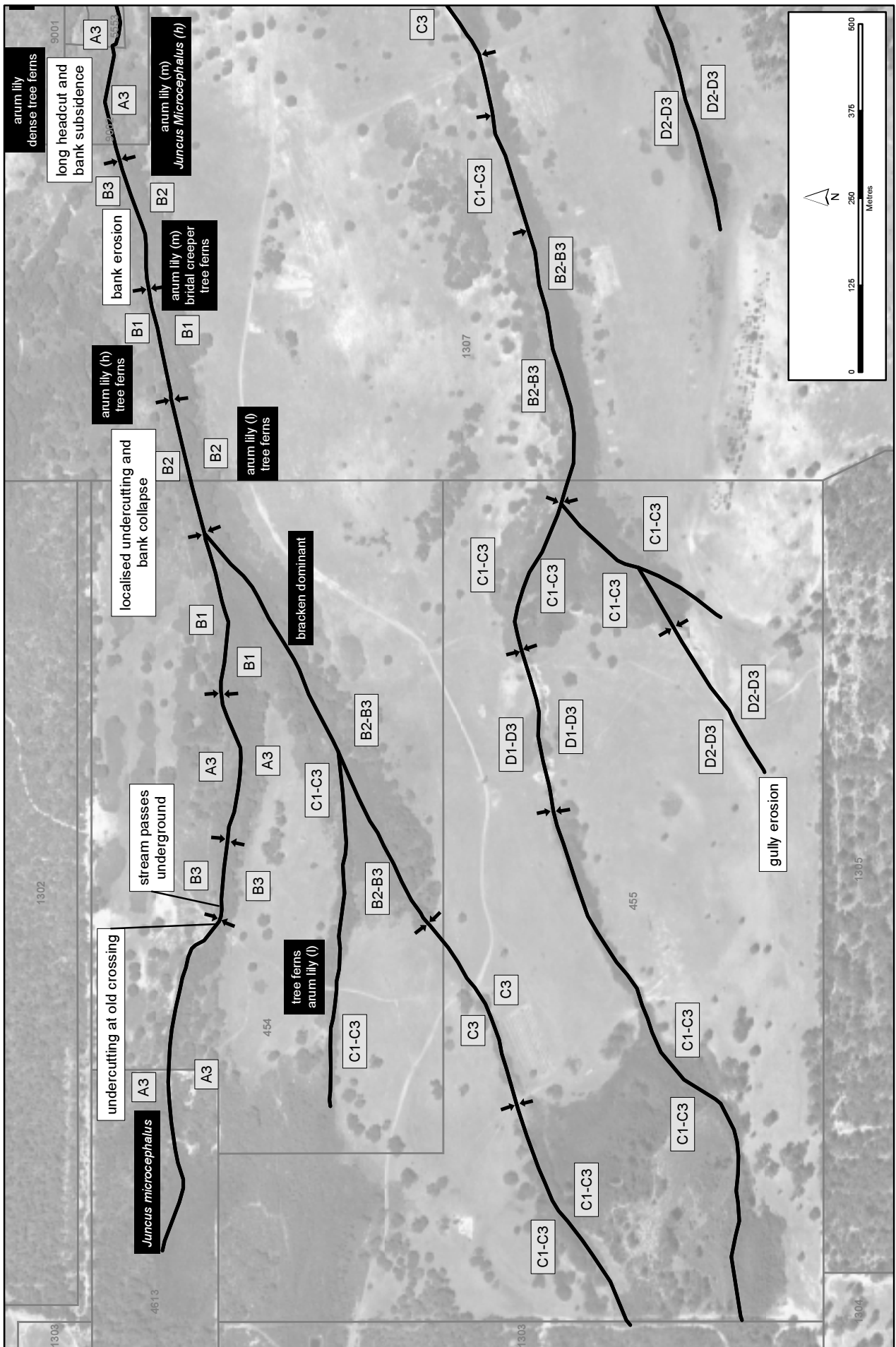
Map 7 Dandatup Brook

Map 7 shows the Dandatup Brook at the headwaters of its middle and southern tributary. Only the middle branch was assessed on the ground. The remainder of the system on this map was assessed from aerial photographs since access was not possible at the time of the survey.

Issues	Comments
Land use and fencing	Location 4613 is a Water Corporation water supply reserve and is fully vegetated aside from a series of small dams and tanks. Locations 455, 454 and 1307 are all rural and while these were previously used for sheep grazing, stock are now only occasionally present on these lots. Location 454 and parts of location 1307 have been rezoned for rural residential development. There is no foreshore fencing present.
Landform, soils and erosion	Localised undercutting and sites of bank collapse are present on the middle branch. There is some evidence of gully erosion on non-vegetated parts of the southern branch, predominantly in the headwaters. Soils are deep brown loamy duplexes.
Native vegetation	Dense Swamp peppermint (<i>Agonis linearifolia</i>) with Fine tea tree (<i>Agonis parviceps</i>) and the occasional Blackbutt (<i>Eucalyptus patens</i>) changing to Stout paperbark (<i>Melaleuca preissiana</i>), with Pale rush (<i>Juncus pallidus</i>) and Square sedge (<i>Lepidosperma tetraquetum</i>) in the lower reaches of this section.
Weeds	Arum lily and tree ferns are present throughout the main tributary. Spores from tree ferns travel downstream to cause new infestations in lower parts of the brook, including bushland reserves within the town site that are otherwise weed free. <i>Juncus microcephalus</i> also occurs here in patches. Bracken fern is dominant throughout much of this stretch. While bracken is a native species it frequently dominates streams on old farm land once stock are removed and can out-compete other natives in disturbed areas. In such instances it is considered a weed.
Other comments, special features	The middle tributary was once referred to as 'Butterworth Springs', named after one of the original farmers of location 454. The remnants of the Butterworth farm cottage stand not far from the headwaters of the brook. The name Butterworth Springs is still used by many local residents to refer to this section of the brook today.

Map 7: Management recommendations and advice

- Remove tree ferns using the 'cut-stump' method starting at the headwaters and working downstream.
- Replace tree ferns with an alternative local native species such as freshwater paperbark *Melaleuca raphiophylla* or mohan *Melaleuca preissii* which are aesthetically pleasing, will improve habitat values and will not damage stream ecology.
- Continue and expand the existing arum lily control program.
- Stabilise erosion on the middle tributary and southern branch using rock riffle-pool sequences and revegetation with rushes and sedges.
- Monitor the brook annually for outbreaks of new weeds.
- Liaise with the Shire of Busselton to ensure that appropriate management measures are put in place when locations 454 and 1307 are developed for rural residential development. These should include provision of an adequate foreshore reserve with public access provided; removal of tree ferns and other weeds; control of bracken fern; and stabilisation of existing erosion.



