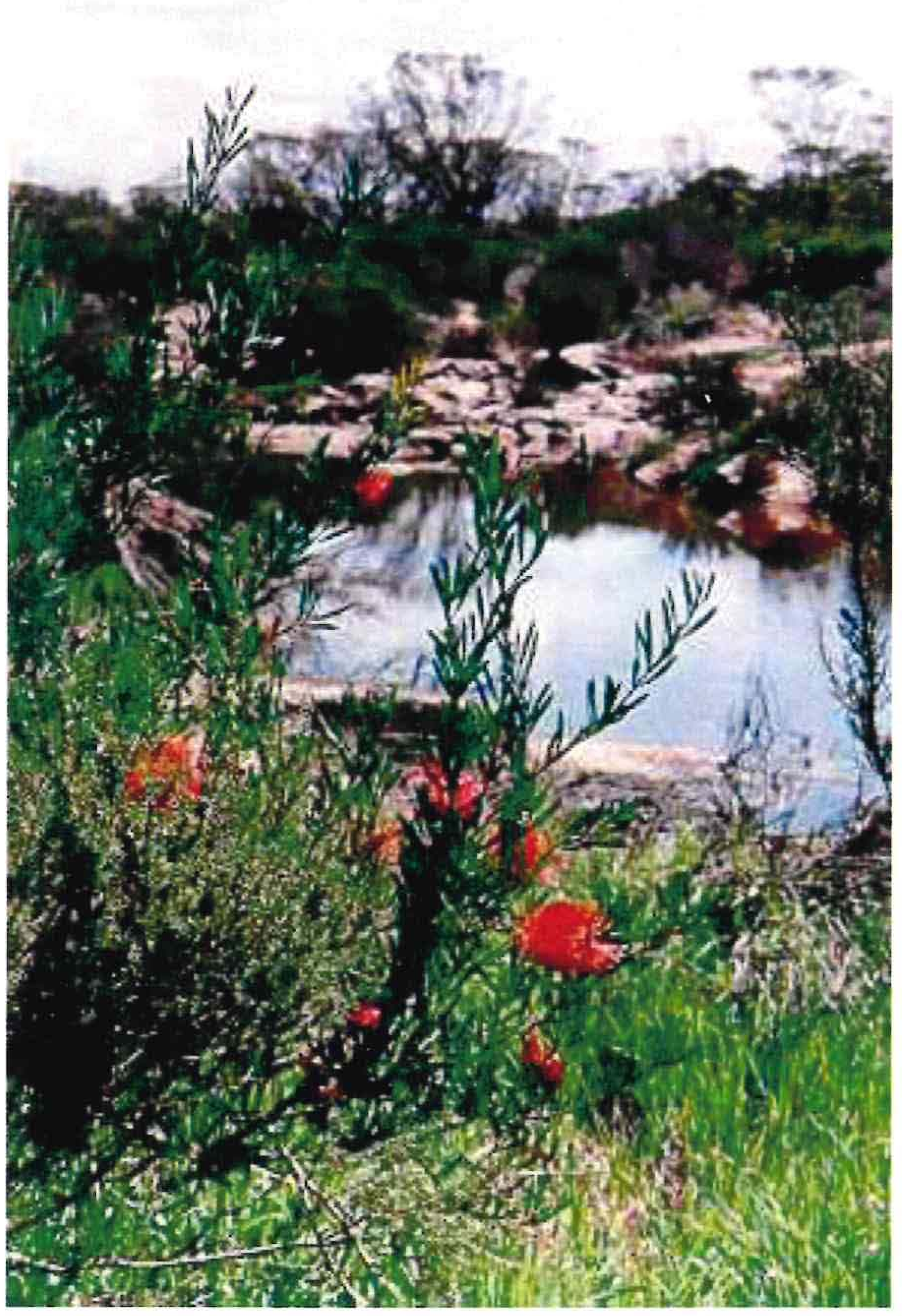
STATE OF THE WATERWAYS IN THE FITZGERALD RIVER CATCHMENT



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State of the waterways in the Fitzgerald River catchment

Water and Rivers Commission

Natural Heritage Trust

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Cover photograph: Fitzgerald River [taken by Kaylene Parker]

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Purpose of this report

The purpose of this report is to provide information on the condition and status of the waterways in the Fitzgerald River catchment, and to provide management recommendations to address the major issues threatening the health of the waterways.

The report provides:

- a record of the condition of waterways in the catchment;
- general information on the waterways in the catchment – including water quality, foreshore vegetation and ecological information such as native fish, frogs and fauna;
- a summary of on-ground works completed and planned (map 1);
- an indication of problem areas;
- management guidance and technical advice;
- a mechanism to increase community knowledge of waterways management issues;
- a mechanism for recording and prioritising on-ground work;
- a tool to apply for further funding opportunities; and
- a layer of information to incorporate into future catchment and farm planning activities.

How to use this report

This report was prepared for the Water and Rivers Commission, Jerramungup Landcare Centre and landholders in the Fitzgerald River catchment.

Section 1 lists the aims and objectives of the project and outlines relevant background information.

Section 2 describes the waterways in the catchment including Fitzgerald River and Fitzgerald Inlet. This includes information on water quality information, macroinvertebrates, native fish and foreshore vegetation. It also includes a summary on the current condition of waterways in the catchment.

Section 3 includes general management recommendations to protect waterways in the catchment.

Section 4 includes case studies and historical stories.

Each landholder in the catchment recorded information collected as part of this survey. This includes existing on-ground works and proposed on-ground works. The maps can be updated through your local landcare centre.

Values of the Fitzgerald River

- The Fitzgerald River is located within the Fitzgerald River National Park (FRNP), which is recognised as an international bisophere reserve under UNESCO's Man and the Biosphere Program. More than 1800 beautiful and bizarre species of flowering plants, as well as a myriad of lichens, mosses and fungi, have been recorded in Fitzgerald River National Park. This represents nearly 20 per cent of the total number of plant species in Western Australia, in an area that covers only a tiny fraction of the State (ANCA web page).
- The Fitzgerald River starts in the Lake Magenta Nature Reserve, which is a Class A reserve, encompassing an area of 94 170 hectares. The nature reserve was set aside in 1958 and has important conservation values due to its size and because it encompasses a naturally discrete area of eucalypt-dominated vegetation with all its variation of floristic composition and structure, from forests to woodlands and from closed mallees to mallee-scrublands and mallee-heaths (Crook and Burbidge, 1982).
- The Fitzgerald Inlet is registered on the Directory of Important Wetlands in Australia. This includes the Demster Inlet, Charles Bay Lake and the lower and middle reaches of the Fitzgerald and Sussetta rivers. They are significant examples of naturally saline 'rivers' and undisturbed coastal lagoons that exhibit cycles of flooding and drying of variable length (ANCA, 1994).
- The Fitgerald River is important for its ecological value as in connects the Lake Magenta Nature Reserve in the north to the Fitzgerald River National Park to the south. This is one of the four major linkages to the Fitzgerald River National Park Biosphere Reserve, which has excellent nature conservation values, linking natural landscapes from coastal and montane environs through to inland semi-arid.
- The Fitzgerald River foreshore (initial survey results) recorded 84 vertebrate species, 14 invertebrate and many flora species, also breeding Malleefowl. In addition many vegetation communities that are not adequately represented within existing CALM protected networks were found. The FRNP and the Lake Magenta Nature Reserve contain representatives from many species of rare and threatened flora and fauna.

Executive summary

The Fitzgerald River is an extremely important river in the South Coast Region as it forms an important macrocorridor between the Fitzgerald River National Park and the Lake Magenta Nature Reserve. In addition to this, the Fitzgerald River drains to the Fitzgerald River Inlet, which is registered on the Directory of Important Wetlands in Australia (ANCA, 1994).

To help the Fitzgerald River Catchment Group gauge where future action is needed, the Water and Rivers Commission in cooperation with the Jerramungup Landcare Centre, conducted a survey of all farms in the catchment. The survey collated information on the condition of the waterways in addition to existing and planned on-ground work including fencing, revegetation, perennial pastures, groundwater monitoring bores and creek crossings. The information was recorded on maps and provided to each individual landholder.

The results of the survey indicate that the condition of waterways in the catchment ranged from excellent (A grade) to poor condition (D grade). Some tributaries were graded as A grade condition including the Twertup Creek, the western end of Jacup Creek and the lower section of Jims Creek. These have never been cleared for agriculture. Grade D tributaries generally included the first order streams that were directly influenced by agricultural activity.

The Fitzgerald River is entirely fenced from stock except for one section south of the South Coast Highway. The survey results indicate the following:

Tributaries:

A grade (excellent condition)	=	41%
B grade (good)	=	19%
C grade (weeds and erosion)	=	21%
D grade (poor)	=	19%

The survey recorded 625 km of fencing had been completed, which included 269 km that was part funded by the Natural Heritage Trust. Landholders had also planned to complete a further 100km of fencing. The NHT project also planted 686 000 seedlings.

The survey recorded the most prominent issues of concern along waterways included:

- secondary salinity;
- loss of native vegetation;
- weed invasion; and
- erosion and sedimentation.

The recommendations to improve the condition of the waterways are to:

- Continue implementing on-ground works as planned in individual farm maps.
- Revegetate and fence degraded creek lines, particularly those graded as C or D grade condition (or use alternative farming practices such as perennial fodder crops, commercial tree plantations).
- Continually record on-ground works completed in the catchment by providing updated maps to the Jerramungup Landcare Centre.
- Continue to source options for funding to implement proposed work.

1 Introduction

1.1 Background

Many Western Australian rivers are becoming degraded as a result of human activity within and along waterways, and through the off-site effects of catchment and land uses. The erosion of foreshores and invasion of weeds and feral animals are some of the more pressing issues. Water quality in our rivers is declining with many carrying excessive loads of nutrients and sediment, and in some cases contaminated with synthetic chemicals and other pollutants (Water and Rivers Commission, 1999).

The Water and Rivers Commission selected the Fitzgerald River catchment because it is environmentally-significant. The river forms an important corridor between the FRNP and the Lake Magenta Nature Reserve. In addition to this, the Fitzgerald River drains to the Fitzgerald River Inlet, which is registered on the Directory of Important Wetlands in Australia (ANCA, 1994).

To help the Fitzgerald River Catchment Group gauge where future action is needed, the Water and Rivers Commission in cooperation with the Jerramungup Landcare Centre conducted a survey of all farms in the catchment. The surveyed collated a wealth of information that can be incorporated into future catchment and farm planning.

1.2 Aim

The aim of this report is to encourage a more coordinated attempt to protect the waterways in the catchment that drain to the Fitzgerald River and ultimately the Fitzgerald Inlet.

1.3 Objectives

The objectives of the project are to:

1. Produce a description of the state of the waterways in the Fitzgerald River catchment.
2. Provide a layer of information to incorporate into future catchment and farm planning activities.
3. Provide a benchmark of the condition of waterways against which future work to protect and rehabilitate the river can be gauged.
4. Help guide future work to protect and rehabilitate waterways.
5. Provide management recommendations to help ensure the long-term protection of our waterways.
6. Provide a sound technical basis for future funding and/or project submissions.

1.4 Study area

The catchment covers 1610 km between the Lake Magenta Nature Reserve and the south coast of Western Australia. The upper reaches lie in the Lake Magenta Nature Reserve, the middle reaches in cleared agricultural land and the lower reaches in the Fitzgerald River National Park. The Fitzgerald River and is tributaries are in the Fitzgerald Biosphere sub-region. This sub-region is the largest of the six sub-regions in the South Coast of Western Australia and is an internationally recognised area of significant heritage and environmental value. The Fitzgerald River catchment is located in the Shire of Jerramungup, 20 km east of the town of Jerramungup. Thirty-five percent of the catchment is cleared, with the largest portion of the catchment contained in the Fitzgerald River National Park.

1.5 Methodology

Water and Rivers Commission contracted Katie Tomlinson through the Jerramungup Landcare Centre to conduct the survey of each farm in the Fitzgerald River catchment. Each landholder mapped information required on aerial photographs. This information was then digitised by Geotask in Albany (Microstation format), then converted to Arc View format – with copies of the data held at the Jerramungup Landcare Centre and the Regional Information Centre.

The survey recorded:

- condition of vegetation – using Pen and Scott (1995) survey technique;
- completed and proposed on-ground works;
- perennial pastures (existing and proposed);
- groundwater monitoring bores; and
- creek crossings.

The study area encompassed 36 private landowners and almost all properties were surveyed in the catchment.

The survey was conducted on the cleared agricultural land with the assumption that the condition of the waterways in the Lake Magenta Nature Reserve and the Fitzgerald River is in good condition, and that the priority areas are in the cleared sections of the catchment. The survey covered the channel embankments, floodplain and the riparian zone. An example of a farm survey map is included in figure 2.

The Pen-Scott method of assessing condition of riparian vegetation was used (Water and Rivers Commission, 1999). The system provides a graded description of the river foreshore from pristine (A grade) to degraded (D grade).

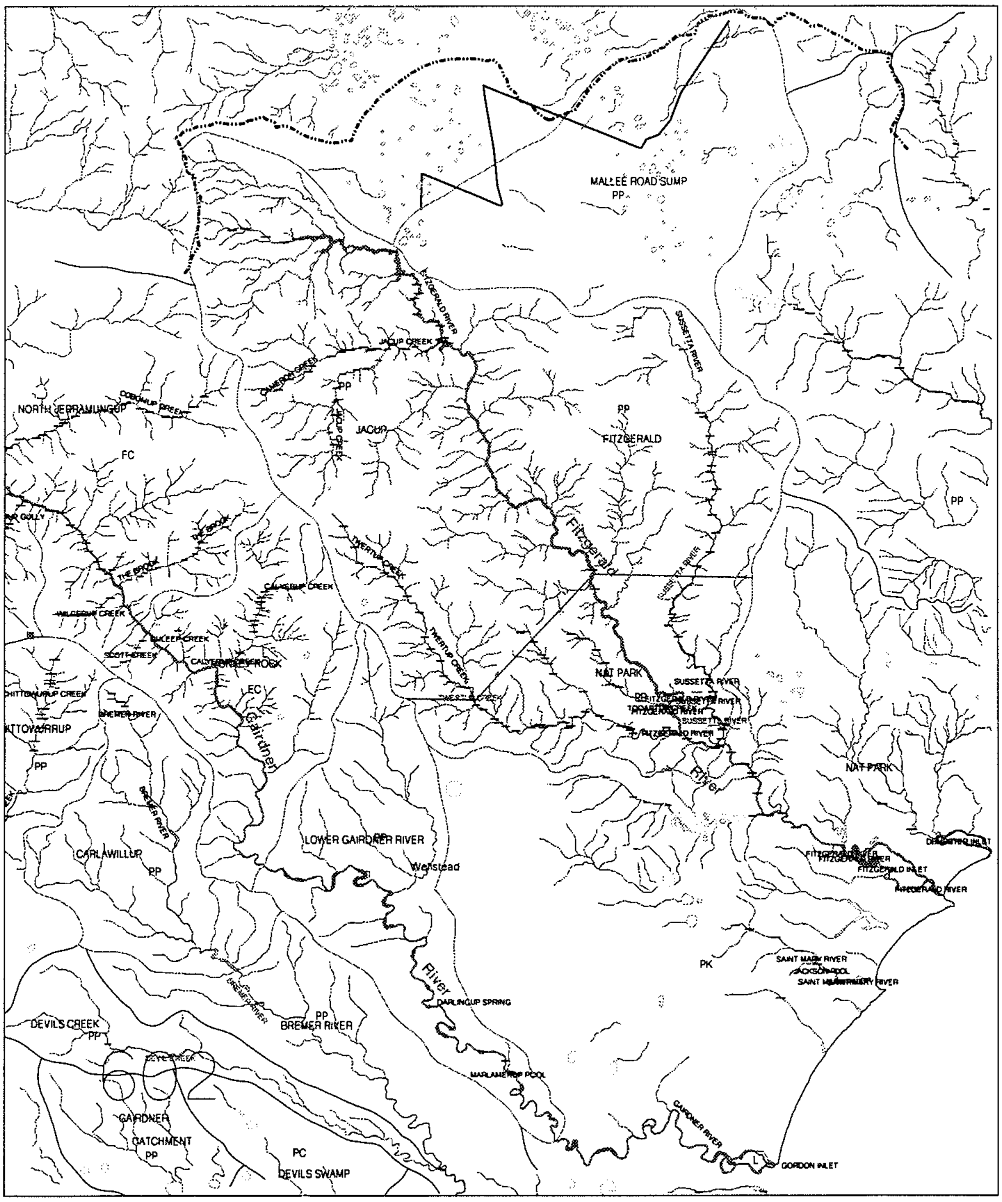

Figure 1. Fitzgerald River catchment

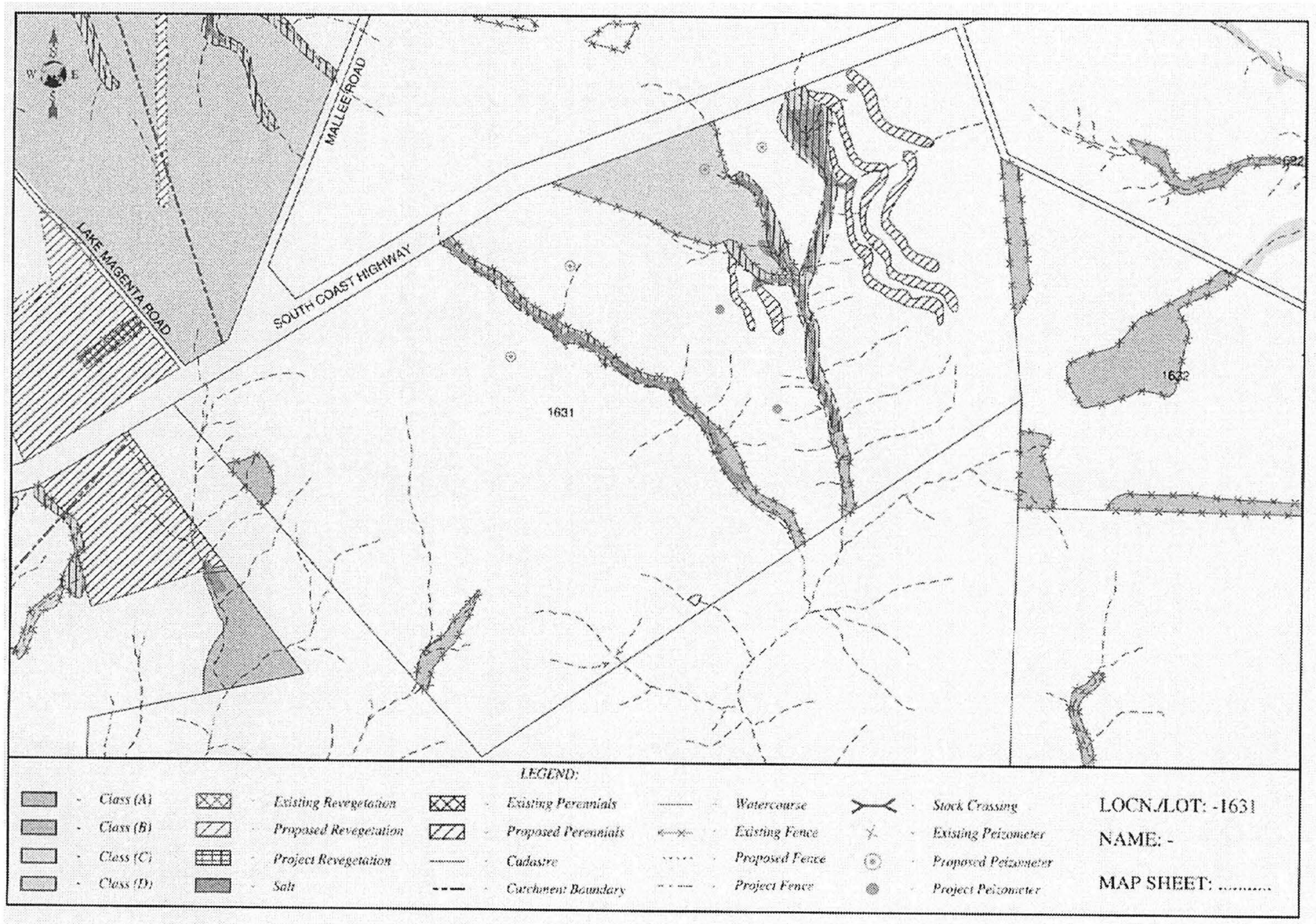

Figure 2. Example farm map completed as part of the State of the waterways in the Fitzgerald River catchment

A grade foreshore

The waterways embankments and channel are entirely vegetated with native species. There are occasionally weeds present in the understorey with some areas of localised human disturbance.

B grade foreshore

Weeds have become a significant component of the understorey, although native species remain. Some tree and large shrub species may have declined altogether. The condition of the waterway is still relatively good and if stock is excluded it is likely to remain in good condition.

C grade foreshore

The foreshore vegetation often consists entirely of weeds with some large shrubs or trees. These waterways often show levels of soil erosion by either wind or water. In many cases C grade foreshores are grazed by stock that remove the understorey species and leave the waterway more open to erosion. If stock is excluded, some supplementary revegetation is often required.

D grade foreshore

There is often little native foreshore vegetation – over storey or understorey. The banks are often undermined or eroded.

The values of fringing vegetation

Vegetation adjacent to waterways is important to help protect waterways. In particular, for streambank stabilisation, soil conservation, sediment and nutrient retention and the ecology of the environment. These values are described by Pen (1994) below.

Streambank stabilisation and soil conservation

The soils of the natural stream valley support a varied flora of trees, shrubs, sedges and herbs. In turn, the vegetation supports the stream bank and protects it from erosion and subsidence. The vegetation does this in a number of ways. Firstly, fringing vegetation increases stream bank roughness that acts to dissipate the energy of running water, and so reduce the erosive capacity of the stream flow (Troeh *et al.*, 1980). Secondly, roots and rhizomes bind and reinforce the soil of the embankments. The large roots of trees anchor the embankment in place and the smaller roots and rhizomes of shrubs, sedges and grasses hold the soil firmly at the surface of the ground between the large tree roots. In fact, the soil root matrix can add extra cohesion of the order of ten times that of an unvegetated embankment (Thorne, 1990).

The roots and rhizomes also act to loosen and break up the soil, with the result that a well vegetated bank enables rapid infiltration of rain water (Riding and Carter, 1992). Together with the extraction of water by the plants themselves, greater hydrological conductivity causes the bank to be drier than a similar unvegetated bank. In wet weather, this means that the embankment is less likely to become saturated with water, and thus is less prone to mass failure, such as subsidence and toppling caused by the added bulk weight of the water (Thorne, 1990). Lastly, riparian vegetation is highly resilient, exhibiting quick regeneration and recolonisation following severe floods. In this way the vegetation helps stabilise the river system against the effects of severe erosion and sedimentation (DeBano and Schmidt, 1990).

Sediment and nutrient retention

Ongoing international research increasingly highlights the important function that riparian zone vegetation has in filtering out sediment and nutrients carried in flowing waters. Work on vegetated buffer strips along waterways or between waterways and agricultural land has shown that vegetation of many forms, including grasslands, sedgelands, woodlands and forests, can filter out and retain substantial amounts of sediment and nutrients (Knauer and Mander, 1989). Dissolved nutrient, especially nitrate, are readily taken up and assimilated by plants (Pinay *et al*, 1990). By reducing stream flow, riparian vegetation promotes sediment deposition (Thorne, 1990). Sand can be deposited even where water is fast moving and silt will settle out where vegetation causes a marked reduction in flow. However, near-still water, such as that caught in densely vegetated floodplains, is required for the deposition of the very fine clay fractions (Troeh *et al*, 1980). Over time, substantial stream bank and floodplain accretion can occur in certain areas as a result of sediment deposition, and this can alter hydrological processes (Thorne, 1990). The removal of suspended sediment by vegetation is especially important, as water-carrying sediment has a greater momentum and is more abrasive than clean water, and thus has an enhanced capacity to cause erosion (Troeh *et al*, 1980). Much of the nutrient trapped in the vegetation of waterways or in buffer strips is assimilated by the vegetation. Generally, the longer the water is held by the vegetation, the greater the uptake of nutrients (Howard-Williams and Downes, 1986). Of course, the nutrients may be eventually released back into the water column when plant material decays, but much of this will once again be assimilated. In this way the riparian system retards the rate of transfer of nutrient particles downstream, in a process known as nutrient spiralling (Pinay *et al*, 1990). Nitrogen can be removed from riparian systems completely. This occurs via the biochemical process of denitrification, which causes nitrate to be converted to gaseous nitrogen. This process can be the major form of removal in certain riparian zones and during particular environmental conditions such as those which occur during and after flooding (Pinay *et al*, 1990).

Ecological values

Streamline vegetation not only has natural resource value in its own right, it also provides a range of habitats for a large variety of plants and animals, particularly species which are restricted to moist or aquatic environments, or species which are restricted to particular rivers or streams. For example, the freshwater streams along the south coast provide one of the few breeding environments for the Pouched lamprey, *Geotria australis*, and some of the freshwater streams along the Leeuwin Naturaliste Ridge are the only known habitat for the rare snail, *Austroassiminea letha*. Furthermore as stream systems are linear in form and cover large distance, their vegetation helps to create ecological corridors. These natural corridors, along with unnatural ones, such as vegetated strips planted along road and rail reserves, enable plant and animal species to move between larger patches of remnant habitat (Hussey *et al*, 1989).

Recreational, educational and landscape value

The Fitzgerald River has important landscape value, particularly in relation to the Lake Magenta Nature Reserve and Fitzgerald River National Park. Tourists, research scientists and students frequent these areas to observe and study the unique flora and fauna of the Fitzgerald Biosphere. The Fitzgerald River National Park is frequented for recreational purposes, especially during wildflower season and whale watching months. Fishing, boating and four-wheel driving is enjoyed on the beaches. The river itself is picturesque, meandering through the farmland with numerous pools present all year round. These provide a valuable environment for wildlife, including waterbirds, reptiles and aquatic organisms.

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2 Waterways information

2.1 Fitzgerald River

Six major river systems are located in the Fitzgerald Biosphere including the Fitzgerald, Bremer, Gairdner, Hamersley, Phillips and Jerdacuttup rivers, all extending between 50 and 100 km inland, and flowing roughly parallel to each other in a southerly or south-easterly direction.

The Fitzgerald River has its headwaters in the Lake Magenta Nature Reserve in the north and flows approximately 80 km through cleared farmland and the Fitzgerald National Park before draining into the Fitzgerald Inlet. The Fitzgerald River is important for its ecological value, connecting the Lake Magenta Nature Reserve in the north to the Fitzgerald River National Park in the south. The middle reaches of the river is in cleared farmland but the foreshore vegetation is secured and in relatively good condition. This is an important nature corridor providing flora and faunal habitats and enabling the movement of species between reserves. The corridor is relatively short (19 km) however is the only continuous corridor in the western Fitzgerald Biosphere Reserve (Robinson, 1997). The corridor is also one of the four major linkages to the Fitzgerald National Park Biosphere Reserve.

In the upper catchment, the Fitzgerald River flows over the gently undulating sandplain that covers the hard granitic and gneissic Archaean rocks of the Yilgarn Block at about 300m above sea level. The river then traverses an area south of the South Coast Highway where the valleys have cut down through the sandplain to the underlying bedrock. Within 20 – 30km of the coast, the river drains through the Pallinup Siltstone which is a relatively soft rock formed from marine sediments which were deposited 40 millions years ago. The softer rock eroded below the upper surface, which has hardened with wind and water - leaving spectacular cliffs, and steep slopes that wall the river valleys. Some valleys are 50 metres deep and 200 metres wide – spectacular features of the landscape (Hodgkin and Clarke, 1990).

The major tributaries of the Fitzgerald River include the Sussetta River (35 km long) and the Twertup Creek (15 km long). These meet up with the Fitzgerald River within the Fitzgerald River National Park 25 km from the sea.

Fitzgerald Inlet is registered on the directory of important wetlands in Australia. The site comprises of the Fitzgerald Inlet and it's associated marshes, Dempster Inlet, Charles Bay Lake, and the lower and middle reaches of the Fitzgerald River and Sussetta Rivers. They are significant as good examples of naturally saline 'rivers', and undisturbed coastal lagoons that exhibit cycles of flooding and drying of variable length (ANCA, 1994).

The Fitzgerald River flow is strongly seasonally and flows strongly following exceptionally heavy or prolonged rainfall, which may occur over a few days or weeks, mainly each winter. In many years, the flow is low and may be negligible in dry years. Despite this, the Fitzgerald River retains considerable permanent aquatic habitat in the form of deep and often very long permanent river pools which tend to be larger in the lower reaches (Pen, 1999). These strings of pools along the dry riverbeds are often associated with a dense growth of shrubs and trees between them. The smaller pools may dry in summer but the larger pools can be several metres deep and always hold water. Floodwaters may flow several metres deep and scour these pools.

The Fitzgerald River is unique in that there is a broad vegetated corridor along the river as it passes through agricultural land. These corridors make a major contribution to the environmental values of the rivers.

Floods – the inevitable habit of rivers

In summer, rivers are mainly series of river pools, along an otherwise dry riverbed. These become increasingly connected downstream by a trickle of flow as the rivers pass through higher rainfall country towards the coast. When the first rains come (usually between April and June), the tributaries begin to flow and the low-flow channel of the river is filled, connecting the river pools once again. By mid winter, many sections of the river floodplains are inundated, some permanently and other sections for a few days at a time. If rain persists over a number of weeks, floods drown the river valley and spill out onto the floodplains.

This pattern of summer drought and winter flood is important as it drives the ecology of the river system. Flooding creates habitat ready to be exploited by highly mobile animals or plant species, which can lay dormant for many years. Drought conditions are also important so that fringing plant species have time to dry out. Many of our aquatic fauna species rely on this cycle including some of our native fish species which are known to breed in floodwaters. It is the flood events that help to drive the ecology of our river systems.

Source: Managing Our Rivers (Pen, 1999)

2.1.1 Water quality

A gauging station operated on the Fitzgerald River at Jacup from 1974–1986. This measured river stage height in addition to various physical parameters including conductivity, temperature, pH and some limited nutrient sampling.

Salinity

The Fitzgerald River is naturally saline, partly as a result of the drainage of salt lakes in the headwater catchments and naturally saline soils. The salinity of the Fitzgerald River varies from almost fresh to greater than the concentration of sea water.

At the South Coast Highway, the Fitzgerald River from 1977–1978 showed salinity levels ranging from 1560 - 4700 mS/m (seawater is 5100mS/m). At the Jacup gauging station – river water salinity varied from 271 - 5070 mS/m (figure 3).

The salinity levels vary with generally higher levels during the supper period due to evaporation and the influence of base flows. There are however some high salinity levels over winter, and often this is likely to correspond to the first flush where evaporated salts would be dissolved and carried downstream.

Water and Rivers Commission conducted a snapshot of water quality in the catchment in 2000. The salinity levels showed an interesting feature, with extremely high levels in the upper catchment, to less than seawater in the lower catchment. This may reflect the dilution factor of rainfall as you move towards the coast.

Nutrients

There has been no long-term sampling of nutrients for the Fitzgerald River. Nitrate analysis of the water samples taken between 1979–1986 during flow events. The results indicate that all nutrient levels are greater than the recommended guideline of 0.75 mg/L for ecosystem health (ANZECC, 1992). Nutrient samples taken during higher flow events (ie. 1986) would potentially have reflected the first flush off the catchment and thus higher nutrient levels (figure 4).

Flow rates

The gauging station recorded flow rates of the Fitzgerald River from May 1974–1986 (WRC site Number 602002). The ~site was decommissioned in April 1987.

The flow rate of the Fitzgerald River is extremely seasonal and there is often no flow for much of the year. The estimated annual discharge to the Fitzgerald Inlet from the Fitzgerald River is 8000 megalitres (Hodkin and Clarke, 1990). This is based on figures of catchment clearing undertaken as of January 1987, and this figure is likely to have increased.

The average annual flow rate from the gauging station recorded 1935 megalitres of water (figure 5).

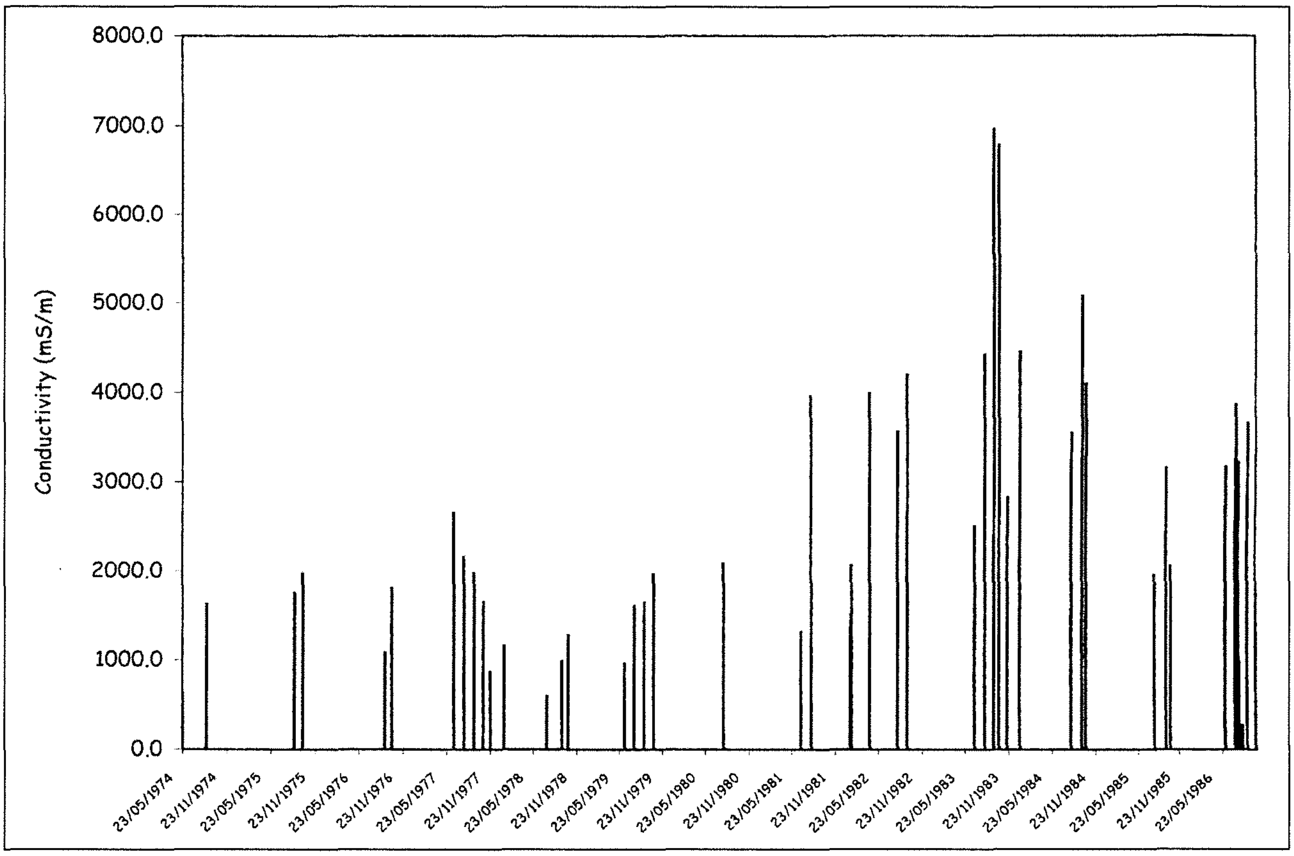


Figure 3. Salinity levels of the Fitzgerald River 1977–1986 (Jacup gauging station)