Dandatup Brook Map 7

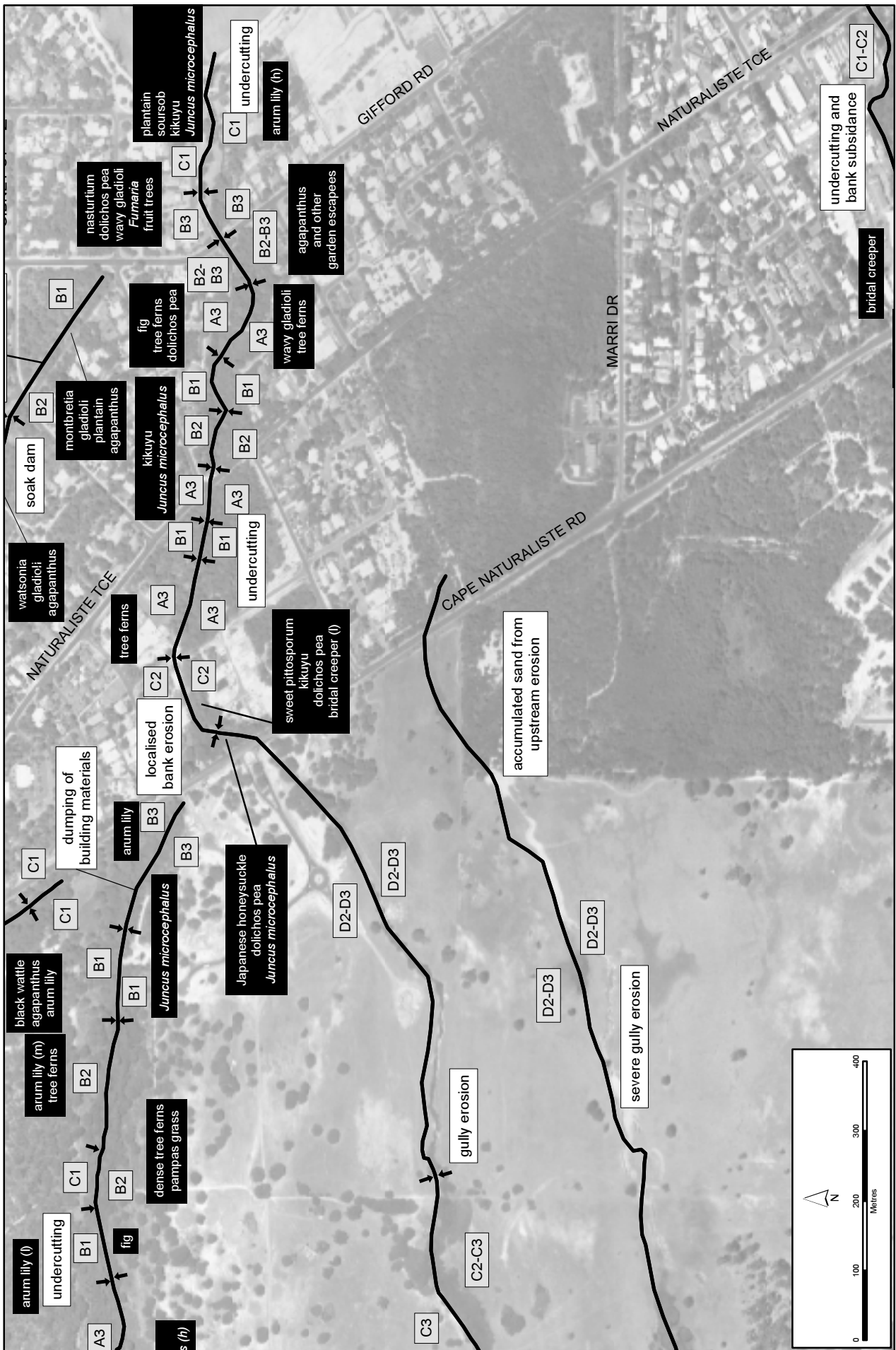
Map 8 Dandatup Brook

Map 8 shows the Dandatup Brook middle and south branches from upstream of the Cape Rise residential development to the mouth. An additional streamline to the south ('Dandatup old branch') was probably once part of the Dandatup system but has now been diverted. Upstream of Cape Naturaliste Rd only the middle branch was assessed on the ground with the remainder of the upper system assessed from aerial photographs since access was not possible at the time of the survey.

Issues	Comments
Land use and fencing	Lot 1307 is rural though stock are no longer present. Most of the remainder of the brook flows through foreshore reserve adjoining residential development. Lot 59 Cape Naturaliste Road (Old Dunsborough Winery) is private land used until recently for wine production and cellar door sales, though it is largely a vegetated lot. Immediately downstream is Reserve 60, a public reserve.
Landform, soils and erosion	Long head cuts, bank subsidence and undercutting are present on the middle branch upstream of the Cape Rise development. The south branch has signs of gully erosion. The Dandatup old branch has severe gully erosion which is currently being addressed by the landowner. Downstream of Cape Naturaliste Rd there is localised bank erosion in the foreshore reserve behind Curtis St, and undercutting at Reserve 60 and near the mouth of the brook.
Native vegetation	Vegetation is dominated by Stout paperbark (<i>Melaleuca preissiana</i>), Freshwater paperbark (<i>Melaleuca raphiophylla</i>) and Peppermint (<i>Agonis flexuosa</i>) with the occasional Marri (<i>Corymbia calophylla</i>).
Weeds	Weeds are a major issue in this location. Arum lily, tree ferns and <i>Juncus microcephalus</i> are present throughout. Tree ferns are particularly dense on the middle branch behind the Cape Rise estate. Here there is also fig and patches of pampas grass. At the Curtis Street foreshore reserve there is dolichos pea, Japanese honeysuckle, sweet pittosporum and light bridal creeper. Immediately upstream of Gifford Road there is a 'cocktail' of garden escapees including agapanthus, fig and a variety of palms, ferns and bulbs.
Other comments, special features	Small sections of the foreshore are in outstanding condition given its proximity to residential development. These include private land on Lot 59 Naturaliste Terrace, the adjoining reserve Lot 60 and patches downstream in foreshore reserve Lot 330. Dumping of building materials has occurred in the foreshore behind the Cape Rise Estate.