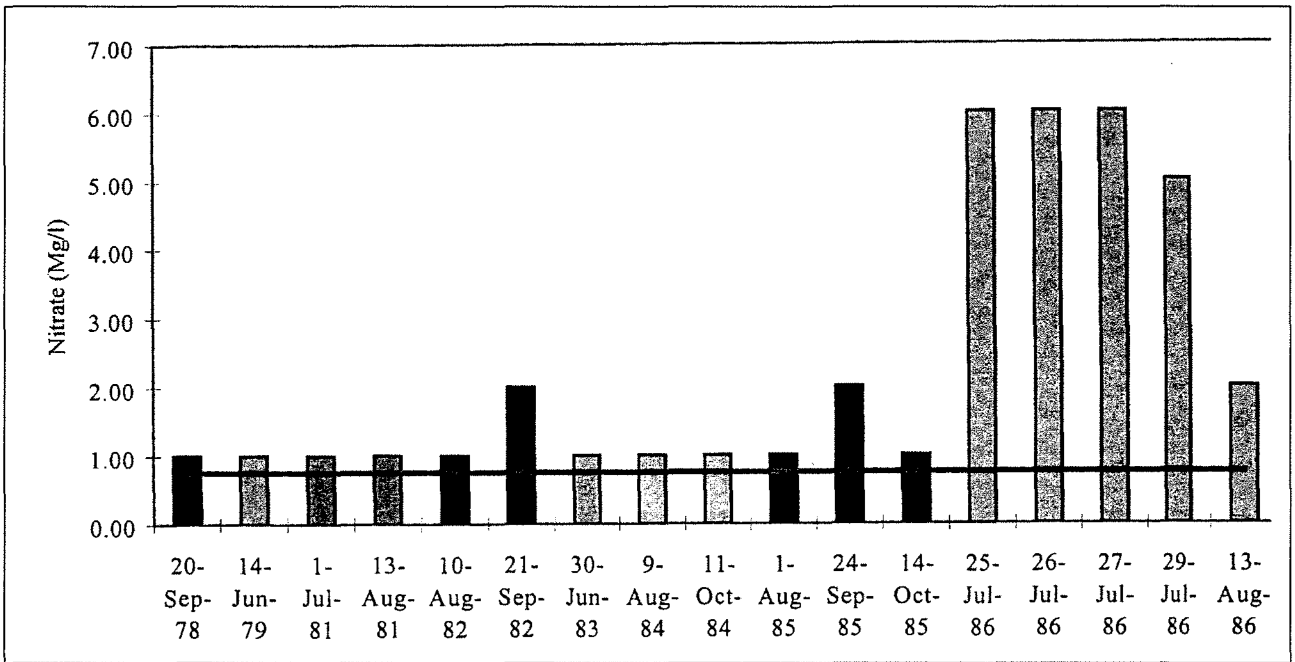


Figure 4. Nitrate levels in Fitzgerald River, recorded at Jacup Gauging Station

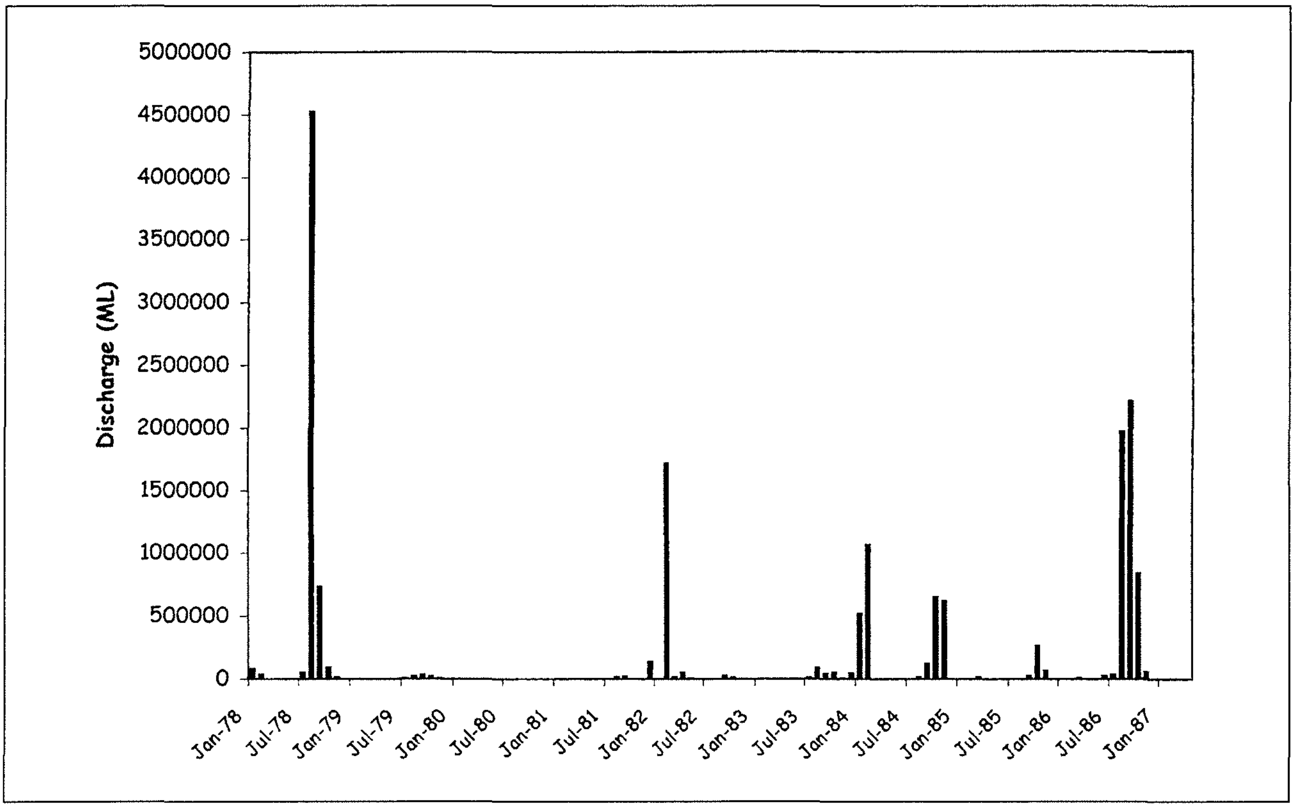


Figure 5. Discharge from the Fitzgerald River 1978–1988

Table 1. Annual flow at Jacup gauging station on the Fitzgerald River (station 602001) between 1974 and 1986 (Water and Rivers Commission)

Year	Annual total megalitres	Rank
1974	725.7	8
1975	241.5	10
1976	5635	1
1977	4264	4
1978	5445	2
1979	78.2	12
1980	0	13
1981	171.3	11
1982	1815	6
1983	748.3	7
1984	2463	5
1985	367.9	9
1986	5136	3
1987	0	14
Mean	1935	
Median	737	

Water quality ' snapshot'

The Water and Rivers Commission carried out a water quality 'snapshot' in March 2000 (table 2.). The snapshot was designed to gain a 'picture' of water quality on a particular day in the catchment. Considerable flows had occurred prior to sampling as the summer was unseasonably wet. Samples were taken where the tributaries were flowing.

Five sites on the Fitzgerald River were sampled and four sites on major tributaries draining to the river. Water quality parameters tested included pH, dissolved oxygen, electrical conductivity (salinity), temperature and turbidity. Types of aquatic plants and native fish present were also recorded.

The salinity of the Fitzgerald River ranged from 119 mS/cm (seawater is 52mS/cm) in water draining from the Lake Magenta Nature Reserve (greater than twice the concentration of seawater) to 28.6 mS/cm (approximately half the concentration of seawater) south of the South Coast Highway. The decrease in salinity is due to the dilution effect by rainfall. During the snapshot, Twertup creek showed higher levels of salinity than Cameron or Jacup Creek.

The WRC snapshot temperature ranged from 18.6 to 22.8°C and pH ranged from 7.44 to 8.35. The foreshore condition was graded at each site with most sites recorded in A grade condition (excellent). There was, however, in most sites recorded evidence that sedimentation was a major issue in some of the tributaries.

Table 2. Water and Rivers Commission – water quality monitoring results (17 March 2000)

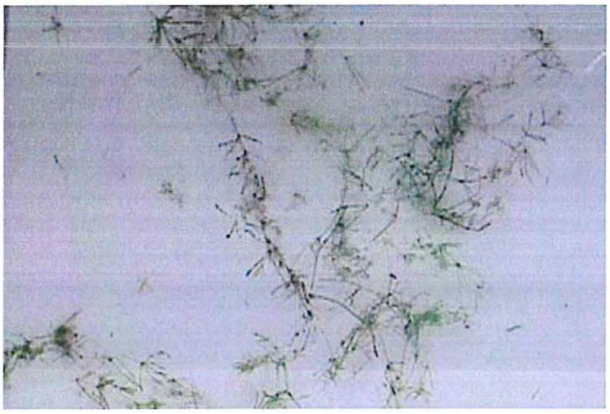
Site description	GPS	Dissolved	Tempera -ture °C	Conductivity	ph	Foreshore	Comments
Fitzgerald River – south Lake Magenta Nature Reserve	507 036 10 H62682 60	7.5	22.2	119.9	7.44	A2	Pool
Fitzgerald River - Middamidjup Road	507 07121 H6263136	20.6 10.7	44.4	7.93	A2	Pool	
Fitzgerald River - Lester property	507 081 40 H62580 32	9.0	19.4	38.9	8.2	A3	Flowing, algae present.
Fitzgerald River- South Coast Hwy	507 092 H6254364	10	18.6	29.3	8.1	B1	Flowing, algae visible. Remains of an old stock crossing.
Fitzgerald River - south of South Coast Hwy (Don Reid's property).	507 105 02 H62521 64	6.9	17.6	28.6	7.95	B3	Creek eroded, considerable sediment in river.
Cameron Creek (Morgan)	507 047 84 H62633 75	6.25	20.3	18.9	7.91	A2	Pool - reserve, good condition.
Cameron Creek (Geoff Bee)	506 998 19 H6263415	6.95	19.6	35.1	7.81	C2	Pool, lots of macrophytes, stock crossing.
Jacup Creek(Geoff Bee)	50700703 H62620 65	15.6	19.7	33.6	8.35	B2	Pool
Twertup Creek (Spinks)	507 032 41 H62583 36	2.4	22.8	68.8	7.96	B3	Lots of macrophytes.

Sampling the Fitzgerald River – Kaylene Parker (Rivercare Officer) and the late Don Reid (photograph Katie Tomlinson)

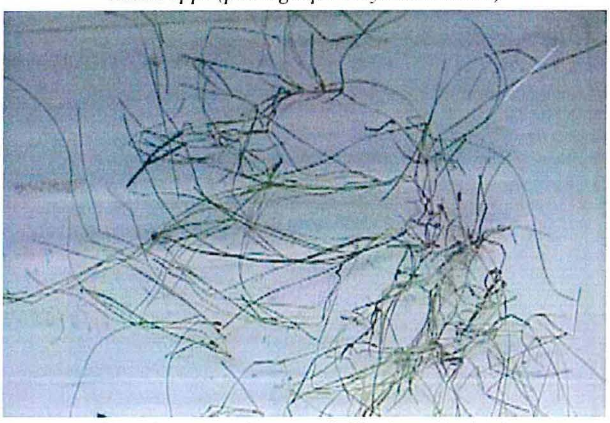
2.1.2 Aquatic plants - macrophytes

Macrophytes and algae can be an indication of the health of a system. The type of species and density of species is influenced by a number of factors such as temperature, light availability, salinity, water flow and nutrient concentration. For this reason there is often variation between seasons. Prolific growth is often experienced in late spring and during summer. There are a number of symptoms that indicate excessive nutrients in a river or drainage system. These are dense blooms of filamentous algae such as *Cladophora* and *Stigeoclonium*, dense blooms of diatoms such as *Melosira* or Chlorophytes such as *Scenedesmus* and dense blooms of blue-green algae such as *Nodularia, Anabaena, Microcystis* and occasionally *Oscillatoria* (Entwisle *et al.* & Vas Hosja pers. comm. 1997) Low species diversity is also an indication of excessive nutrients.

The two main species of macrophytes identified by the Water and Rivers Commission during the 'snapshot' were the angiosperm, *Ruppia megacarpa* and the Charophyte species - *Chara*. There may be other macrophyte species present in the river system however more intense surveys would need to be conducted to confirm this.



Chara *spp. (photograph Kaylene Parker)*



Ruppia *spp. (photograph Kaylene Parker)*

2.1.3 Native fish

Two native fish species have been recorded in the Fitzgerald River by the West Australian Museum Fitzgerald River Fitzgerald River – including *Galaxias maculatus* (Spotted minnow) and *Pseudogobius olorum* (Swan River Goby). David Morgan from Murdoch University, currently researching a study of riverine fish from Albany to Esperance recorded an additional two families including Sparidae (Black bream) and Atherinidae (Western Hardyheads).

Spotted Minnow *(Galaxias maculatus)* is a small fish that is found in a variety of habitats, but is most common in still or slow-flowing waters, mainly in streams, rivers and lakes within a short distance of sea. They can survive in salinities up to 50 ppt (Allen, 1989). These were seen in the Fitzgerald River during Water and Rivers Commission's snapshot in March 2000.

Swan River Goby (*Pseudogobius olorum)* are fish with a brown or tan colour and narrow darker brown blotches. It is silvery white colour on the belly, and the dorsal fins may have irregular blackish stripes. This species is also commonly known as a blue spotted goby as it has a black or blue spot on the dorsal fin. It is found in many parts of Australia and inhabits streams, ponds and brackish estuaries. It is usually found over mud bottoms, sometimes among weeds or adjacent to rocky areas. Spawning occurs during spring, and each female deposit up to 150 eggs. The male guards the eggs during the incubation periods. The larvae then often migrate to fresh water however there is evidence that some populations are landlocked. The diet consists mainly of insects, crustaceans and algae (Allen, 1989).

Wallace Hardyhead (also commonly known as Western Hardyhead) are small, silvery fish that tend to swim

Swan River Goby (photograph Kaylene Parker) around in schools. It generally is an olive-green colour with silvery sheen on its sides and belly. It is normally seen in schools near the surface or around the shoreline vegetation and log debris. Spawning occurs during spring and summer months. The diet consists largely of insects and small crustaceans (Allen, 1989).

2.1.4 Macroinvertebrates

Macroinvertebrates or aquatic bugs consist of worms, snails, crustaceans (prawns and marron) and insects (such as mayflies, stoneflies, beetles, and bugs). Many macroinvertebrate species are found in the waterways throughout the Fitzgerald River catchment. Macroinvertebrates play an important role in the ecology of the river system. In the upper catchment, macroinvertebrates are responsible for shredding larger particles including bark, leaves and other detritus that falls into the waterway. Further downstream, macroinvertebrates such as worms, gilgies and marron take small particles of organic matter from the sediment and digest them further. Algae that grow on the rocks is 'scraped off' by snails and limpets. There are also predator species of macroinvertebrates including the dragon fly, adult beetles and stonefly larvae that prey on smaller animals.

The quality of the water is linked to the survival of macroinvertebrates and in turn larger animals such as fish and aquatic birds. Macroinvertebrates are sensitive to changes in the physical and chemical conditions of the water, including salinity, flow and temperature. The most important feature in a stream is vegetation – including logs, branches, bark and leaves. This forms the basis of a food web for macroinvertebrates in our waterways. Vegetation removal can impact on food availability, light penetration, water flow, sediment levels, and temperature of the water. Removal of riparian vegetation upstream can have serious consequence on downstream macroinvertebrates that rely on the input of organic matter to the system.

Macroinvertebrates have been sampled as part of the National Rivers Health Program. Four sites on the Fitzgerald River were sampled including Middajimup Road Fitzgerald River South Coast Highway, Fitzgerald Inlet and Lake Magenta Nature Reserve (table 3).

Shrimp – example of a macroinvertebrate found in many river systems (photograph Kaylene Parker)

Table 3. Macroinvertebrate species collected in the Dalyup River as part of the National River Health Program

Taxa	Common name
Acarina indeterminate	Mite
Branchipodidae	Fairy shrimp
Ceinidae	Mayfly larvae
Ceratopogonidae	Biting Midge larvae
Chironominae *	Non-biting Midge larvae
Coenagrionidae	Damselfly larvae
Culicidae	Mosquito larvae
Dolichopodidae	Fly larvae
Dytiscidae	Beetle
Ephydridae	Fly larvae
Hydraenidae	Beetle
Hydrobiidae	Aquatic snail
Hydrophilidae	Beetle
Leptoceridae	Caddisfly larvae
Lestidae	Damselfly larvae
Oligochaete indeterm.	Aquatic worm
Oniscidae	Slaters
Orthocladiinae *	Non-biting midge larvae
Palaemonidae	Shrimp
Pyralidae	Moth-fly larvae
Stratiomyidae	Soldier fly larvae
Tanypodinae *	Non-biting midge larvae
Tipulidae	Cranefly larvae

National River Health Dataset 1994–1998, CALM

2.2 Fitzgerald Inlet

(Source: Hodgin and Clarke, 1990)

Fitzgerald Inlet is the largest estuary in the Fitzgerald National Park. The Inlet is often described as a 'temporary' or 'transient' estuary as it is seldom opens to the sea, and is shallow and often dries out in summer (Hodgkin and Clarke, 1990). Often the only remaining water is a deep gutter near the mouth, and the riverine reaches of the Fitzgerald River.

The Inlet lies in a valley in the Pallinup Siltstone and around the margin of the lagoon are spectacular red and yellow cliffs nearly 40 m high in soft spongolite rock. The Fitzgerald River winds about 4 km through an area of deltaic sediments before discharging into the lagoon. The former meanders of the river through the delta now hold samphire swamps. The river widens from 10 m to over 100 m before discharging into the Inlet.