Map 8: Management recommendations and advice

- Concentrate management efforts in and around Lots 59, 60 and 330 as these are the best quality areas of foreshore (i.e. work outwards from the best quality areas).
- Undertake control of Japanese honeysuckle, dolichos pea, fig and sweet pittosporum as a high priority.
- Remove tree ferns using the 'cutstump' method starting at the upstream areas and working downstream, and replace with a local native species such as freshwater paperbark *Melaleuca raphiophylla* or mohan *Melaleuca preissii*. These are aesthetically pleasing, will improve habitat values and will not damage stream ecology.
- Ensure weed control is followed by replanting with local native species to prevent re-invasion.
- Plant local native rushes and sedges to improve stream habitat values and reduce erosion of the stream bank.
- Provide targeted and regular information to town residents adjoining the foreshore reserve regarding garden plants with potential to become invasive weeds, and the benefits of landscaping with local native species.
- Encourage the development of a local friends group to assist with long term management of the foreshore reserve at lots 60 and 330.
- Monitor the success of erosion control measure on the Dandatup old branch and, if not successful, use rock riffle-pool sequences to improve stabilisation.
- Remove building refuse from behind the Cape Rise estate and liaise with the Shire of Busselton regarding measures to prevent dumping of refuse on foreshore reserves.



Dandatup Brook Map 8

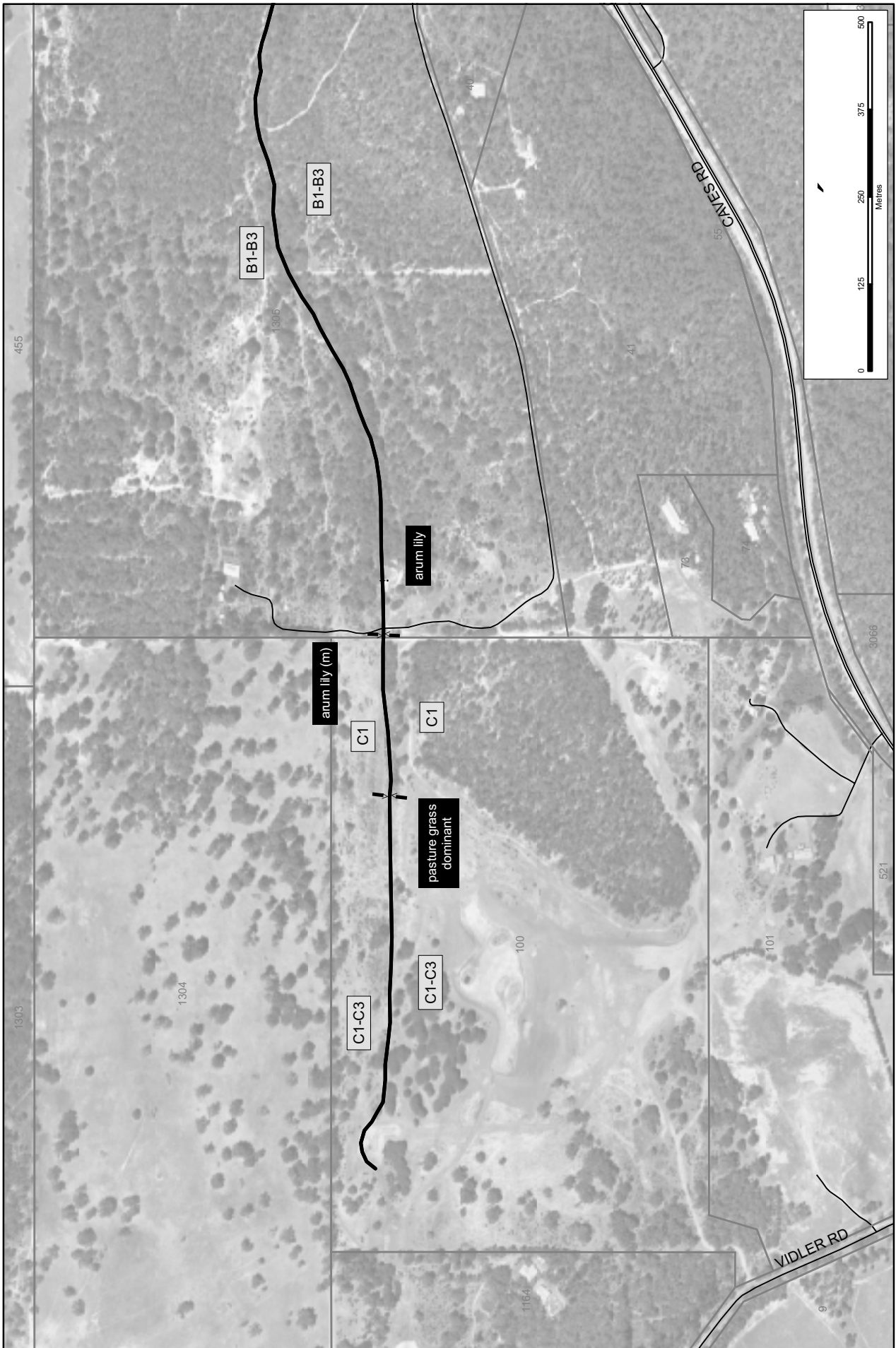
Map 9 Dugulup Brook

Map 9 shows the Dugulup Brook from its headwaters on Lot 100 to the boundary of Lot 1305.

Issues	Comments
Land use and fencing	Lots 100 and 1305 are a rural lots used for lifestyle purposes with no stock. Lot 1305 was assessed from aerial photographs since access for an on ground assessment was not available at the time of the survey.
Landform, soils and erosion	Landform units include the Metricup rocky valley and Cowaramup deep sandy rises. Soils are loamy gravels and duplex sandy gravels; and pale deep sands.
Native Vegetation	Vegetation on the main channel is predominantly Marri (<i>Corymbia callophylla</i>) with Peppermint (<i>Agonis flexuosa</i>) with Soapbush (<i>Trymalium floribundum</i>), Square sedge (<i>Lepidosperma tetraquetum</i>) and Spreading sword sedge (<i>Lepidosperma effusum</i>) where the under storey structure is in tact.
Weeds	Arum lily is present throughout.
Other comments, special features	An on-stream dam located Lot 1305 is visible on the aerial photograph. Extensive rehabilitation works surrounding a series of constructed wetlands have been undertaken on Lot 100 using local native species.

Map 9: Management recommendations and advice

- Extend rehabilitation efforts on lot 100 to include replanting of the foreshore with local native species. Control of introduced grasses will need to be undertaken first in this area.
- Plant local native rushes and sedges to improve stream habitat values and reduce the risk of erosion of the stream bank.
- Seek permission from the landholder of Loc 1305 to develop a list of native plants occurring on the foreshore of this property. Given the extensive area of in-tact vegetation, this property would provide an excellent reference point for identifying appropriate rehabilitation species for other parts of Dugulup Brook.



Dugulup Brook Map 9

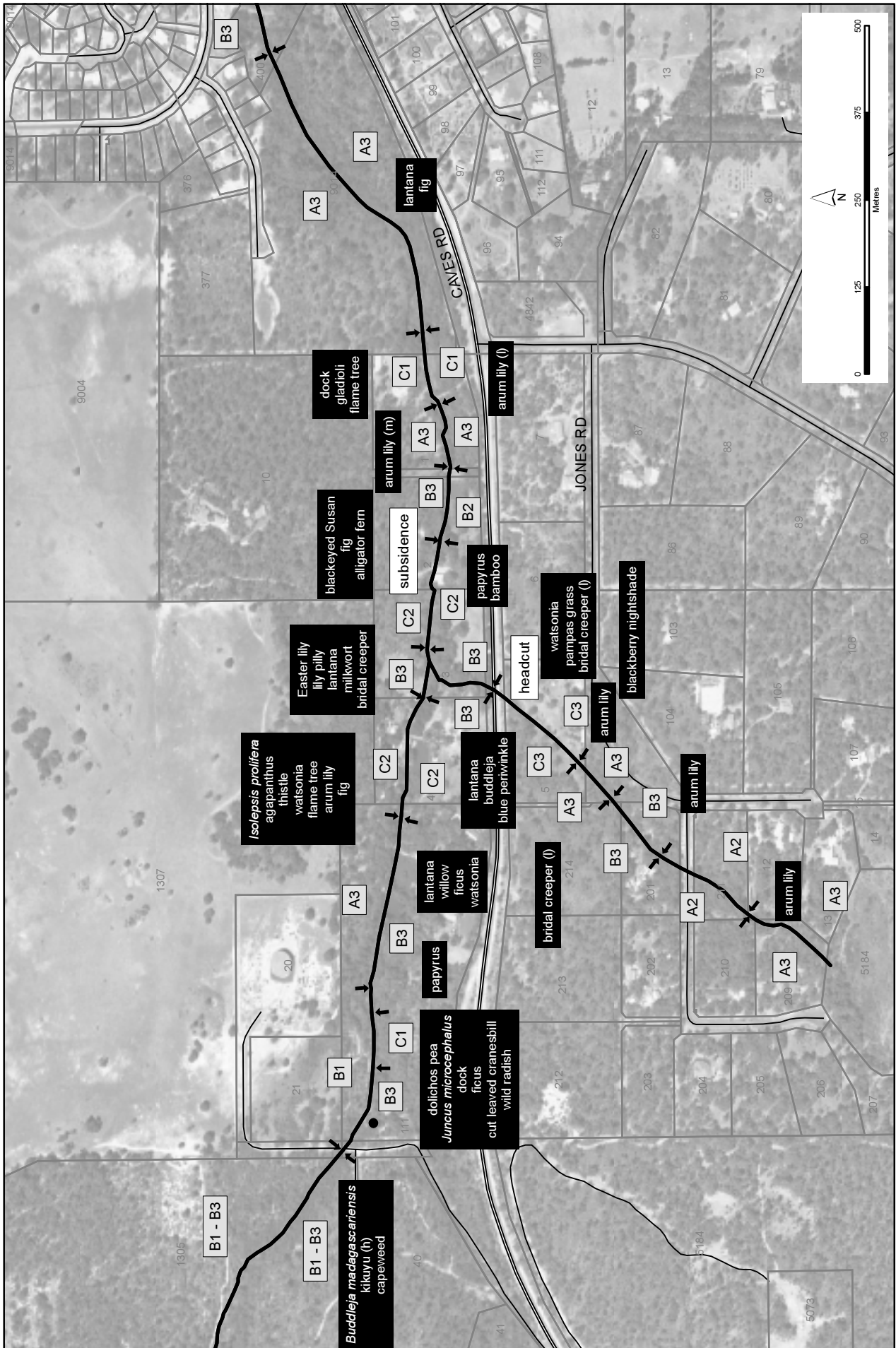
Map 10 Dugulup Brook

Map 10 Shows the Dugulup Brook from the boundary of Lot 1305 to just upstream of the Dunsborough townsite in the middle of Location 9014. A small tributary extends to the south west.

Issues	Comments
Land use and fencing	Lot 111 is a rural lot used for lifestyle purposes with no stock and also has a garden nursery business occupying a small corner. Lot 4 is used to exhibit farm animals. Lot 1, 2 and 3 are lifestyle lots. There is no foreshore fencing in this area and no stock.
Landform, soils and erosion	Minor bank erosion and subsidence is present on lots 3 and 4 and a head cut is present on lot 5.
Native Vegetation	Vegetation on the main channel is predominantly Marri (<i>Corymbia callophylla</i>) with Peppermint (<i>Agonis flexuosa</i>) with Soapbush (<i>Trymalium floribundum</i>), Square sedge (<i>Lepidosperma tetraquetum</i>) and Spreading sword sedge (<i>Lepidosperma effusum</i>) where the under storey structure is in tact. The tributary flowing from Big Rock Reserve is in excellent condition and has Marri (<i>Corymbia callophylla</i>) with Peppermint (<i>Agonis flexuosa</i>), Bull banksia (<i>Banksia grandis</i>) and Jarrah (<i>Eucalyptus marginata</i>).
Weeds	Arum lily is present throughout. Lot 111 is infested with an extensive range of garden escapees, possibly as result of plantings associated with its historic use. Weeds are also extensive on Lots 3 and 4. Weeds of concern here include Lantana, Dolichos pea, Papyrus, Watsonia, Fig, Milkwort, and Blue periwinkle. The small tributary to the south is largely in good condition though has isolated outbreaks of Arum lily, Blackberry nightshade and Bridal creeper. Lot 5 has Pampas grass, Gladioli and Watsonia.
Other comments, special features	A series of dams have been established both on the main brook and on the tributary. There has been a long history of conflict over water allocation in this area. 'A' class foreshore vegetation was recently cleared from Lot 1, accordingly the classification was amended from A3 to C3 in this area.

Map 10: Management recommendations and advice

- Liaise with the Shire of Busselton to ensure that appropriate rehabilitation of the foreshore on Lot 1 Caves Road is achieved.
- Remove Lantana and Fig from location 9014 as a high priority since this area contains high quality vegetation and is otherwise weed free.
- Continue and extend the current control program for arum lily to include other invasive species identified on the map with a priority for control of Dolichos pea, Fig, Lantana, Blue periwinkle, Bamboo and Pampas grass since these are currently at manageable levels of infestation but will continue to spread if not controlled.
- Control weeds on the south bank of Lot 111 as a high priority since the north bank contains remnant vegetation of high quality and is relatively free of weeds.
- Plant local native rushes and sedges to improve stream habitat values and reduce erosion of the stream bank.
- Ensure that where control burns are undertaken they are followed by weed control and monitoring of weed invasion and that a sufficient period is allowed between burns to enable recovery and seed germination of native species to occur. A minimum of four years is recommended though a longer period may be needed for some species.
- Provide targeted and regular information to landowners regarding garden plants with potential to become invasive weeds, and the benefits of landscaping with local native species.