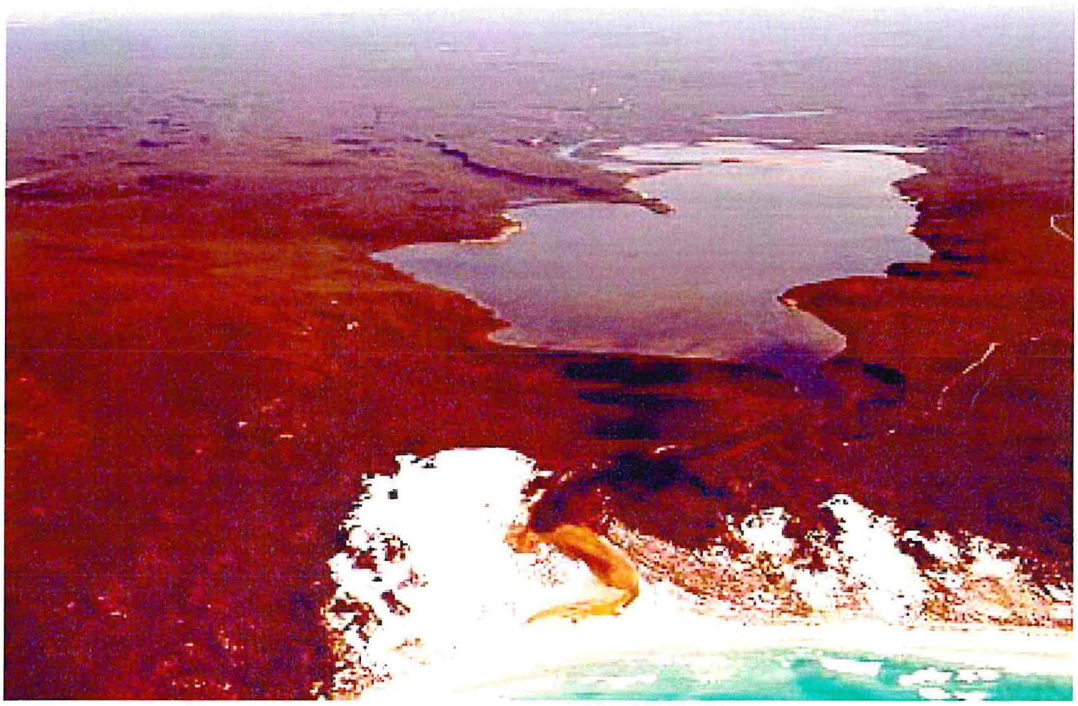
The inlet covers an area of 7 km^2 with 4 km of river reaches and a 1 km long narrow channel from the Inlet to the sea. The beach is only 1 – 1.5 m above sea level and the floor of the lagoon appears to be at about sea level so that the water is probably never more than 1 m deep.

2.2.1 Geological history

Fitzgerald Inlet is a 'drowned' river valley that formed 3000 – 4000 years ago. The Inlet lies in ancient river valleys approximately 1600 millions years old. At first, the estuaries would always have been open to the sea. They were tidal and seawater flowed into them. They were also deeper than they are now. Growth of the bars as the sea level retreated has reduced exchange with the sea to the brief and infrequent periods when the bar is open. Sediment from the catchments and the beaches has progressively shallowed the lagoons and reduced their volume.

2.2.2 The bar

The Inlet discharges onto the beach near Point Charles after high rainfall events. The bar breaks infrequently and generally only stays open for a few days. It is said once to have remained open for 18 months and to have had abundant fish and shellfish at the turn of the century. A flood broke the bar in about 1963 and again in 1971, 1978 and 1988. Runoff from the catchment is estimated to be 5 mm and the mean annual flow into the estuary 8 x 10^6 m^3.



Fitzgerald Inlet (photograph Simon Neville)

2.2.3 Water quality

The Fitzgerald Inlet is very shallow and is often dry. There is very little water quality monitoring data on the Inlet. It is likely to be around 5000 mg/L when first filled by winter rains, but it becomes progressively more saline as the water dries up in summer and figures in excess of 200 000 mg/L have been recorded even in the inlet channel.

2.2.4 Aquatic flora

The aquatic plants *Ruppia megacarpa* and the stonewort *Lamprothamnium papulosum* have been recorded. There appears to be fewer of these plants in the Inlets in comparison to other inlets and it is thought that this may be due to the light limitation by resuspended sediment from the shallow muddy bottoms and by brown tannin-stained water. A small green alga has also been recorded – *Polyphysa peniculus.* No detailed vegetation studies have been conducted on the surrounds of the Fitzgerald Inlet.

2.2.5 Aquatic fauna

Estuaries are extremely important breeding grounds for many native fish. After the inlets become too saline or dry – the fish have to be recruited from the sea or from the rivers. Only four families of fish breed in the estuaries and saline rivers: Sparidae (black bream), Atherinidae (Hardyheads), Galaxidae (minnows), Gobbidae (gobies). They are the only fish recorded from pools in the rivers. There are marine species that breed only in the sea, but enter the estuaries during the brief and infrequent times when the bars are open and flourish while conditions are favourable. As the Inlet water evaporates they progress to the deeper riverine reaches and die out progressively in the increasingly salty water (Lenanton, 1984). Sea mullet is the most common marine species found in many estuaries of the South Coast. Inlet waters can be very productive and black bream and sea mullet are often present in great abundance following flooding.

Estuaries also have extremely important feeding and habitat values for a variety of birds. Fitzgerald River Inlet is registered on the Directory of Important Wetlands in Australia. (ANCA, 1994). J. Wallace sampled bottom fauna in 1977. The survey recorded many estuarine and marine species – including small snails, bivalves, shrimps, amphipods, cockles, tube worms, ostracod crustaceans (seed shrimps) and various insect larvae (Hodgkin and Clarke, 1990).

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3 State of the waterways

3.1 Summary of the conditions of the waterways

Overall, the results of the survey indicate that the condition of waterways in the catchment range from A grade (excellent condition) to D grade (poor condition). A summary of the state of the Waterways is described in table 4.

Many waterways in the catchment are graded as A grade condition including many tributaries that have never been cleared including most of the Fitzgerald River, Twertup Creek, the western end of Jacup Creek and the lower section of Jims Creek. Forty-one percent of the waterways surveyed in the agricultural land were graded as A grade condition. There are however signs of degradation on the first and second order streams with 19% of the surveyed tributaries showing declining health of vegetation due to stock access, salinity, waterlogging and weed invasion. In addition, the riverbanks are showing signs of instability due to the decline of vegetation and a changing catchment hydrology. Sediment plumes are also evident in the Fitzgerald River, and there is evidence that the water quality is deteriorating with higher salinity levels and recorded high nutrient levels. Secondary salinity is, however, the major issue threatening the health of waterways in the catchment.

Landholders have completed considerable amounts of on-ground works to protect the waterways in the catchment including fencing 625 km of riparian and remnant vegetation (figure 6). There have also been considerable on-farm improvements to improve the sustainability of farming including surface water management, claying, planting of perennials. These activities are also benefiting the health of the waterways downstream.

Table 4. State of the waterways in the Fitzgerald River catchment

Category	Waterway issue	Overall rating	Comment
Waterway condition	Foreshore vegetation	A grade	Tributary assessment – 41% A grade, 19% B grade, 21% C grade and 19% D grade. The main river corridor itself is graded 100% A grade. The foreshore vegetation of tributaries is showing signs of degradation from clearing, grazing, weed infestation, salinisation and erosion- mainly in the first order tributaries or where waterways are not fenced from stock.
	Weeds	Modified	Major weed species include annual pasture species and crop weeds (raddish).
	Water quality	Modified	Nutrient samples taken pre 1986 indicated total phosphorous and total nitrogen levels higher than ANZECC guidelines. Gauging station data indicates increased salinity levels and increased catchment discharge. Further monitoring is required.
	Waterlogging and inundation	Modified	Waterlogging, inundation and salinity is causing loss of riparian vegetation, particularly yate trees and many understorey species, particularly in the upper catchment.
	Erosion and sedimentation	Modified	Considerable evidence of sediment instream – indicating unstable river banks. Further assessment is needed. Erosion and sedimentation is a common problem in the higher order streams where erosion is significant. Further downstream and in the Fitzgerald River, sediment is clogging up river pools.
	On-ground work completed	Excellent	625 km of fencing of riparian and remnant vegetation.

continued over

Table 4. State of the waterways in the Fitzgerald River catchment (continued)

Category	Waterway issue	Overall rating	Comment
Waterway Pressures	Land development – residential, agriculture	Low	Farm size increasing.
	Pollution from point-sources	Low	No point source of pollution ie. piggeries.
	Water development	Low	No water development along the river (ie. Aquaculture, boating facilities).
	Recreation	Low	No recreational pressure in Fitzgerald River or the Inlet, however the area has extremely high recreation/tourism value due to the National Park.
	Commercial fishing	Low	No commercial or recreational fishing in the Fitzgerald River or Fitzgerald Inlet.
	Water abstraction, industrial discharge	Low	No industrial discharge or water abstraction.
	Groundwater and surface water contamination	Low	There are community concerns regarding use of pesticides and herbicides on broadacre agriculture and their impact on the health of the waterways.
	Drainage (saline land drainage)	Low	Drainage policy in catchment – no deep drainage.
Waterway Values	Economic benefits	High	Extremely high economic values from tourism. Also catchment group developing marketing strategy that includes protection of natural resources in the catchment.
	Biodiversity	High	Extremely high biodiversity values. The Fitzgerald River is a and endangered animals. major corridor linking Fitzgerald National Park (Biosphere) to Lake Magenta. Many rare and endangered species found within the river corridor.
	Recreation	High	High tourism value, however many areas are inaccessible the public.
	Aesthetics	Medium	Many areas are inaccessible to the public.
	Spirituality and	Medium	Social, cultural and historical values of the area are high but not recorded. Few cultural values studies completed in the area to determine the importance/ connections to the river by indigenous Australians.
	Conservation values	High	Extremely high.
Management response-Existing	Regional or town planning schemes		CALM Management Plan – Fitzgerald River National Park and Regional Management Plan. The Department of Conservation and Land Management is responsible for protection and existing management of the reserve system and National Park.
	Community action		Extremely active catchment group – Fitzgerald Biosphere Marketing Association and the Jerramungup Landcare Services Inc. Supported by the Shire of Jerramungup and the Jerramungup Landcare Centre.
Overall importance			The Fitzgerald River, Fitzgerald Inlet and its associated tributaries rate as an extremely high priority in the South Coast Region due to their ecological significance as a corridor between the Fitzgerald Biosphere and the Lake Magenta Reserve. Also due to their significant biodiversity values.

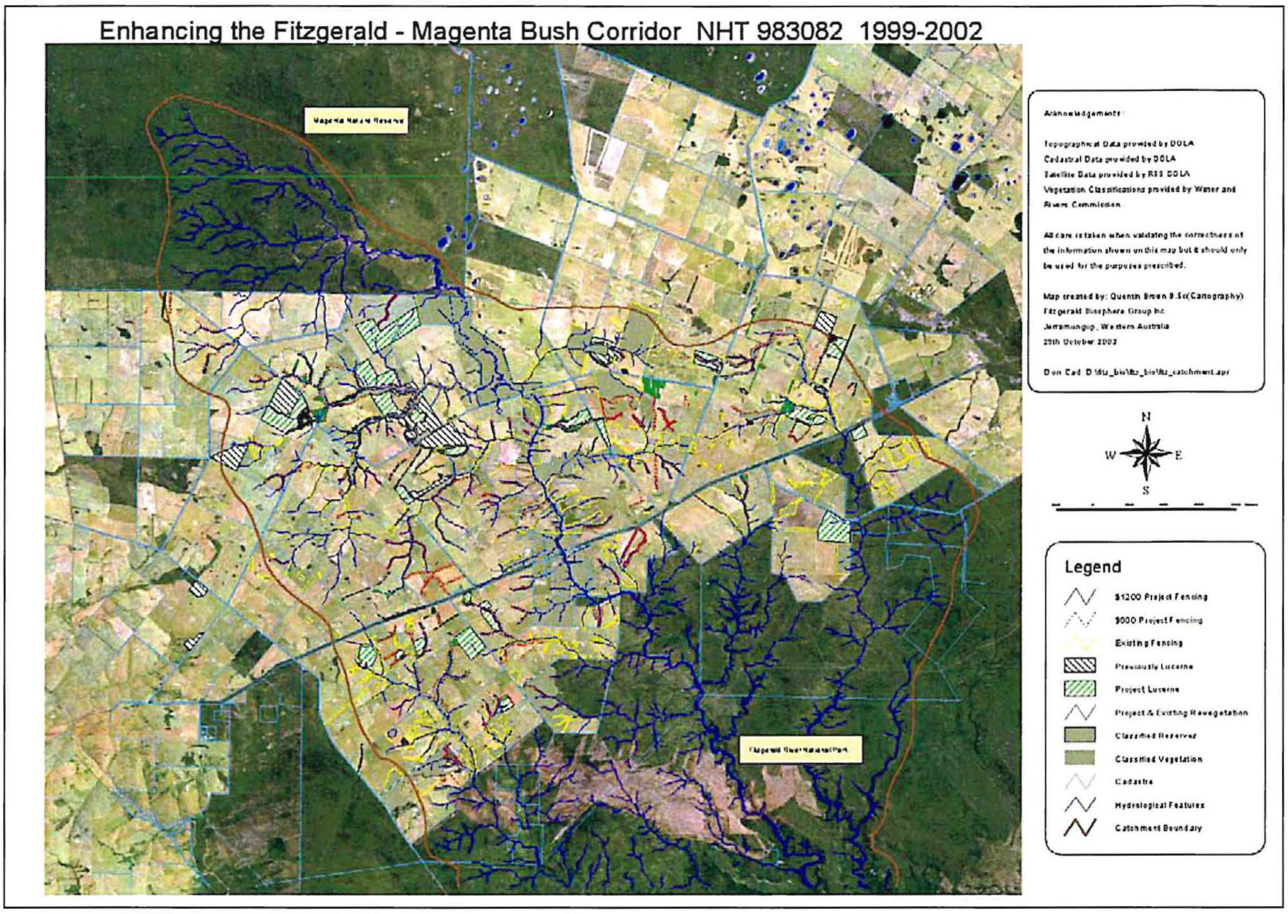

Figure 6. On-ground works recorded in the Fitzgerald River catchment

3.2 Waterways management issues

The management issues faced by the landowners, vary throughout the catchment depending on the specific location within the catchment, past and current management practices, fencing status, livestock access and adjacent landuse. The main management issues are summarised below.

3.2.1 Salinisation and waterlogging

Secondary salinity is encroaching farmland within the Fitzgerald River catchment, particularly along waterways. The WA Agriculture Department's groundwater monitoring bores are showing an average rate of groundwater rise of 15 cm/yr. The onset of salinity is leading landholders to address existing salinity and implement precautionary measures, such as lucerne and surface water control through gradebanks. Salinity is the biggest threat to the health of waterways in the catchment.

The Fitzgerald River catchment is located near the coast and receives ocean salt laden rain. About 100–170 kg of salt per hectare is deposited annually on land near the coast, gradually decreasing inland beyond the Wheatbelt to 20 kg per hectare (Pen, 1999). Most of the rain that falls on the land is taken up by vegetation, and the salt is left behind in the soil. Heavy rainfall will pass through the soil and flush much of the salt from the soil. Further inland, and with less rainfall and poorer drainage, there is less water to flush salt from the land. Over thousands of years, salt has gradually accumulated in the soils where rainfall has been generally less than 1100 mm per year. In the lower rainfall areas of the Wheatbelt, salt storage can be in the thousands of tonnes per hectare (McFarlane and George, 1992).

With clearing of native vegetation and its replacement with lower water-using annual crops and pastures, more water is passing into the groundwater, raising the watertable and mobilising and bringing salt to the surface. Some areas within the catchment are naturally saline, such as areas within the Lake Magenta Nature Reserve on the Fitzgerald River. This is called primary salinity. The intervention of people into the natural ecosystem eventually leading to salinity is termed secondary salinity (Hunt and Gilkes, 1992). Secondary salinity effects the agricultural productivity of land.

Very few plants can withstand saline conditions. Where salt is carried to a normally dry ground the effect is known as dryland salinity. Where salt is carried to wetlands and causes an increase in the salinity of flowing surface water it is known as stream salinisation (Pen, 1999).

Early settlers in the Fitzgerald area have noted that the Fitzgerald River and many of its tributaries were naturally brackish or saline. The Fitzgerald River has always been saline, whereas the Sussetta River was brackish (Don Reid, pers. comm., 2000; Linda Lee, pers. comm., 2000). Since clearing, the tributaries have become noticeably saltier, with landholders recalling swimming in once freshwater pools that have since gone salty. Stream salinisation happens in two ways. Firstly, increasing groundwater flows carry larger quantities of salt directly to streams. The second process involves dryland salinisation, in which rising groundwater carries salt to the land surface where it can be washed away by surface flows and carried into streams (Pen, 1999).

With rising watertables and greater groundwater discharge, inundation and waterlogging of waterways is increasing. Many areas along the waterways that would have ordinarily dried out immediately after rains, now remain waterlogged for longer periods (Pen, 1999).

The effect of inundation and waterlogging, together with salinisation, explains stands of dead and dying trees along many waterways within the Fitzgerald River catchment. The yate tree, (*Eucalyptus occidentalis*), is particularly sensitive to salinity and inundation.

3.2.2 Loss of native riparian vegetation

In the Fitzgerald River catchment, the riparian vegetation of many waterways in the upper catchment has been removed. This clearing was first undertaken after 1961 through the 'Conditional Purchase' program to open up the Fitzgerald area for agriculture. The entire main channel of the Fitzgerald River is still vegetated but many of the tributaries have had the riparian vegetation removed. Waterways that have never been cleared, or have been fenced off for a long time retain riparian vegetation in good condition. Areas that have been disturbed through clearing, grazing and erosion have modified vegetation communities with the native understorey being replaced with exotic weed species.

In the Fitzgerald River catchment, livestock have access to some waterways. Uncontrolled stock access to riparian land can lead to excessive runoff, bank erosion, loss of productive land, loss of important habitat, reduced water quality, damage to in-stream ecosystems, loss of plant species, soil compaction and weed invasion.

Tributaries of the Fitzgerald River – showing a good buffer of vegetation (photograph Kaylene Parker)

Landholders within the catchment are trying to address the lack of riparian vegetation by fencing off waterways to protect the riparian zone from livestock. Also, extensive revegetation efforts have been undertaken, either through planting of native seed or seedlings, to replace the riparian vegetation. This has proved very successful, but it takes time for the vegetation to re-establish.

The loss of native riparian vegetation and replacement with monocultures and exotics breaks up the ecological corridors used by mammals and birds. Ecological simplification in rural environments has been shown to reduce both species diversity and numbers of particular species of flora and fauna. Fragmentation of native vegetation in the Western Australian Wheatbelt has led to significant impacts in the form of either extinctions or loss of viable populations of flora and fauna (Hobbs, 1987).