Dugulup Brook Map 10

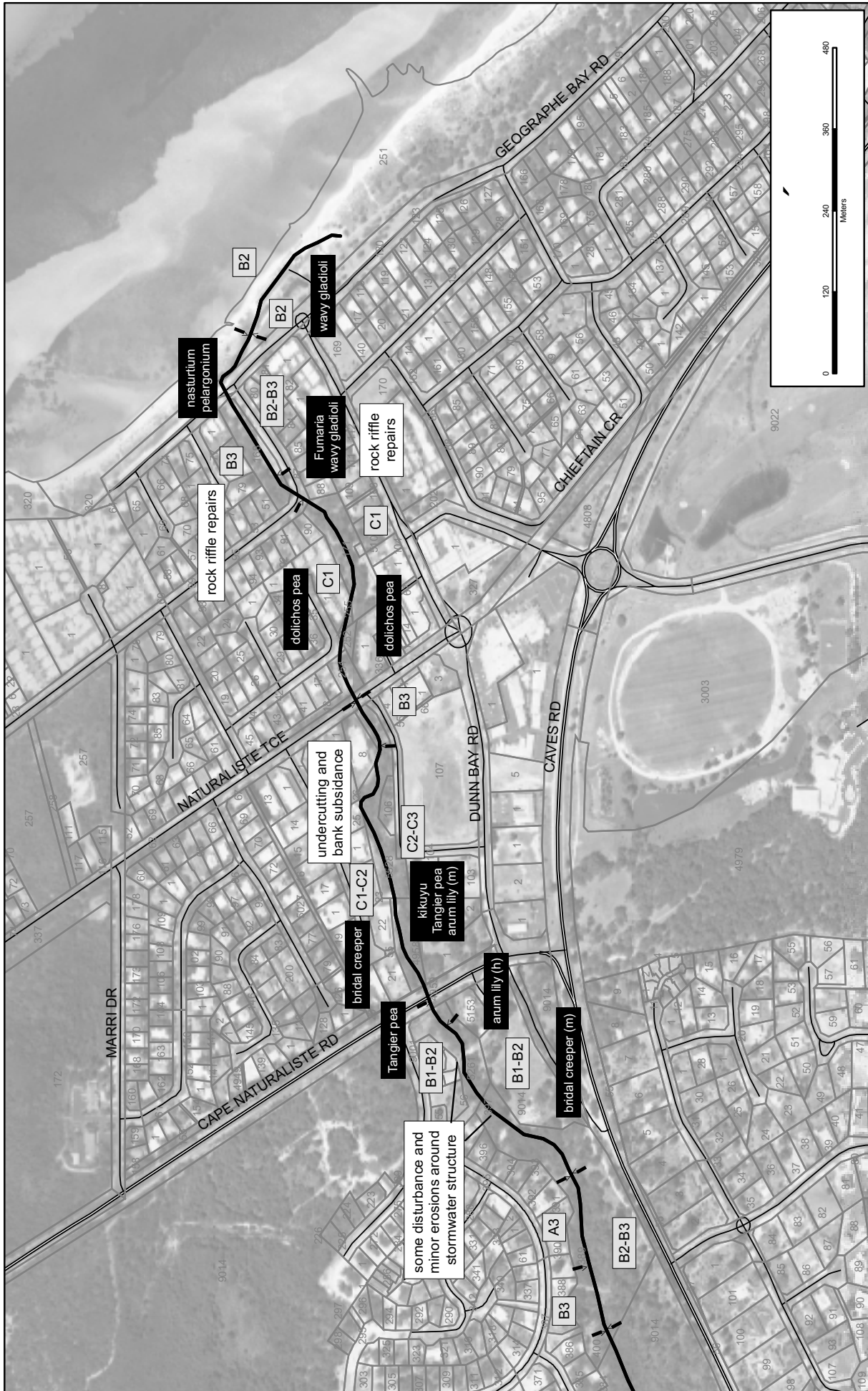
Map 11 Dugulup Brook

Map 11 Shows the Dugulup Brook from the midpoint of Location 9014 to the mouth near the intersection of Gifford Road and Geographe Bay Road.

Issues	Comments
Land use and fencing	Location 9014 is private bushland but has been rezoned for residential development. Downstream the brook flows through foreshore reserve all the way to the mouth. Fencing exists along the rear boundaries of properties in the Naturaliste Heights estate, but downstream the boundary of the foreshore reserve is generally poorly delineated. There are many incursions into the foreshore reserve from properties in the light industrial area along Clarke St.
Landform, soils and erosion	Behind the Naturaliste Heights estate there is minor erosion around storm water structures built to detain flow for flood mitigation purposes. Undercutting and bank subsidence is present where the brook flows behind the Coles Shopping Centre car park. Downstream there are a few areas of minor bank erosion, though substantial in-stream works involving construction of rock riffle pool sequences and revegetation of the stream bank have stabilised erosion.
Native Vegetation	Over storey is dominated by Peppermint (<i>Agonis flexuosa</i>) and the occasional Bull Banksia (<i>Banksia grandis</i>), changing to peppermint with the occasional flooded gum (<i>Eucalyptus rudis</i>).
Weeds	There are minor infestations of Lantana and Fig on location 9014, though otherwise this location is largely weed free. Bridal creeper, Arum lily and Tangier pea occur in the lower area of Reserve 5261. Dolichos pea is found in scattered locations throughout the remainder of the foreshore though is at low levels due to recent control efforts. Tangier pea is spreading in the middle sections of reserve 5528. Near the mouth there is Wavy gladioli, Nasturtium and Pelargonium.
Other comments, special features	The lower section of the brook contains some excellent and successful examples of river restoration techniques using rock-riffle sequences combined with extensive replanting with local native species. These may be viewed from Naturaliste Terrace to the parkland area on Gifford Road. A detailed concept plan has been developed for the rehabilitation of the foreshore reserve between Cape Naturaliste Road and Naturaliste Terrace including provision of public access pathways.

Map 11: Management recommendations and advice

- Liaise with the Shire of Busselton to ensure that appropriate management measures are put in place when location 9014 is developed for residential development. These should include provision of an adequate foreshore reserve with public access provided, removal of weeds and prevention of disturbance to the brook when establishing services. Ideally lots should be designed such that houses face rather than back on to the foreshore reserve.
- Concentrate weed control efforts on the reserve adjoining location 9014 to prevent weeds from spreading into 'A' class condition foreshore.
- Continue and extend the current weed control program for Dolichos pea and Arum lily to include Tangier pea and Wavy gladioli since these weeds are spreading along the brook.
- Replace Nasturtium and Pelargonium at the coast with local native species tolerant of coastal condition such as coastal sword sedge *Lepidosperma gladiatum* and sea rush *Juncus kraussii*.



Dugulup Brook Map 11

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Appendices

Appendix 1: Native vegetation of the Cape Naturaliste streams

This table provides a list of the native plants identified on the foreshore of the Cape Naturaliste streams during the foreshore assessments. The last column indicates whether the species is available from local plant nurseries. For assistance in developing a species list for your rehabilitation project, please contact GeoCatch.

Form	Scientific Name	Common Name	Jingarmup	Meelup	Dolugup	Dandatup	Dugulup	Available
Shrub	<i>Acacia cyclops</i>	Coastal wattle		✓				✓
Shrub	<i>Acacia extensa</i>	Wiry wattle	✓	✓		✓	✓	✓
Shrub	<i>Acacia divergens</i>	Wattle		✓		✓	✓	✓
Shrub	<i>Acacia pulchella</i>	Prickly moses	✓	✓		✓	✓	✓
Shrub	<i>Acacia saligna</i>	Golden wreath wattle		✓	✓	✓		✓
Shrub	<i>Adenanthos barbiger</i>	Hairy jugflower			✓			
Fern	<i>Adiantum aethiopicum</i>	Common maidenhair		✓		✓		
Tree	<i>Agonis flexuosa</i>	WA peppermint	✓	✓	✓	✓	✓	✓
Tree	<i>Agonis linearifolia</i>	Swamp peppermint	✓			✓	✓	✓
Tree	<i>Agonis juniperina</i>	Wattie				✓		
Herb	<i>Agrostocrinum stypandroides</i>	Blue grass lily				✓		
Herb	<i>Anigozanthos flavidus</i>	Tall kangaroo paw	✓	✓	✓	✓	✓	✓
Herb	<i>Anigozanthos manglesii</i>	Red and green kangaroo paw				✓		✓
Fern	<i>Asplenium obtusatum</i>	Common spleenwort				✓		
Tree	<i>Banksia grandis</i>	Bull banksia				✓	✓	✓
Tree	<i>Banksia attenuata</i>	Candle banksia					✓	✓
Sedge	<i>Baumea vaginalis</i>	Sheath twig rush				✓		✓
Sedge	<i>Baumea preissii</i>	Baumea				✓		✓
Sedge	<i>Baumea juncea</i>	Baumea		✓		✓		✓
Rush	<i>Bolboschoenus caldwellii</i>	Marsh club-rush			✓			✓
Shrub	<i>Bossiaea linophylla</i>	Bossiaea		✓	✓	✓		✓
Herb	<i>Burchardia umbellata</i>	Milkmaids		✓		✓	✓	
Herb	<i>Caladenia flava</i>	Cowslip orchid		✓		✓	✓	
Tree	<i>Callistachys lanceolata</i>	Native willow				✓		✓
Shrub	<i>Calothamnus graniticus</i>	One sided bottlebrush	✓	✓			✓	✓
Shrub	<i>Calothamnus sanguineus</i>	Silky leaved bloodflower		✓	✓		✓	✓
Herb	<i>Centella asiatica</i>	Pennywort	✓	✓	✓	✓		✓
Herb	<i>Chamaescilla corymbosa</i>	Blue squill				✓	✓	
Fern	<i>Cheilanthes austrotenuifolia</i>	Rock fern		✓				
Herb	<i>Cheiranthra preissiana</i> var. <i>planifolia</i>	Cheiranthra				✓		
Sedge	<i>Chorizandra cymbria</i>	Heron bristle rush				✓		
Shrub	<i>Chorizema ilicifolium</i>	Holly leaved flame pea		✓	✓	✓	✓	✓
Shrub	<i>Chorizema diversifolium</i>	Flame pea		✓				
Shrub	<i>Chorizema rhombeum</i>	Flame pea		✓				

Form	Scientific Name	Common Name	Jingarmup	Meelup	Dolugup	Dandatup	Dugulup	Available
Climber	<i>Clematis pubescens</i>	Old mans beard		✓				✓
Herb	<i>Conostylis laxiflora</i>	Cottonhead				✓	✓	✓
Herb	<i>Conostylis setigera</i>	Bristly cottonhead		✓				✓
Tree	<i>Corymbia calophylla</i>	Marri	✓	✓		✓	✓	✓
Herb	<i>Cyanicula sericea</i>	Silky blue orchid	✓	✓		✓		
Sedge	<i>Cyathochaeta avenacea</i>	Cyathochaeta				✓		
Herb	<i>Dampiera alata</i>	Wing stemmed dampiera	✓	✓				
Shrub	<i>Darwinia citriodora</i>	Lemon scented darwinia	✓	✓			✓	
Shrub	<i>Daviesia cordata</i>	Bookleaf		✓	✓			
Herb	<i>Diuris aff. amplissima</i>	Giant donkey orchid				✓		
Shrub	<i>Dondonae ceratocarpa</i>	Hop bush				✓		
Herb	<i>Drosera stelliflora</i>	Dwarf drosera					✓	
Herb	<i>Drosera glanduligara</i>	Pimpernel sundew					✓	
Herb	<i>Drosera macrantha</i>	Bridal rainbow				✓		
Herb	<i>Drosera pallida</i>	Pale rainbow		✓			✓	
Shrub	<i>Dryandra lindleyana</i> subs.lindleyana	Couch honeypot		✓	✓	✓	✓	
Herb	<i>Elythranthera brunonis</i>	Purple enamel orchid			✓	✓		
Herb	<i>Elythranthera emarginata</i>	Pink enamel orchid		✓	✓	✓		
Herb	<i>Eriochilus dilatatus</i>	White bunny orchid			✓			
Tree	<i>Eucalyptus diversicolor</i>	Karri (probably planted)		✓				✓
Tree	<i>Eucalyptus marginata</i>	Jarraah		✓		✓	✓	✓
Tree	<i>Eucalyptus megacarpa</i>	Bullich						✓
Tree	<i>Eucalyptus patens</i>	Blackbutt				✓		✓
Tree	<i>Eucalyptus rudis</i>	Flooded gum	✓			✓		✓
Shrub	<i>Gastrolobium spinosum</i>	Prickly poison		✓				
Sedge	<i>Gahnia trifida</i>	Coast saw-sedge			✓			
Shrub	<i>Hakea amplexicaulis</i>	Prickly hakea		✓				✓
Shrub	<i>Hakea lasianthiodes</i>	Hakea			✓			✓
Shrub	<i>Hakea lissocarpha</i>	Honey bush		✓	✓	✓	✓	✓
Shrub	<i>Hakea trifurcata</i>	Two leaf hakea		✓				✓
Climber	<i>Hardenburgia comptoniana</i>	Native wisteria		✓		✓	✓	✓
Shrub	<i>Hibbertia cuneiformis</i>	Cutleaf hibbertia	✓	✓	✓	✓	✓	✓
Shrub	<i>Hibbertia cunninghamii</i>	Hibbertia sp.		✓				
Shrub	<i>Hibbertia hypericoides</i>	Yellow buttercups	✓	✓		✓	✓	
Shrub	<i>Hibbertia spicata</i>	Hibbertia sp.		✓				
Shrub / tree	<i>Homalospernum firmum</i>	Homalospernum	✓		✓			
Shrub	<i>Hovea elliptica</i>	Tree hovea		✓		✓	✓	✓
Herb	<i>Hovea trisperma</i>	Common hovea		✓				
Shrub	<i>Hypocalymma angustifolium</i>	White myrtle		✓				✓
Shrub	<i>Hypocalymma robustum</i>	Swan river myrtle		✓		✓	✓	✓