3.2.3 Hydrology changes

Due to catchment clearing, the volume of water draining from the catchment into the waterways is likely to have increased. Pen (1999) estimates that catchment clearing can result in 2–4 times the volume of water draining from a cleared catchment in comparison to a naturally vegetated catchment. The speed at which the water leaves the catchment is also likely to increase with peak flows occurring faster.

Catchment hydrology changes are likely to significantly impact on the stability of the channels and may result in considerable erosion and sedimentation. It also means that flood events may happen more frequently and will cause greater damage. The Fitzgerald River has advantages in that the wide riparian buffers along the river will protect the channel and any new channels that form. In catchments such as the Dalyup River, Esperance since there is less vegetation along the main channel – massive erosion and channel damage occurred. In particular, catchment hydrology changes are likely to result in:

- larger volumes of runoff;
- faster surface flows;
- higher peak flows during floods (high water levels during floods);
- shorter periods of peak flows (high velocity of water flow);
- siltation (flood water slows down and drops suspended soil particles);
- more water entering the groundwater system;
- higher proportion of waterlogged areas;
- increase in frequency of waterlogging and inundation; and
- increases in areas affected by groundwater discharge and salinity.

Currently the river channels are unstable in response to the catchment hydrology changes, therefore the location of fences must take into account the need for the river to find its new equilibrium. In addition to this, there may be increased flood risks as the water flows faster and has a greater volume. This means there is a greater risk to fences and riparian vegetation placed in flood plains. Further impacts of catchment hydrology changes including increased areas affected by salinity, further sedimentation and erosion.

3.2.4 Water quality and eutrophication

With broad scale agriculture in most catchments in the south coast, it is inevitable that rivers will receive large quantities of nutrients – either dissolved in water, adhering to soil particles eroded from the land or contained within dead plant and animal material, including manure washed from the paddock (Pen, 1999). There are also point sources of pollutants such as animal feedlots, or sewerage that can input considerable amounts of nutrients into the system. Excessive amounts of nutrients can cause excessive growth of microscopic algae – a classic symptom of nutrient enrichment.

Water samples taken on the Fitzgerald River catchment indicated especially high levels particularly in 1986. More routine samples are required to determine if the trend is increasing.

3.2.5 Weed invasion

Weeds displace native species, altering not only the diversity and interactions of the flora, but also its value for fauna. Weeds are plants that grow outside their native environment and usually where they are not wanted. Their ability to establish and reproduce quickly make them successful as weeds, and 'disturbance opportunists' that invade disturbed areas rapidly before the native vegetation has a chance to re-establish? (Hussey *et al*, 1997).

In the Fitzgerald River catchment, weeds have flourished in cleared areas – with the weeds dominating the understorey of many remnants. Once weeds have become established in native vegetation they are difficult to remove and restrict from further dispersal. Weed dispersal can occur through animals, wind and water. This presents a problem in areas in pristine condition because weeds can infiltrate the remnant through no fault of the landholder.

3.2.6 Erosion and sedimentation

Banks sometimes naturally erode on bends, however when vegetation is cleared the river banks can become unstable, resulting in extensive erosion along the floodway and the build up of sediment that is then slowly washed downstream (Water and Rivers Commission, 1999). Erosion and sedimentation is one of the major problems on the Fitzgerald River and its tributaries. Erosion not only causes a valuable loss of soil, it also effects the system downstream where it contributes to a significant level of sediment deposition and silting-up of the channel.

Bed incision and bank collapse can occur where riparian vegetation has been removed. Incision will occur where stream power is greatest. As the channel deepens the banks become steeper and increasingly prone to collapse or mass failure (Pen, 1999). Tracks and firebreaks, as well as exposed sandy areas, can erode during floods. This creates washouts. Other forms of erosion can occur, such as gully, sheet or rill erosion.

Sedimentation can result in a build up of coarse sediment in the stream channel, forming long plumes or bars. When these plumes meet, they form a long slug which smothers aquatic habitat or fills river pools (Pen, 1999). This has happened to many of the pools in tributaries of the Fitzgerald River. Darryl Spinks can remember swimming in a freshwater pool in Quandong Creek but after 6–8 years after clearing started, it filled with sediment.

Sedimentation can:

- retard streamflow and cause upstream flooding;
- deflect flow into the adjacent streambank or even onto adjacent land, causing further erosion (Schmidt and DeBano 1990; Thorne, 1990);
- result in lateral erosion of the channel;
- reduce light penetration and in turn photosynthesis;
- decrease the diversity of invertebrate fauna;
- damage the fine gills and mouth parts of invertebrates and the gills of fish; and

Sediment in the Fitzgerald River – south of South Coast Hwy (photograph Kaylene Parker)

- slow the breakdown of organic material and reduce the availability of oxygen to microbes and macroinvertebrates involved in detrital processing (Pen, 1999).

Erosion can undermine trees and shrubs causing them to fall into the channel and to be washed downstream during the next flood. This debris becomes jammed in the channel and can cause upstream flooding or even lead to the carving of a new channel. Large quantities of woody debris can also be produced by salinisation and waterlogging as dead trees eventually break up and fall over.

3.2.7 Fire

Fire played a major part in clearing of the middle catchment area. Much of the remnant vegetation was burnt in wildfires that escaped during clearing. These areas have regenerated and are stable vegetation communities. There are some areas on the Fitzgerald River that are still burnt quite frequently to stimulate pasture growth.

The impact of fire on riparian communities depends on their floristic and structural composition and on the intensity and frequency of burning. Various species can respond differently to fire, for some they take advantage of fire while others can suffer. Riparian communities are generally not adapted to frequent burning, with many species sensitive to fire. Frequent fire can encourage fire-tolerant species and discourage fire-sensitive species, leading to changes in the composition and structure of plant communities (Askey-Doran and Pettit, 1999).

The area burnt frequently on the Fitzgerald River is burnt to promote 'green pick' for stock. If these fires are of low intensity and well controlled they should not affect riparian vegetation. However, escaping fires do burn into riparian areas and can lead to the death of plants (Askey-Doran and Pettit, 1999).

3.2.8 Other

Protection of Aboriginal and European cultures

Our creeks, rivers and wetlands form a unique part of European and Aboriginal culture. There is a need to increase the understanding and awareness of these social, cultural and historical values.

There is a lack of Aboriginal history of the area. It is important to ensure that management recognises the historical values of the rivers – from both an aboriginal occupation and early settlement view. Waterways are important from a traditional aspect in that they were often used as a source of food and occupation sites.

Socio-economic climate

There are many problems associated with socio-economic situations in the catchment, particularly in the upper catchment with the need to maintain or improve farm economic viability. Falling prices has lead to many farm businesses becoming marginal. This has often resulted in smaller farms being incorporated with other farms.

This means that there are fewer landowners in the upper catchments – hence there is often less resources (particularly time) to deal with fire, weed control and landcare activities.

3.3 Management recommendations

The waterways in the Fitzgerald River catchment face a myriad of challenges. There are many management techniques to address degradation of waterways including protecting foreshore vegetation, revegetating degraded areas, channel stabilisation, and controlling surface water runoff. In addition to this, individual maps have been provided to each landholder. The map shows the condition of the riparian vegetation and maps on-ground work such as fencing and revegetation.

Some activities may require approval from relevant management agencies. There are laws covering management of rivers for irrigation, drainage, flood management, and for the protection of wildlife and heritage, including Aboriginal heritage. For clarification of legal matters and the need for coordination in a particular area, contact the Water and Rivers Commission's office in Albany.

3.3.1 Fencing

Controlling the access of livestock to rivers is a simple management decision that will improve the condition of a river. Fencing is not necessarily used to exclude stock totally from the riparian zone. It may involve managing stock to encourage natural regeneration of the bush while minimising weed invasion in heavily degraded systems. It is generally recommended that riparian zones are fenced to completely exclude stock – particularly where the river is steep and the embankments are poorly to moderately cohesive.

The placement and type of fencing are other factors that have to be considered so that little maintenance is required. Fences are ideally placed above the river valley. Fences should be placed 5 – 20 m back from the edge of the river valley, depending on the steepness of the embankment.

3.3.2 Livestock crossings

Many livestock crossings within the Fitzgerald River catchment have not been designed correctly and problems of inundation and salinity are occurring due to stream flow being held up. Crossings should be established where sediment deposition is occurring rather than erosion, and where the bedrock is rocky and hard. The crossing should preferably use the existing base of the channel and be lined with small stones rather than the use of culverts, which increase the erosive power of the water downstream. The following are some basic principles for crossing design.

1. *Firm foundations* – choose a site that has stable soil or visible rocks in the river. Sandy bottoms and river pools are the worst locations, with rock sheets and clay soils being the best.

2. *Straight river section and crossing* – choosing a straight section of river is very important to the survival of crossings during big storm events and floods. Putting a crossing on a bend means in high flows the erosive force of the river acts mainly on one point of the crossing rather than equally on all points of the crossing, if on a straight stretch of river. Crossings on bends will wash out more often than crossings on straight sections. Also make sure the crossing goes straight across the river and not on an angle or the same principle applies.

3. *Angled approach roads* – roads that head straight down a steep river embankment are more likely to erode. Therefore an approach road built across and angling down the embankment will minimise erosion of the road.

4. *Crossing materials* – heavy, small rocks are probably the best materials that most farmers have available. Some use concreted meld mesh. A mixture of sizes rather than all the same size should be ensured.

5. *Height of crossing* – The crossing should be kept low and flat so that when high flows occur the water flows over the top of the crossing and not through the crossing. A rocky crossing that follows the stream contour is more likely to survive high flows than a culvert.

For further information on designing river crossings please read Water Note 6: Livestock Management – Construction of Livestock Crossings or phone the Water and Rivers Commission in Albany on (08) 9842 5760.

3.3.3 Revegetation

Riparian vegetation is necessary for the maintenance of habitats, bio-filtering and ecological corridor functions of the river, to combat erosion and preserve the riverine landscape (APACE and Pen, 1995). The vegetation on the Fitzgerald River and its tributaries varies in condition with some areas devoid of vegetation and needing intensive rehabilitation. Other areas that have sparse vegetation need little rehabilitation. Where large buffer zones have been recently fenced out, and grazed land has been incorporated into the buffer zone, weeds dominate. These areas lack any native vegetation and are ideal for rehabilitation, whether it be direct seeding or seedlings.

Successful revegetation sites exist throughout the catchment with a variety of species used, native trees, pine trees and salt bush. These examples show that restoration work can and has been successful in controlling erosion and salinity. Revegetation advice and information on techniques are available from the Jerramungup Landcare Service Centre or Wendy Bradshaw, Bushcare Support Officer.

Rushes and sedges

Rushes and Sedges are a vital component of foreshore vegetation. Rushes and sedges are excellent species for stabilising slopes, filtering nutrients and sediment out of the water and providing habitat for animals such as frogs and fish. They also are an excellent plant species for rehabilitation of actively-eroding banks and headcuts. The most common rush and sedge species found along channels of the Dalyup and West Dalyup rivers are described below:

Table 5. Sedge and rush species suitable for revegetation of waterways in the Fitzgerald River catchment (wet saline areas)

Common name	Botanical name	Propagation technique
pale rush	*Juncus pallidus*	Seed
shore rush	*Juncus kraussii*	Seed
bare twig rush	*Baumea juncea*	Tissue culture, division
jointed twig rush	*Baumea articulata*	Tissue culture, division
coastal saw sedge	*Gahnia trifida*	Seed
knotted club rush	*Isolepis nodosa*	Seed
native couch	*Sporobolus virginicus*	Seed, rhizome spreader

Source: Linda Taman, Native Environmental Systems

Note: No inventory of the rushes and sedges of the Esperance region exist.

The knotted club rush is an excellent species that can be used to stabilise river banks and will survive in many environments. These can be grown by seed or gently separated and replanted during the wetter months. The bull rush – a common species seen in paddocks is also excellent in stabilising river banks, however they can become a nuisance for farmers in the paddocks.

Native grasses

Native couch (*Sporobolus virginicus)* is a viable alternative to help in rehabilitation of river foreshores. It has many assets because it grows on eroded riverbanks, spreads easily by rhizome, is highly salt tolerant, is a local/native plant (grows at Lake Gore) and will not become a weed or climb over other vegetation. Native seed would have to be sourced from Perth. Be careful not to get the lawn variety of couch.

Windmill grass (*Chloris truncata*) – is a native grass of the mallee region and is palatable stock food if kept grazed.

Direct seeding trials - case study Location 1631

Written by Nathan McQuoid, Manager of Vegetation Services, Greening Australia WA

Wendy Bradshaw, Bushcare Support Officer and Nathan McQuoid, Manager of Vegetation Services, both employed by Greening Australia WA under the Bushcare program, are conducting direct seeding trials in 2000 on Location 1631, Brian and Robin Wisewould's property. The site is 5000 m^2 with soil type gravelly lateritic loam over clay. The project aims to:

- trial and demonstrate establishment by direct seeding of a moort/green mallet vegetation system, including the use of coloniser plants;
- mimic the natural re-establishment processes of a comparatively simple natural vegetation system;
- investigate and trial the use of coloniser plants in revegetation systems in a way that mimics nature; and
- investigate the amount of seed and establishment methods needed to achieve establishment success.

The species being trialled include moort (*Eucalyptus platypus*), green mallet (*Eucalyptus clivicola*), net leaf poison (*Gastrolobium reticulum*), Gold edge wattle (*Acacia patagiata*), native grasses (*Austrostipa tenuifolia*), *Kennedia eximia*, running postman (*Kennedia prostrata*) and *Glischrocaryon auereum*. The Wisewould's direct seeding site will help to construct, as closely as possible, the simplest and common natural vegetation communities by mimicking their recruitment systems. In this case the common moort (*Eucalyptus platypus* ssp *platypus*) community, which being a 'mallet' eucalypt community is considered 'simple' because its species members are exclusively obligate seeders. This means that nearly all the plants in the majority of moort communities only recruit (or replace themselves) from seed. Most other common plant communities such as shrublands, mallee and heath have a high proportion of plants naturally geared to replacing themselves vegetatively or from rootstock (if you consider the above ground bits separate from the roots).

We need to understand how to reconstruct actual natural systems as foundations for appropriate and robust ecological systems. This study provides a start by identifying the simplest ones - mallee communities. Currently most revegetation ranges from basic tree planting by direct seeding with popular and pretty vegetation, to direct seeding more sophisticated selections from broader plant communities. This 'new' selection of simple communities considers that over time the community will change.

At birth, mallet communities are huge numbers of individuals of not so many taxa (genera, species, subspecies) dominated in number and structure by pioneer plants, commonly peas, herbs and grasses. In a short time (~3–15 years) many of the pioneers have dropped out as visible plants to remain as seed in the soil built up by the parent plants when they were alive and setting seed banks. The mallets then take over, grow taller and develop a tannin rich surface litter that excludes other plants from recruiting while they are alive.

The site at Wisewould's allows us to put in a mallet community in relation to the above context, next to an existing one as both a benchmark measure and as a source for recruitment of other organisms. The trial will also include the inclusion of soil donor scrapes from the adjacent remnant to test establishment of lichens, mosses and algae that hold the surface together (cryptogams). Seeding of the site will take place as early as possible in winter and involve hand seeding with a representative mix of plant taxa, brushing for seed placement and microclimate improvement, and the use of soil donor scrapes. Site preparation will be by scalping and herbicide. The success of the project will include assessing what is using the 'new' bush compared to the 'real' bush adjacent.

3.3.4 Weed management

Weed invasion is an issue in the Fitzgerald River catchment and control is needed, particularly when establishing vegetation. The understorey of disturbed yate woodlands are dominated by weeds, and weeds have encroached the perimeters of pristine remnants. The best method of weed control is prevention of establishment by ensuring minimal disturbance in native vegetation. Undisturbed native vegetation is quite resistant to weed invasion (Hussey *et al*, 1997). Appendix I lists some excellent references on weed control.

Once weeds become established there are four ways of control:

1. Physical – hand-pulling or mechanical mowing, slashing, cultivating or scalping.

2. Natural suppression – creating a situation where the required plants (native or cultivated) are encouraged to grow and weeds are discouraged.

3. Biological – the introduction of a natural predator or a disease that will destroy the weed without affecting non-target plants.

4. Chemical – the use of herbicides (Hussey *et al*, 1997).

Rules to be aware of when dealing with weeds

Written by Wendy Bradshaw, Bushcare Support Officer, Greening Australia WA (Bushcare program)

- Avoid bare ground. This creates a perfect place for weed seeds to blow in and proliferate.
- Fire promotes weeds. Burning a remnant that is weed infested will only make the weeds worse as this process creates bare ground. Native plants cannot compete with the rapid growth of weeds, which then become a greater fire hazard.
- If weed control is carried out, revegetate to prevent further weed invasion onto the bare soil.
- Be sure that they are weeds. Many native grasses exist and may not be recognised. Only control the weeds you know and get advice on others before acting. Native grasses are often found growing with weeds. In this case, selective herbicides can be used to control the weeds and promote the native grasses such as Fuselade at the rate of 1 L/ha.
- Any disturbance that creates bare ground will promote weeds unless revegetation is undertaken in the process.
- Weeds are better for soil health than bare ground.

3.3.5 Erosion and sedimentation

Many waterways are currently finding a new equilibrium due to increased flooding frequencies, increased volume and speed of water coming down from catchment. This is resulting in unstable riverbanks, severe erosion and subsequent sedimentation. Management is needed to ensure that fence locations and vegetative buffers are wide enough to cope with these changes, also ensure that erosion control measures are put in place in severely degraded areas to encourage actively eroding channels to become more stable.

Eroding stream embankments can be protected and repaired in a number of ways, however ultimately the bank must be revegetated for the streambank to be stable. Different methods of bank stabilisation will depend on the steepness of the slope, the power of the water flow in a normal year and the cost and available materials to stabilise the banks.