Form	Scientific Name	Common Name	Jingarmup	Meelup	Dolugup	Dandatup	Dugulup	Available
Rush	<i>Isolepis nodosa</i>	Knotted club rush	✓			✓		✓
Herb	<i>Isotropis cuneifolia</i> sub. <i>cuneifolia</i>	Granny bonnets				✓		
Rush	<i>Juncus kraussii</i>	Sea rush	✓			✓	✓	✓
Rush	<i>Juncus pallidus</i>	Pale rush	✓	✓		✓	✓	✓
Creeper	<i>Kennedia carinata</i>	Kennedia		✓			✓	
Creeper	<i>Kennedia prostrata</i>	Running postman					✓	✓
Climber	<i>Kennedia coccinea</i>	Coral vine		✓				✓
Shrub	<i>Kunzea glabrescens</i>	Spearwood				✓		✓
Sedge	<i>Lepidosperma gladiatum</i>	Coastal sword sedge	✓			✓	✓	✓
Sedge	<i>Lepidosperma tetraquetum</i>	Square sedge		✓		✓	✓	
Sedge	<i>Lepidosperma effusum</i>	Spreading sword sedge				✓	✓	
Sedge	<i>Lepidosperma pubisquamatum</i>					✓	✓	
Herb	<i>Leschenaultia biloba</i>	Blue leschenaultia	✓				✓	✓
Shrub	<i>Leucopogon verticillatus</i>	Tassel flower			✓		✓	
Shrub	<i>Logania vaginalis</i>	White spray		✓	✓	✓	✓	
Rush	<i>Lygnia imberbis</i>	Lygnia	✓			✓		
Shrub	<i>Macrozamia reidlei</i>	Zamia palm	✓	✓		✓	✓	
Tree	<i>Melaleuca raphiophylla</i>	Fresh water paperbark	✓			✓		✓
Tree	<i>Melaleuca preissiana</i>	Stout paperbark	✓			✓		✓
Shrub	<i>Mirbelia dilatatum</i>					✓	✓	✓
Sedge	<i>Mesomelaena tetragona</i>	Semaphore sedge	✓	✓		✓	✓	
Herb	<i>Patersonia occidentales</i>	Purple flags		✓	✓	✓		✓
Herb	<i>Patersonia umbrosa</i> var <i>xanthina</i>	Yellow flags		✓		✓	✓	✓
Herb	<i>Persoonia longifolia</i>	Snottygobble		✓	✓	✓	✓	
Shrub	<i>Phyllanthus calycinus</i>	False boronia	✓	✓				✓
Shrub	<i>Pimelea rosea</i>	Rose banjine	✓	✓		✓		✓
Shrub	<i>Pimelea spectabilis</i>	Bunjong			✓	✓		✓
Fern	<i>Pteridium esculentum</i>	Bracken fern		✓	✓	✓	✓	
Herb	<i>Pterostylis vittata</i>	Banded greenhood (orchid)				✓		
Herb	<i>Scaevola glandulifera</i>	Viscid hand flower		✓				
Herb	<i>Scaevola microphylla</i>	Small-leaved scaevola			✓			
Shrub	<i>Sollya heterophylla</i>	Australian bluebell		✓			✓	✓
Herb	<i>Sowerbaea laxiflora</i>	Vanilla lily		✓		✓		
Grass	<i>Spinifex hirsutis</i>	Hairy spinifex	✓	✓	✓	✓	✓	✓
Shrub	<i>Spyridium globulosum</i>	Basket bush	✓	✓		✓	✓	✓
Herb	<i>Stylidium</i> sp	Trigger plant		✓	✓	✓	✓	
Herb	<i>Stylidium megacarpum</i>	Trigger plant	✓	✓		✓		
Herb	<i>Thelymitra</i> sp	Sun orchid			✓	✓		
Herb	<i>Thysonatus gracilis</i>	Fringed lily		✓				
Climber	<i>Thysonatus manglesianis</i>	Fringed lily (climbing)		✓				

Form	Scientific Name	Common Name	Jingarmup	Meelup	Dolugup	Dandatup	Dugulup	Available
Creeper	<i>Tremandra diffusa</i>	Tremandra		✓		✓	✓	
Herb	<i>Thomasia foliosa</i>	Thomasia	✓	✓		✓	✓	
Aquatic herb	<i>Triglochin huegelii</i>	Water ribbons		✓				
Herb	<i>Tripterococcus brunonis</i>	Yellow candles		✓	✓			
Tree	<i>Trymalium floribundum</i>	Soap bush					✓	
Herb	<i>Wurmbea dioica</i> subsp <i>alba</i>	Early nancy		✓		✓	✓	
Shrub	<i>Xanthorrhoea gracilis</i>	Graceful grass tree			✓			
Shrub	<i>Xanthorrhoea preissii</i>	Grass tree, Balga	✓	✓	✓	✓	✓	
Tree	<i>Xylomelon occidentale</i>	Western woody pear				✓		✓
Aquatic herb	<i>Villarsia albiflora</i>	Villarsia sp.		✓				

Appendix 2. Common weeds found in the study area

This table provides a list of the weeds found on the foreshore of the Cape Naturaliste streams. The species highlighted in grey are those that are still commonly planted in gardens today. Ideally, these should be replaced with local native plant species such as those presented in Appendix 1. Some of the species presented below are highly invasive and will require a number of years of follow-up control to achieve eradication.