Brushing involves cutting trees or branches from trees and securing them to the bank to provide erosion protection. This method is most applicable where bank erosion is caused by direct washing action of the water removing material from the face of the bank. The brush needs to be anchored to the top of the bank. This can be achieved by encasing the brush in old ringlock fencing. The bank may need to be battered prior to placing the material on the bank (Davey, 2000). Brushing using *Melaleuca cuticularis* or *Melaleuca brevifolia* is recommended. The seed can be released from the brushing and can provide natural regeneration and the woody cover provides protection for the seedlings. The brush can be layered against the bank in two ways either horizontally against the bank with the butt of the branch pointing upstream or with the butts at the top of the bank and the heads angled downstream against the bank (Davey, 2000). Brushing in only a temporary stabilisation technique that relies on establishment of vegetation on the bank. This technique is not as stable as harder methods however is one of the cheaper options that encourages natural regeneration.

3.3.6 Water quality and eutrophication

Nutrients enter the waterways either dissolved in water, adhering to soil particles eroded from the land or contained within dead plant and animal material – including manure washed from the paddock (Pen, 1999). There are also point sources of pollutants such as animal feedlots, or sewerage that can input considerable amounts of nutrients into the system.
The main management actions to reduce the risk of nutrient enrichment of waterways includes:

- conduct soil tests to ensure that your fertilizer regime is appropriate and that there is minimal runoff into the waterways.;
- ensure that sewerage systems in the catchment do not transport runoff into the downstream waterways, in particular that they have an adequate depth to groundwater and where the effluent is not able to runoff to nearby waterways; and
- ensure an adequate buffer of vegetation along the waterways to trap nutrients that runoff into the waterways, but also to ensure that the banks do not erode and transport nutrients into the system.

3.3.7 Feral animal control

Controlling feral cats is often difficult. The three main methods used are shooting, poisoning and trapping (Hussey and Wallace, 1993). Shooting cats is very difficult, as they are often very secretive and more wary than foxes. Poisoning with 1080 is unlikely to work, as they do not usually scavenge. However they have been known to die through eating rabbits that have consumed 1080 baits. Baits are available from Department of Agriculture. Trapping cats seems to be the most effective method especially when used during times of food shortage such as summer. Traps should be set with a strong smelling fish type catfood in the evening and visited in the morning.

Shooting, poisoning and fumigation can control foxes. The best time to control foxes is during spring when cubs are being reared although supplementary control during the year may be necessary (Hussey and Wallace, 1993). Shooting is most effective during the following periods August to October when new cubs are being reared and mid-January to April when the cubs are dispersing and finding a new territory. Target areas such as creeks, fencelines and tracks as they prefer these areas. Evidence from Victoria suggests that a determined shooting campaign will remove about one third of the population.

Poisoning using 1080 baits can be effective. Dried meat baits should be used and can be injected with 1080 by an agriculture protection officer at Agriculture WA. Baits can be thrown under shrubs or buried about 5 cm under the surface to prevent birds and other animals taking the baits. The Department of Conservation and Land Management's research has shown that baiting once a month is sufficient to keep an area reasonably free of foxes and that baiting less frequently than this can also be beneficial (Hussey and Wallace, 1993). Fumigation of dens can be carried out similarly with rabbits, if it is known that young cubs are residing there. The Department of Agriculture, CSIRO, the Department of Conservation and Land Management and Curtin University are currently working on research involving a genetically engineered fox virus. The virus is aimed at attacking the fox's immune and reproductive systems. Exclusion fencing can also control foxes although it is very expensive (Hussey and Wallace, 1993).

Shooting, poisoning, fumigation, warren destruction, genetic methods and exclusion fencing can control rabbits. Shooting is generally a short-term measure and is not effective on its own due to the ability of rabbits to breed rapidly (Hussey and Wallace, 1993).
Poisoning with 1080 in oats is effective in reducing numbers especially if done in late summer/early autumn before the breeding season. The Bunny Buster appears to be highly effective on small landholdings in the lower Dalyup. Eradication is necessary and reliance on Myxomatosis and the Calicivirus is not enough. If Calicivirus passes through the rabbit populations, it is recommended that follow up baiting occur, as it doesn't affect juveniles. The best options are destroying the rabbit burrows by deep ripping, with follow up baiting. Baiting is done with One Shot 1080 Oats, which have to be ordered from Agriculture Western Australia. The shoot could be for foxes, cats and rabbits and would ideally be held in spring. This may be a good activity to carry out as a catchment group. This encourages both feral animal control and involvement in the group.

3.3.8 Salinity

Encroaching salinity affects the production capabilities of the land and threatens the economic feasibility of farming systems. A whole catchment approach is needed when tackling the salinity issue, and involves considering techniques and changing management practices to reduce the amount of recharge. Recharge is rainfall that soaks deep into the soil and replenishes the groundwater. This causes the watertable to rise (Negus, 1991).

Various drainage systems already exist in the catchment with the large majority being used to manage surface water. Surface water management is required to manage catchment hydrology changes, however these also have the potential to fail and cause considerable erosion across paddocks, and subsequent sedimentation of downstream waterways. The use of permanent raised beds in the catchment is restricted to a small number of properties. In general, raised beds used on wet areas function successfully, and farmers commented on improvement in the productivity and reduction of waterlogging and/or ponding. Permanent raised beds located at Esperance Downs Research Station are performing well in waterlogging control and improvement to production. Application of raised beds at the station increased yield by 45% (Hamilton, 1997).

Grassed waterways/grade banks can be useful for controlling erosion and loss of nutrients into waterways. An excellent publication that addresses the factors to consider for grassed waterways and grade banks is *"Preventing Soil Erosion and Soil Structure Decline"* published by Agriculture WA, 1997. The current options available for salinity management in Western Australia are to:

1. Increase water use of annual crops and pastures. Annual pastures allow nearly twice the amount of water to flow to recharge as annual cereal or legume crops.
2. Grow perennial pastures: eg. tall wheat grass, lucerne, kikuyu and fodder crops including Tagasaste and *Acacia saligna*. Landholders within the Fitzgerald River catchment are already integrating lucerne, a leguminous perennial, into their farming systems to increase water use.
3. Control surface water: using different types of banks and drainage structures.
4. Plant commercial plantations: combining forestry and agriculture for recharge control and diversification of income eg. oil mallees, maritime pines and bluegums.
5. Improve and manage remnant native vegetation: through de-stocking, weed control, feral animal control and fire management. Better management means the remnant vegetation in the catchment can continue using water in the catchment for longer and not go into decline and increase water going to recharge.
6. Grow horticultural crops: high water usages on a small area of land with potentially higher returns eg. potatoes (deep sands), grapes (Dalyup loams) and olives.
7. Grow summer crops: this utilises untapped summer rain eg. forage sorghum, grain sorghum and sunflowers.
8. Use perennial forage plants on salt-affected land: as this provides surface mulch to reduce salt accumulation on the soil surface and plants use groundwater.

9. Drain groundwater: can alleviate rising groundwater problems in some locations, however is often the most expensive option available. Notice of intent to drain and approval by downstream neighbours needs to be applied for through the Department of Agriculture.

10. Pump groundwater to lower the groundwater table: is a temporarily and short term solution. Safe disposal of saline groundwater and cost of running and maintaining pumps are problems. Notice of intent needs to be applied for through the Department of Agriculture (George *et al*, 1997).

Taken from Negus (1991).

Currently not one of these options works perfectly in isolation. Salinity management has no easy solution and is often a combination of a number of these strategies.

Why manage your riparian land with care?

1. Decreased erosion – Overclearing and intensive use of riparian lands results in more water moving quickly off the land surface in times of heavy rain, leading to floodouts, stripping of topsoil and accelerated bank erosion which can result in the loss of valuable agricultural land.
2. Improved water quality – Good management of riparian land can decrease the amount of soil and nutrients moving from the land up slope of the riparian land to the river. By trapping soil and nutrients water quality will improve and the loss of in-stream habitat through siltation will decrease.
3. Healthy ecosystems – Good management of riparian land can prevent or minimise damage to both land-based and river ecosystems. Such damage can upset fragile biological balances and lead to a decrease in productivity and the deterioration or even destruction of interdependent environmental systems.
4. Maintaining river courses – Increase flow from cleared land and riverbanks can cause rivers to change their courses and form new meanders or flood channels.
5. Stock management – Stock allowed free and controlled access to riparian land, can directly foul the water with their urine and faeces and increase soil erosion by overgrazing and developing walking tracks and pads, reducing water quality for downstream users and impacting on the estuary.
6. Decrease in insect pests – Healthy, vegetated riparian land provides habitat for insect-eating birds and insect parasites that can protect pastures and crops from damage. Losing even a small number of birds can allow significantly more below-ground pasture grubs to survive and become adults.
7. Increase in capital values – Anecdotal evidence from real estate agents suggests that well-managed riparian land can add value to the property.
8. Opportunities for diversification – Some landholders have combined riparian management with agroforestry production.
9. Climate protection – Well-managed riparian land can provide windbreaks, providing shelter for stock and slowing down erodable winds.
10. Retention of nutrients – In addition to preventing erosion and improving water quality, riparian vegetation can absorb and use natural or added nutrients that might otherwise be washed into streams, resulting in the growth of nuisance plants and algae within rivers and estuaries.
11. Lowered water tables – Deep-rooted vegetation may, in some circumstances, act to lower water tables, reducing the flow of salt and nutrients into stream from sub-surface flows.
12. Increased fish stocks – Healthy riparian vegetation helps maintain good habitat for aquatic animals, including insects and the fish that feed on them. Rivers and estuaries are an important recreational resource for fishing.
13. Decreased algal growth – Riparian vegetation helps to control the light and temperature levels for stream ecosystems. This also helps to control the growth of nuisance plants and algae.

(Source: Riparian Management Factsheet 1: Managing Riparian Land, produced by the Land and Water Resources Research and Development Corporation (1), 1996)

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4 History, heritage, land tenure and case studies

4.1 Aboriginal heritage

The Aboriginal history of the Fitzgerald River and the adjacent area is relatively unknown. There is however no doubt that the Fitzgerald River featured in the lives of Aboriginal people prior to European settlement. The river and valley would have provided water, hunting and other food gathering opportunities on river flats, access from the coast to inland sites and sites for ceremonial and religious activities.

At the time of European settlement, the Aboriginal family group the Goreng (Koreng) occupied the Gnowangerup Bremer Bay area and spoke the Noongar (Nyungar) language (Shire of Jerramungup, 1994). Roni Forrest and Stuart Crowe produced a report on the Noongar social history of the Jerramungup region, *'Yarra-mo-up Place of the Tall Yate Trees'* (1996). This report includes some references to place names on the Fitzgerald River.

- Waijacollap on the river means 'listen to the emu'.
- Janacoonack on the upper reaches of the Fitzgerald River means 'ghost faeces'. Noongars thought the seam of coal there was ghost faeces. Also, there are huge footprints in the coal and they thought it was a place where ghosts (jannocks) lived so they avoided it.
- Tooartup Creek, a tributary of the Fitzgerald River situated in the Fitzgerald River National Park, was the place of dingoes. 'Toort' means 'the wild dog'. It is now called Twertup (Forrest and Crowe, 1996).
- The Fitzgerald Inlet is known as 'Gnangmeip' (Sandiford, 1988).
- Other names of places are: Eyre Range 'Koichen-ungup', Hamersley River 'Wonjarup', Mid Mt Barren 'Narpulungup', Mt Bland 'Poorijunup' and Mt Drummond 'Jindenup'.

4.2 European heritage

The history of the Fitzgerald River catchment varies for each area within the catchment. The northern area of the catchment was set aside in 1958 in the Lake Magenta Nature Reserve, the middle reaches were opened up for agriculture in 1961 and the lower catchment was gazetted as the Fitzgerald River National Park in 1973.

The Fitzgerald area was opened up for settlement as part of the Conditional Purchase Program. Land in the Fitzgerald area could be bought for $1.36 a hectare, and half this price for ex-servicemen. After the War Service Land Settlement Scheme in the 1950s, the unsettled land was opened up through a Conditional Purchase Scheme.

In context of the condition of the catchment, it was the Conditional Purchase Scheme that altered the catchment, resulting in the clearing of native vegetation for agriculture. In September 1961, 28 blocks comprising 35 000 ha, were made available east of Jerramungup through the Conditional Purchase Program. Land could be bought as cheap as $1.36 per/ha, and half this price for ex-servicemen. The State Government allocated uncleared public lands to successful applicants, under the condition that they were expected to clear 100 ha a year for the first four years and to meet other obligations relating to cultivation, fencing and occupancy (Thomas, 1989). Conditional Purchase development was unplanned. The Department of Agriculture provided technical advice and financial institutions sent advisers to help landowners make decisions.

The program attracted a diverse group of 'hopefuls' of mixed occupations. There were 26 successful applicants that took up conditional land purchases. Two of the successful applicants were from overseas, 18 from the Eastern States and six from Western Australia. Only about a quarter had any farming experience and those about to confront the wilderness included a milkman, a painter, a policeman, a theatre manager, a miner and a women's dress shop manager (Thomas, 1989). The Conditional Purchase Program was unplanned and there were no local, regional or State control's on the clearing. As a result, many waterways were cleared of all native vegetation.

The Fitzgerald River catchment was overcleared. Four main reasons account for overclearing:

1. Government pressure: the land was under 'conditional purchase' where half the farm had to be cleared and boundary fenced within five years, and all the farm fenced and cleared within ten years.

2. Financial pressure: at the time of clearing, costs associated with clearing land, with no immediate return on investment, led to extreme financial pressure.

3. Poison pea plant: the land was purchased for grazing but was covered with poison bush. Fencing was not an option financially, so clearing occurred in small blocks at a time.

4. Lack of information and understanding: land was allotted to soldiers on return from the war to settle rural areas. These settlers were not necessarily farmers. They were from other states and countries and were of diverse backgrounds, with electricians, policemen and pastry cooks (Lester, 1993).

The Hassell family were the first settlers of the Jerramungup area. Their original homestead is located on the South Coast Highway, five kilometres east of Jerramungup. The Hassell's watered their sheep on the Fitzgerald River when droving them to Bremer Bay. Don Reid, landholder on the Fitzgerald River where the Hassell's watering point is located, said he found an old camping billy near where the Hassell's erected the brush yards for containing their sheep.

The Dunn brothers who settled on the Phillips River in the 1870s, had a bullock dray track running through many of the farms in the Fitzgerald River catchment. The wheel marks from the cart are still visible at some sites.

Some historical sites are present in the Fitzgerald River National Park. An oil rig is located near the coal seam on the Fitzgerald River. This is left over from the mining days. An old limestone quarry is cut into the rock face at Twertup.

4.3 Historical information from interviews

The history of the Fitzgerald River area can be found in publications, such as Athol Thomas's 'Trembling Horizons', but a lot of historical information can be discovered by talking to long-term residents. Of particular interest is Don Reid's and Betty Wellstead's (nee Reid) description of the changing fauna, from the domination of the dingo and chuditch, their decline followed by an increase in kangaroos, to the introduction and spreading of the rabbit and fox. It is important to document these memories, for it will soon be forgotten and lost. Unfortunately Don has since passed away. Both interviews give a different perspective on life before today.

4.3.1 Don Reid (recently deceased) and Betty Wellstead (nee Reid)

Don Reid and Betty Wellstead grew up beside the Fitzgerald River as their father moved there in the early 1920s. Don lives on Location 667, 990 and 54 in the Fitzgerald River catchment, south of the South Coast Highway. The southern property, Location 544 is dissected by the main channel of the Fitzgerald River. The northern property is adjacent to reserve land that includes the main channel of the Fitzgerald River. Don Reid lives with his sister Betty Wellstead.

Don was born at Gnowangerup and Betty was born four years earlier at Ravensthorpe. Don has always lived on the farm at Jacup. Betty has also lived in Perth, where she worked in a hotel for six months. She has also lived at Perilup, 36 miles west of Mt Barker, on a farm with her husband. This farm was opened up as part of the Mt Barker War Service Land Settlement Scheme. Don has been a farmer all his life. Don and Betty's dad, Reg Reid, came to look for grazing country in early March, 1916. He camped on the flats on the western side of the Fitzgerald River, and woke to find dingo prints all around his camp. The family moved onto the farm shortly after.

Don grew up on the farm and was used to his surroundings. Betty had lived in Ravensthorpe for a while, and moved to the farm when still young but can remember that she didn't have anyone to play with. Betty could remember fun times playing with other little girls in Ravensthorpe. At Jacup, Betty's mum used to put her in a tub to stop her going walkabout while mum prepared dinner and did the chores. Don and Betty grew up beside the Fitzgerald River.

"The river is a fixture of our life, it has always been there. When we were younger, it was our playground"

Farming then was pretty tough. Dingoes and chuditches caused problems. The dingoes would take calves, foals, lambs and sheep. They were baited, trapped and shot at. The dingoes used to come really close to the house. Reg Reid had taught his roo dogs to catch dingoes. Some of the dingoes were pure white. When the Reid's first came to Jacup it was rare to see a kangaroo, because of all the dingoes. Once the dingoes were gone, the kangaroos came out of the bush. Then the rabbits and foxes came. The chuditch, a native predator, used to kill chickens. The farming was tough. On one occasion Reg Reid, Don and Betty's father, took cattle to Katanning and returned with sheep. It had taken him six weeks, which was pretty good time in those days.

Poison pea plant was a huge problem. At Christmas in 1875, Walter Dunn, at the age of 15, drove 40 fat wethers to Albany and lost 20 to poison. When droving livestock to market, they would camp at night and make brush yards to keep the stock in. They would get their axe out and quickly put together a set of brush yards. Other fauna that Don can remember was these big fat black lizards.

"you just don't see those big fat black lizards like that anymore."

Don and Betty can remember having picnics and barbecues by the river. A German women who lived at Ravensthorpe used to trade meal for salt, she said it was the best salt she'd ever used for curing meat.

"We used to gather salt for use in cooking and for curing meat".

Don can also remember going down to the river near the coal seam in the Fitzgerald River National Park and fishing. They used to catch big black bream. In 1954, there was a drought year followed by the wettest year in 1955. Betty can remember hearing the river roar on one particular occasion, and she hasn't heard it like that ever again.

"Our special place on the river would be where the Hassell's used to camp sheep, is a clearing we used to play and chase lizards".

Don recalled that the Hassell's were the first settlers of the area at 'Jerramongup'. Another family, the Dunn's, drove sheep from their Porongorups property in early 1870 to the Phillips River. This was around the same time Surveyor Roe came and recommended this area be opened up for grazing country. In 1875, four bullocks and a dray were used to make the road to the Fitzgerald River. A road from Ongerup to the Hassell's 'Jerramongup' property had already been made. In 1939, a surveyor by the name of Wright, made the Old Ongerup Road and paved across the Fitzgerald River. From the Reid's property at Jacup, it was 50 miles to Ravensthorpe, 20 miles to the Hassell's 'Jerramongup' estate, and 50 miles to Ongerup.

Don has some Aboriginal firestones, rocks with single holes indented into their surface used by the Aboriginals to make fires. Betty and Don only remember some Aboriginals who used to drop in from time to time on their way from Ravensthorpe to Ongerup. One time Betty can remember only her mother and herself being home and an Aboriginal came to the house thinking it was a shop and he reeled off this list of things he wanted. When he asked for a tin of jam and they said they didn't have any jam he was shocked–he didn't know it wasn't a shop. Betty said they didn't have jam even for themselves, if they wanted jam they used to grind up currants with a bit of sugar and syrup. Betty also remembers visiting spots frequently along the river, often to catch their food.

"The family used to frequent a fresh water hole called Calyerup, which had also been used by the Aboriginals. This was where the kangaroos would frequent and was the best spot to kill a kangaroo".

4.3.2 Bob and Helen Twigg

Bob Twigg arrived in the Jacup sub-catchment as a 'conditional purchase' landholder. Bob and wife Helen moved from a 204 ha dairy farm from Cowra, NSW, which he farmed with his father and brother. The move to Narrikup in 1961 was made after hearing of cheap land in WA. Bob and Helen lived in Narrikup until 1964 when they moved to their Jacup property, Location 1612, under 'conditional purchase'. They purchased the adjoining property, Location 1611, ten years later.

Bob and Helen's first impressions were of shock and horror. Bob had come from the flats of the Lachlan River, NSW, which comprised of rich alluvial soil.

"I could not believe this sand was actually called 'soil' and the trees were scrubby, scratchy looking. It took nearly a week for me to get over the shock that I was supposed to farm this land".

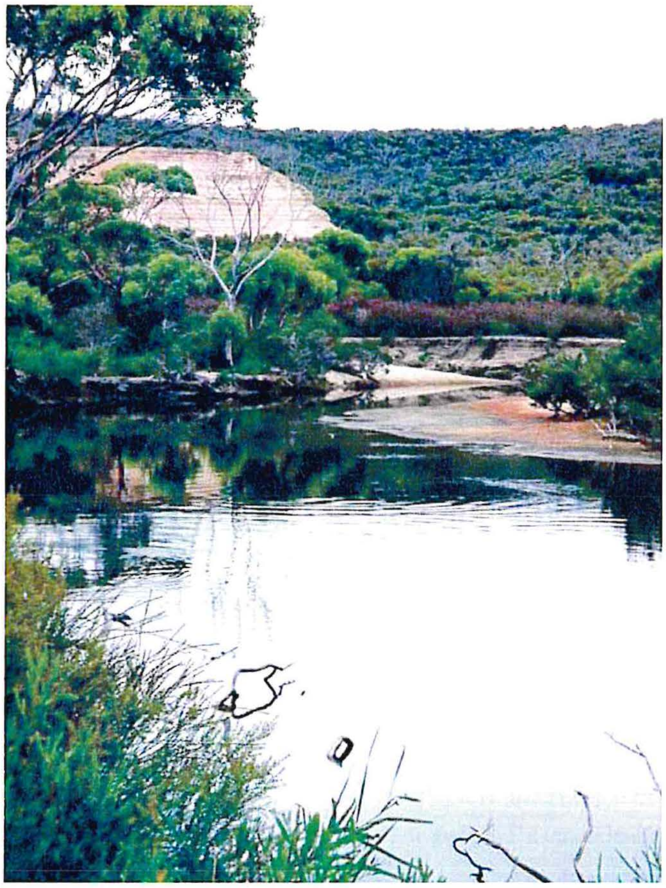
In 1964, Bob and Helen came to Jacup with two little kids, a one month old and a two year old. At this time, there was no bitumen road to Jerramungup, no doctor and no phones on the Twigg's farm. There were recent additions to the town, such as the hotel, hospital, CBH grain bins and the general store. It only took three or four years for the phones to be put on. Medical attention was available through the Royal Flying Doctor Service, with Bob having his own RFDS radio, (and he can still remember his radio number 8WEQ).

When Bob first came, 1964-1968 were all good years but in 1969 drought hit. 1971 was also a dry year and in November 1972, 7-8 inches of rain fell, flattening the crops. 1981 and 1982 were very dry years, and wind erosion issues became really evident. This is a fragile environment. This resulted in the formation of the local Soil Conservation Advisory Committee and eventually the Jerramungup Land Conservation District Committee. 1988 was a heavy flood year and the downpours in the summer of 1999/2000 was a very unusual weather event. Bob has never really had much to do with the river.

"Unlike the rivers in the eastern states which flow all year round, the Fitzgerald dries up limiting many water based activities".

4.4 Case studies

Within the Fitzgerald River catchment, many landholders have implemented river restoration works, whether by fencing and protection of riparian vegetation, revegetation of waterways or the integration of high-water using perennials into the farming system. Five study sites have been used for these case studies, and as examples to show other landholders the benefits of river restoration works.



Fitzgerald River – Spongellite cliffs (photograph Julie Pech, WRC)

4.4.1 DB & JM Bunker, 'Fitzgerald River Pastoral Co.' – Remnant Vegetation Protection Scheme

Background

Don and Julie Bunker, with son Michael, have farmed 'Fitzgerald River Pastoral Co.' since 1990 when they moved from Kendenup. The property, Location 1630, (1181 ha), and Location 1004, (118 ha), is situated on the South Coast Highway one kilometre east of the Fitzgerald River. The Bunker's have farmed the land, with a 45:55 ratio of cropping to sheep, respectively. The back boundary of the property joins the Fitzgerald River National Park.

Two main waterways flow through the property before meeting up with the Fitzgerald River in the Fitzgerald River National Park, illustrated in Figure 7. The Bunker's have fenced Jims Creek and its north-east flowing tributary, entirely through the Remnant Vegetation Protection Scheme (RVPS), and have also fenced a small tributary to the west of Jim's Creek, under the Remnant Vegetation Protection Scheme. The tributary immediately to the west of Jim's Creek is to be fenced this year.

Waterway condition

Native vegetation had been left in all the tributaries that have been fenced under the RVPS when the Bunker's purchased this property. The dominant vegetation communities include yate woodland, with a young *Casuarina* understorey, mallee heath with a mixed native understorey, and mallee scrub, where the vegetation is dominated by mallees and has no real middle layer. The condition varies, with Jim's Creek in near pristine condition in the southern section, and a few weeds present in some northern sections.

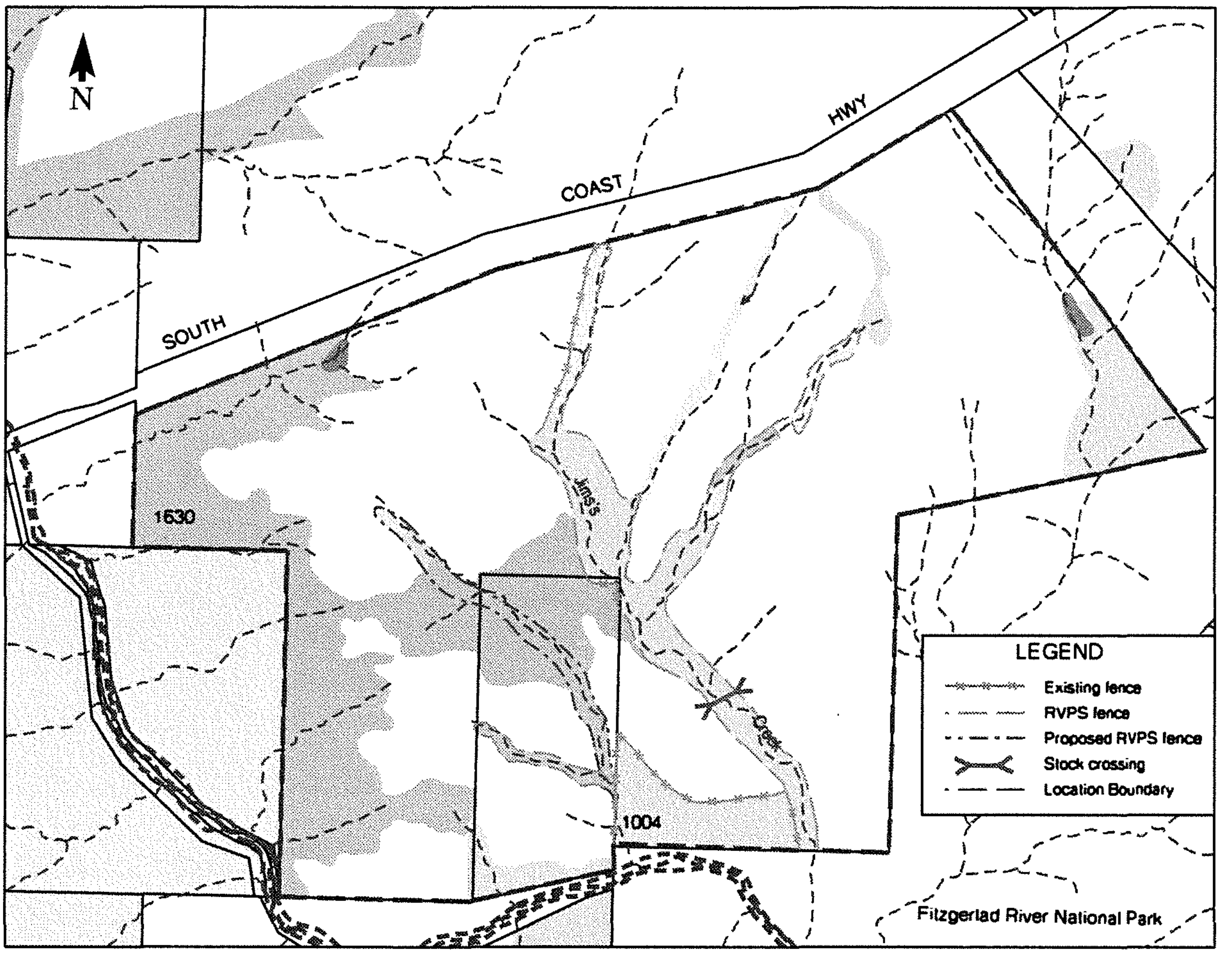


Figure 7. 'Fitzgerald River Pastoral Co.', Kent Location 1630 & 1004, and the waterways protected by fencing and under covenant through the Remnant Vegetation Protection Scheme

The Malleefowl

The Malleefowl (*Leipoa ocellata*), is recognised as a threatened species and has been gazetted under the Western Australian *Wildlife Conservation Act* as 'fauna which is 'rare or likely to become extinct'. It is one of only 14 species of mound-building birds in the world and one of three species in Australia. The birds build a large mound of soil and litter, in which they lay their eggs for incubation. Heat for incubation is produced through the natural fermentation of the organic matter. It is the male Malleefowl's responsibility to build and maintain the mound (Harold and Dennings, 1998).

The Malleefowl mate for life and may live up to 30 years. A female may lay up to 30 eggs in a good season, but on average 20 are laid a year. Once the chick hatches from the egg it must fight it's way to the top of the mound before it's free and then the adult birds offer no parental care. It's no surprise that less than 1% of the chicks survive. Foxes, feral cats and native birds of prey reduce the number of young Malleefowl, and to a lesser extent, the adult birds (Harold and Dennings, 1998).

Malleefowl are also susceptible to fire disturbance in their habitat. Fire destroys the litter used for the mound, and may result in an unsuitable breeding habitat for 15–40 years (Harold and Dennings, 1998). The Malleefowl were originally distributed throughout large areas of southern, central and western Australia but are now restricted to semi-arid rangelands and small remnants (Harold and Dennings, 1998). The Bunker's property, especially the Jim's Creek micro-corridor, is providing a valuable habitat for the Malleefowl population.

The rivercare issue

The Bunker's wanted to protect the waterways from sheep, and to conserve the vegetation for flora and fauna habitats. Jim's Creek links directly with the Fitzgerald River National Park and is an important micro-corridor, particularly for the protected Malleefowl, (*Leipoa ocellata*). Don Bunker, when measuring the RVPS fence on the southern section of Jim's Creek on his motorbike, saw three malleefowl on the western side of the vegetation and 33, of mixed ages, on the eastern side. He has not seen any Malleefowl mounds in Jim's Creek and assumes the birds move to and fro between the FRNP and Jim's Creek.

The solution

To fence and protect the waterways, the Bunkers first applied for funding assistance from the Australian Nature Conservation Agency through the 'Save the Bush' program. This started in 1992 and they received $1600 to fence 4.5 km of the waterway. The next fencing project was through the Remnant Vegetation Protection Scheme in 1996, receiving $2800 to fence 4 km along Jim's Creek. This fencing was completed in 1998. So, through previous fencing, and through the RVPS and ANCA, the Bunkers have secured Jim's Creek, encompassing an area of 73 ha. It is also under a 30-year covenant as a condition of the RVPS. The Bunker's have been generous in the width of fencing, allowing for the floodway of the waterway. They have also coincided fox and rabbit baiting programs with the Department of Conservation and Land Management's Western Shield fox baiting in the FRNP.

The Remnant Vegetation Protection Scheme is administered by the Department of Agriculture (Western Australia) with the objective to maximise the nature conservation value of, and catchment water use by, remnant vegetation in Western Australia by protecting it from grazing stock. The Government has made available funds for grants of $1200 per kilometre towards the cost of fencing, in return for a covenant of at least 30 years duration registered on the land title. The RVPS is one such grant assistance and covenanting scheme with others available through the Department of Conservation and Land Management and the National Trust.

Site facts

- **73 ha under 30-year covenant through the Remnant Protection Vegetation Scheme.**
- **$1600 to fence 4.5 km in 1992, from Australian Nature Conservation Agency through the 'Save the Bush' program.**
- **$2800 to fence 4 km in 1996, through Remnant Protection Vegetation Scheme.**

Outcomes and observations

The Bunker's have noticed regrowth of native vegetation in all the fenced areas, particularly the minor tributary to the west of Jim's Creek. This waterway was quite degraded but since fencing in 1996 through RVPS, the understorey has sprung to life. Young seedlings of yates and mallees have germinated, where previously sheep ate them.

Future action

The Bunker's plan to fence the tributary to the immediate west of Jim's Creek this year. The vegetation is in good condition along this waterway, with the yate woodland understorey still intact even though sheep have grazed. Young saplings or seedlings are sparse but on sheep removal the area should regenerate successfully.

4.4.2 GA & DS Bee, 'Laurinya' - perennial lucerne pasture

Background

Geoff and Di Bee farm two properties, Locations 1609 and 1605, in the Jacup sub-catchment. Geoff moved to these properties in 1963, as a 15-year-old with his father, and took up the 'Conditional Purchase' property. The land has always been used for farming and currently the landuse ratio is 57:43 cropping to sheep, respectively, and income is provided 2/3 from cropping and 1/3 from sheep.Two tributaries flow through Location 1609, and dissect the middle of the property in an east-west direction. The northern waterway is known as Cameron Creek, and the southern waterway Jacup Creek, illustrated in Figure 3. Cameron Creek is only fenced on the southern side, and Jacup Creek is only partially fenced as well. Only minor tributaries drain Location 1605, with most revegetated and fenced.

Geoff and Di have been implementing lucerne pasture into their farming system since 1985 to use out-of-season rainfall and to address the rising watertables of the area. At present a third of their property is in lucerne, with the entire property to be sown to lucerne in coming years and used in rotation with Geoff's cropping program. Using perennials throughout the catchment reduces the amount of water entering the waterways, and lowers the watertable therefore reducing the salinisation of farmland and waterways.

Waterway condition

Cameron Creek and Jacup Creek were left vegetated when the property was cleared. Cameron Creek is only fenced on the southern side and sheep have access to the northern side. The vegetation is in B grade foreshore condition, with weeds present in the understorey.

Jacup Creek has been fenced both sides on the eastern section since the property was purchased. The foreshore vegetation is in A grade condition. The western section is fenced on the northern side but not on the southern side. It is in B grade foreshore condition.

The rivercare issue

Native vegetation has been replaced by agricultural plant communities, which differ in growth periods and rooting depth, with significantly wetter soils under the agricultural system (Ward *et al*, 1998). This causes severe waterlogging during the winter season, which in turn leads to increased vertical water loss from the root zone, rising groundwater tables, and eventually, dryland salinity (Peck and Williamson, 1987). In the Fitzgerald River catchment the waterways are showing signs of degradation. Some waterways have become saline and the native vegetation has died. Increased water levels in the Fitzgerald River and its tributaries has also been noticed by long term residents.

The catchment area used to be well vegetated with native vegetation communities and very little rainfall escaped from the land as runoff into the waterways. Most of it evaporated or was intercepted by the vegetation. Over thousands of years salt deposited by rain has accumulated in the soil in huge quantities. With the advent of clearing in the 1960s, less vegetation has been available to intercept and transpire water, resulting in a net recharge of water to the groundwater (Pen, 1999).

The solution

Lucerne is a deep-rooted, leguminous perennial that provides a means of increasing water use, while maintaining flexibility in agricultural rotations (Ward *et al*, 1998). It has a high capacity to utilise soil moisture and will continue to grow as long as soil moisture is available. It is best suited on soils with pH>5. This extends the growing season in autumn and spring and can provide a green pick over summer (Blacklow and Latta, 1998).

Geoff began trialing lucerne as a hobby in 1971. He took his 'hobby' up again in 1985 using lucerne for border plantings on waterways. In 1990, Geoff established broadacre lucerne pasture throughout his farm as he realised the rising watertable was affecting the whole farm. Since then, Geoff has continued to develop his lucerne pasture, and has participated in various trials conducted by the Department of Agriculture and CSIRO.

Lucerne is only one species of perennial that can be used in agricultural systems, but it is the most tried and tested, and the most familiar to landholders and agencies. While lucerne has been effective at Geoff Bee's property, in other situations it may not be as effective (Lisa Crossing, pers. comm. 2000). The Department of Agriculture, (known then as Agriculture Western Australia) recommended an integrated approach including grade banks and trees – lucerne is not the solution, it is just a very effective part of the solution (Lisa Crossing, 2000 per. comm.).