Common Name	Scientific Name	Jingarmup	Meelup	Dolugup	Dandatup	Dugulup
Agapanthus	<i>Agapanthus praecox</i>				✓	✓
Arum lily	<i>Zantedeschia aethiopica</i>	✓	✓	✓	✓	✓
Bamboo	<i>Phyllostachys</i> sp.				✓	✓
Black wattle	<i>Acacia decurrens</i>	✓	✓		✓	
Blackberry	<i>Rubus</i> sp.		✓		✓	
Blackberry nightshade	<i>Solanum nigrum</i>		✓			✓
Black-eyed susan	<i>Thunbergia alata</i>					✓
Blowfly grass	<i>Briza maxima</i>	✓	✓	✓	✓	✓
Blue perriwinkle	<i>Vinca major</i>					✓
Bracken	<i>Pteridium esculentum</i>	✓	✓		✓	✓
Brassicaceae sp.	<i>Brassicaceae</i> sp			✓		✓
Bridal creeper	<i>Asparagus asparagoides</i>	✓	✓		✓	✓
Broomrape (lesser)	<i>Orobanche minor</i>				✓	
Budding club-rush	<i>Isolepis prolifera</i>		✓			✓
Buddleja	<i>Buddleja madagascariensis</i>					✓
Bulrush	<i>Typha orientalis</i>		✓		✓	
Canary grass	<i>Phalaris paradoxa</i>	✓				
Capeweed	<i>Arctotheca calendula</i>	✓	✓	✓	✓	✓
Castor oil	<i>Ricinus communis</i>					✓
Couch	<i>Cynodon dactylon</i>	✓	✓		✓	
Cut-laf cranesbill	<i>Geranium dissectum</i>					✓
Dock	<i>Rumex</i> sp.		✓		✓	✓
Dolichos pea	<i>Dipogon lignosus</i>		✓		✓	✓
Dune onion weed	<i>Trachyandra divaricata</i>	✓				
Easter lily	<i>Amaryllis belladonna</i>				✓	✓
Edible fig	<i>Ficus carica</i>	✓	✓		✓	✓
Flame tree (Coral tree)	<i>Eruthrina x sykesii</i>					✓
Hares tail grass	<i>Lagurus ovatus</i>	✓				
Holly-leaved senecio	<i>Senecio glastifolius</i>				✓	
Japanese honeysuckle	<i>Lonicera japonica</i>	✓			✓	
Juncus articulatus	<i>Juncus articulatus</i>				✓	✓
Juncus microcephalus	<i>Juncus microcephalus</i>		✓		✓	✓
Kikuyu	<i>Pennisetum clandestinum</i>	✓	✓	✓	✓	✓
Lantana	<i>lantana camara</i>					✓
Lupin	<i>Lupinus</i> sp.				✓	
Milkwort (myrtle leaved)	<i>Polygala myrtifolia</i>				✓	✓
Pennyroyal	<i>Mentha pulegium</i>	✓				✓
Montbretia	<i>Crocsmia x crocosmifolia</i>				✓	

Common Name	Scientific Name	Jingarmup	Meelup	Dolugup	Dandatup	Dugulup
Nasturtium	<i>Tropaeolum majus</i>				✓	
Pampas grass	<i>Cortaderia selloana</i>					✓
Papyrus	<i>Cyperus papyrus</i>					✓
Pine tree	<i>Pinus pinaster</i>				✓	
Ribwort plantain	<i>Plantago lanceolata</i>	✓	✓	✓	✓	✓
Rose pelargonium	<i>Pelargonium capitatum</i>	✓			✓	✓
Sea spurge	<i>Euphorbia paralias</i>	✓	✓	✓	✓	✓
Sorrel	<i>Acetosella vulgaris</i>	✓				
Sour sob	<i>Oxalis</i> sp.				✓	✓
Sweet pittosporum	<i>Pittosporum undulatum</i>		✓	✓	✓	
Tangier pea	<i>Lathyrus tingitanus</i>				✓	✓
Thistle (slender sp.)	<i>Carduus</i> sp.	✓		✓	✓	
Tree fern (rough)	<i>Sphaeropteris cooperi</i>				✓	
Veldt daisy	<i>Domorphotheca ecklonis</i>				✓	
Veldt grass	<i>Ehrharta longiflora</i>				✓	✓
Watsonia	<i>Watsonia</i> sp.	✓	✓		✓	✓
Wavy gladioli	<i>Gladiolus undulatus</i>	✓	✓	✓	✓	✓
White fumitory	<i>Fumaria capreola</i>	✓	✓			✓
Wild oats	<i>Avena fatua</i>	✓	✓		✓	✓
Wild raddish	<i>Raphanus raphansitrum</i>					✓
Willow	<i>Salix babylonica</i>				✓	✓
Yorkshire fog	<i>Holcus lanatus</i>				✓	
Total number of weeds		23	23	10	41	40

Appendix 3. Advice for planning a project

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

Planning a project

Write down your objectives:

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

A written list of objectives:

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

Site selection:

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

Organising a planning committee:

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

Planning creek rehabilitation

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

Issues to be addressed include:

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

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

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

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

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

Bank erosion and/or sedimentation may require remedial action prior to revegetation. Advice should be sought from GeoCatch.

When to survey

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

What's growing on the creek or river bed

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

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

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

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

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

Identifying plants

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

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

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

Appendix 4. Useful contacts

GeoCatch

72 Duchess St, Busselton
PO Box 269, Busselton, 6280
Ph: 9781 0111
Fax: 9754 4335
Email: geocatch@water.wa.gov.au
Web: <http://www.geocatch.asn.au>

Department of Agriculture & Food

RSM 184, Busselton, 6280
Ph: 9752 1688
Web: <http://www.agric.wa.gov.au>

Department of Environment and Conservation

14 Queen Street, Busselton, 6280
Ph: 9752 1677
Web: <http://www.naturebase.com.au>

Department of Water

72 Duchess St, Busselton
PO Box 269, Busselton, 6280
Ph: 9781 0111
Fax: 9754 4335
Web: <http://www.water.wa.gov.au>

Ribbons of Blue

72 Duchess St, Busselton
PO Box 269, Busselton, 6280
Ph: 9781 0111
Fax: 9754 4335

Shire of Busselton

Southern Drive, Busselton
Locked Bag 1, Busselton, 6280
Ph: 9781 0444
Fax: 9752 4958