Why use lucerne?

Geoff and Di use lucerne to benefit from out-of-season rainfall, improve soil fertility, as a reliable legume, for livestock feed, help control groundwater recharge and for its aesthetic value. The Department of Agriculture describe the benefits of lucerne in a cropping/livestock enterprise as:

- improved sustainability;
- increased soil nitrogen;
- potential improvement in grain yield and protein content;

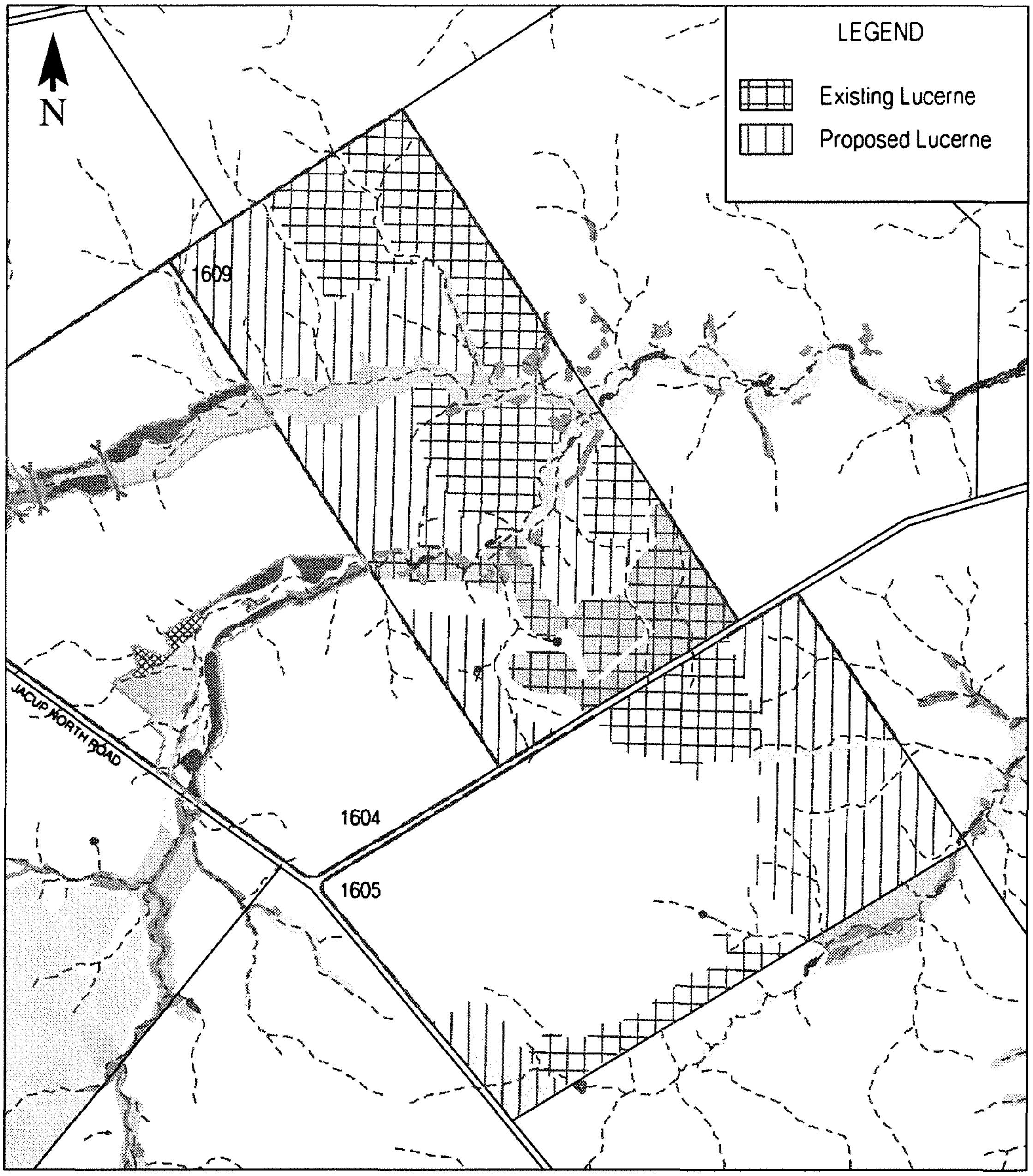


Figure 8. 'Laurinya', Kent Location 1609 & 1605, areas of existing lucerne pasture and areas of proposed lucerne pasture

- control of herbicide resistant weeds;
- disease break;
- out-of-season green feed;
- prime lamb and hay production;
- stabilisation of water table;
- drying out of the soil profile; and
- improved soil structure (Blacklow and Latta, 1998; Ryder *et al*, 1999).

Site facts

- ***Area:* 800 ha in lucerne in 2000.**
- ***Cost:* $115/ha to establish lucerne.**

Innovative actions:
There was a risk of sandblasting in the lucerne, due to it lacking complete groundcover. As a result, inter-rowing plantings with cereals, particularly barley, provides wind protection and income when the barley is harvested.

Treatments:

To establish lucerne Geoff said you need:

- good weed control;
- thorough insect control;
- innoculated seed;
- shallow seeding; and,
- careful grazing in the first year.

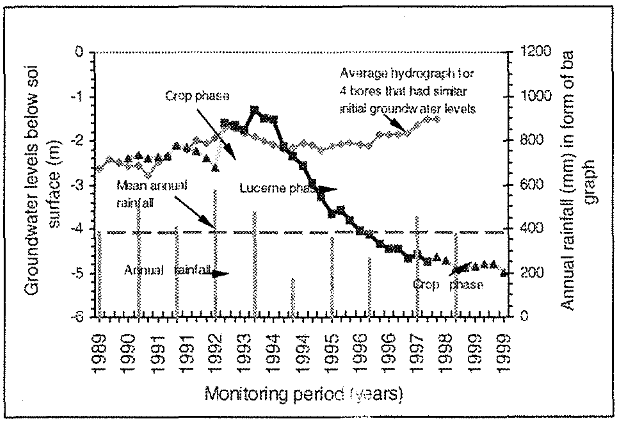


Figure 9. Groundwater levels below soil surface in cropping and lucerne phases over 10-year period on 'Laurinya', Bore Location GB1d90. (Department of Agricutlure, Albany)

Agency involvement:

Roy Latter and Lisa Blacklow, and the Department of Agriculture, Katanning have conducted various trials on Geoff and Di's property. Phil Ward from the CSIRO is also using the property to field proof theories on lucerne.

Cost savings:

Weed control has become easier due to improved soil fertility from leguminous lucerne. This reduces the need for fertiliser use. Also, having perennial pastures has saved Geoff from hand feeding sheep.

Outcomes and observations

Since implementing lucerne rotations in his farming system, Geoff has lowered groundwater levels under lucerne pasture and adjacent salt scalds have contracted.

Figures 9 and 10 illustrate the effect lucerne has had on the watertable on Geoff's property. Both figures show that in the early 1990s, the watertable under the cropping phase was similar to the groundwater levels for the surrounding area, (shown as the average hydrograph of four bores). When lucerne was phased in from 1993–1997, the groundwater levels decreased dramatically. Once the lucerne was removed and a cropping phase implemented, the groundwater levels remained at the same level as the lucerne phase. This highlights how effective lucerne has been in lowering the watertable on Geoff and Di Bee's property.

Future actions

Geoff is using lucerne in rotation throughout his entire farming system. Future actions also involve the continued development of the system and continuing trials by the Department of Agriculture and CSIRO.

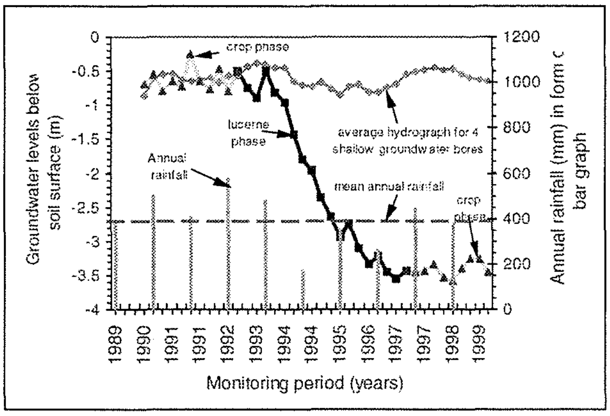


Figure 10. Groundwater levels below soil surface in cropping and lucerne phases over a 10-year period on 'Laurinya', Bore Location GB2d90. (Department of Agriculture, Albany)

4.4.3 RE & ML Lester, 'Karraloo' – revegetation using direct seeding

Background

Rob and Marg Lester have owned Location 1604 since 1982, and they also own land on both sides of the Fitzgerald River. Location 1604 was cleared by the previous landholder through the Conditional Purchase Scheme in the 1960s. The property has always been used for agricultural production and the current landuse is 65:35 cropping to sheep, respectively. A freshwater bore was recently drilled and Rob is contemplating intensive irrigated agriculture such as viticulture or horticulture.

Location 1604 is adjacent to Geoff and Di Bee's farm, (Case Study 2), Location 1609. The two tributaries Cameron Creek and Jacup Creek flow through Lester's farm in an easterly direction, illustrated in figure 11, before flowing into the Bee's property. The tributaries vary in condition, were partially cleared and were open to grazing livestock. Since taking ownership of this property, Rob and Marg have fenced and revegetated the creeks. Direct seeding was first used in 1992/93 on Jacup Creek to re-establish riparian vegetation. It is this site that is the focus area for this case study, as indicated in figure 11. The success of this revegetation led to Rob and Marg using direct seeding for further revegetation.

Waterways condition

Cameron Creek and Jacup Creek are naturally saline tributaries of the Fitzgerald River. The western half of Cameron Creek was cleared of all native vegetation and is degraded. Erosion, sedimentation and salinity have all impacted on the creek. The eastern half was not cleared as extensively and the native vegetation is still in good condition, but was impacted on by stock before it was fenced 8–10 years ago. Cameron Creek is fenced entirely, with the last section completed in 1999. Direct seeding was carried out on the eastern section of this creek on the perimeter of the native riparian vegetation, and the western section was planted to seedlings in 1999.

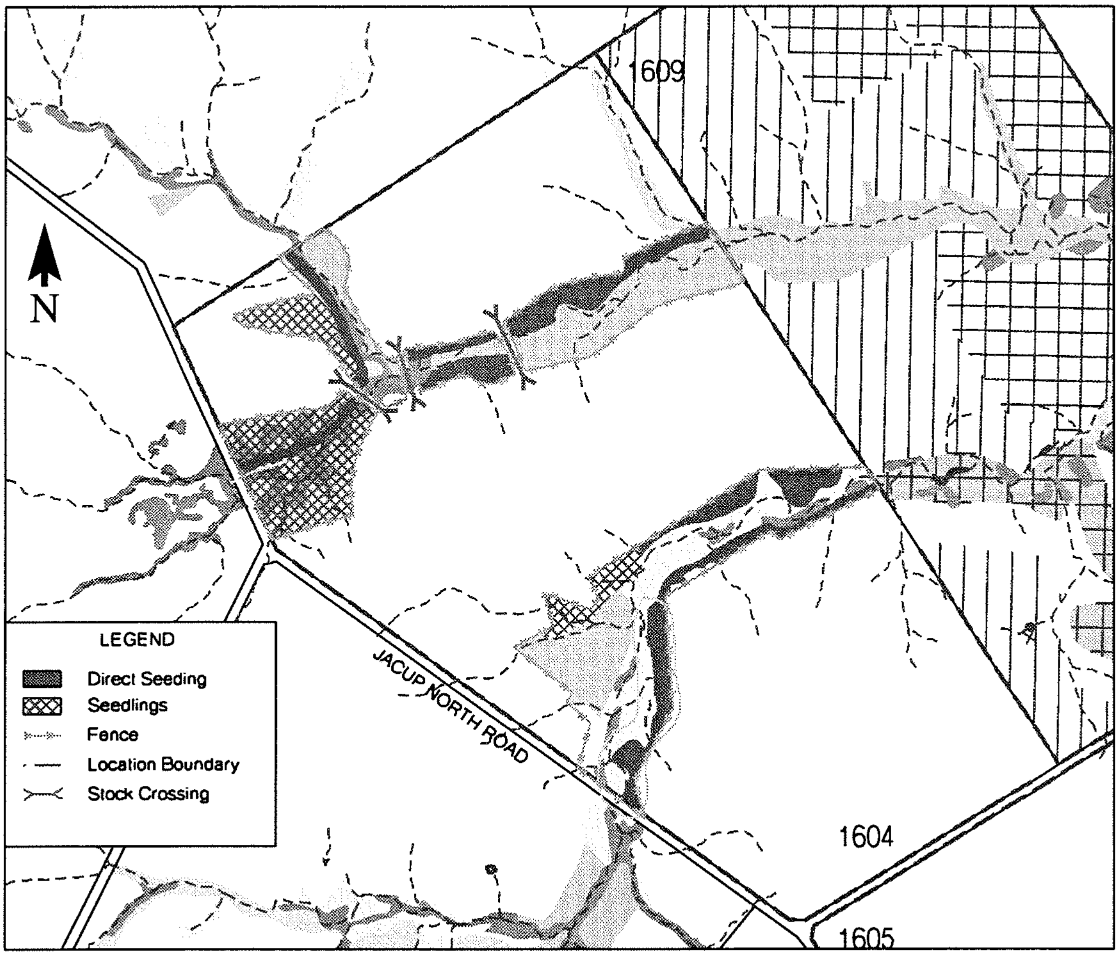


Figure 11. 'Karaloo', Kent Location 1604, areas revegetated using direct seeding and seedlings

Jacup Creek was left partially vegetated but the creek has been impacted on by salinity. Sediment has also filled the main channel. The entire creek is fenced and large areas on the edge of the riparian vegetation have been revegetated using direct seeding. This revegetation is now 7–8 years old, and is the focus site for this case study.

The rivercare issue

Both Cameron Creek and Jacup Creek were showing signs of salinity. Cameron Creek was very degraded and had less riparian vegetation, particularly on the western end. Jacup Creek wasn't as degraded but native vegetation was still dying. For this reason Rob decided to address land degradation on Jacup Creek as there was a greater possibility of the waterway recovering.

The solution

Rob and members of the Jacup Catchment Group collected native tree seed in 1992/93. At the 1993 Jerramungup Land Conservation District Seminar, Rob described the catchment group's activities.

"Another group project is collecting tree seeds. This is an excellent activity for group stimulation. The last gathering took 2.5 hours. We had 14 people and 12 tarpaulins. We put the branches on the tarps and left them there for 2.5 weeks. Then eight members went back, removed the branches from the tarps and sifted the seed. This resulted in 47 kg of seed for 2.5 hours work. Commercial retail value of the seed is $8460. It is a worthwhile group project, especially where members want to seed large areas in the most cost effective method." (Lester, 1993).

It was this seed that was used by Rob to revegetate Jacup Creek in 1992/93. The 30-ha site borders the creek's main channel, widening the existing riparian vegetation.

The direct seeder

The direct tree seeder was modelled on a commercial tree seeder and constructed by Jerramungup Engineering in 1986 for the JLCDC. It is a single furrow, hydraulically operated machine that direct sows native and fodder trees, shrubs and saltbush. A tine and two discs are mounted on the front section which gives a small rip line and a 'V' furrow for weed control and water catchment. The discs can be turned over by loosening the bolts on the brackets, moving them along and twisting around. This creates a mound instead of a furrow making it suitable for saltland plantings to give good drainage and leaching of salt (Lullfitz, 1995).

The seed is put into the revolving drum and dispensed through adjustable holes into the furrow. The drum rotates once for each 2.8 m of forward travel and there are two openings - one at 2.8 m and the other at 1.4

Robbie Lester, standing in his direct seeding site in 1992/93 metres. Speed needed is 4.5 km/hr. Depending on soil type there are two different sized chains dragged behind for soil coverage and a press wheel follows to compact the seed and soil. The seeder needs only a 50 hp tractor to operate and a ute can quite easily tow it along the road by means of either a tow ball or bolt hitch (Lullfitz, 1995).

Site facts

- *Size of area:* **Approximately 30 ha**
- *Fencing status:* **Jacup Creek was fenced before direct seeding was undertaken in 1992/93.**
- *Tree seed:* **Native tree seed was collected from the area by members of the Jacup Catchment Group.**
- *Costs:* **The only costs, besides time, were the chemicals used for weed control and the follow up spray for pests. The seed was collected by the Jacup Catchment Group and the direct tree seeder was borrowed from the JLCDC.**
- *Treatments:* **Herbicide was sprayed three weeks prior to direct seeding to control weeds. A follow up 'bug' spray was carried out as a precautionary measure.**

Outcomes and observations

The revegetation was very successful, as can be seen in the photo. This vegetation was the first area that was direct seeded by Rob, in 1992/93. The trees are at different heights, with a mixture of native 'local' species. A few trees have died and natural regeneration is occurring.

Recently, Rob had some tree seedlings planted on the degraded area of Cameron Creek. He commented on the difference between seedlings and direct seeding. Seedlings are visible immediately after planting whereas seed takes a while to germinate and become visible. Seedlings provided instant good 'gut' feelings while seed takes longer to offer this good feeling. Rob said though, that direct seeding looks better than seedlings in the future as it is thicker and the trees species are more randomly place, similar to nature. When asked how he feels when he sees the revegetation along the waterway, Rob answered with ...*'it makes you feel good in the guts'*. (Rob Lester, pers. comm. 2000).

Future actions

Rob has completed fencing and revegetation on Jacup and Cameron creeks. Future works on this property will focus on the minor tributaries of these two creeks. This will involve fencing and revegetation. Rob is also carrying out his own trial. In 1999 seedlings were planted in Cameron Creek and at the same time Rob direct seeded a row among the seedlings to compare the success and growth rates of seedlings versus seed. Rob's prediction is that the seed will outgrow the seedlings.

4.4.4 TA & AR Ross, 'Pineplace' – early revegetation efforts

Background

Trevor and Allyson Ross farm 'Pineplace', Location 1620, in the Jacup catchment. The property was partially cleared when purchased by Trevor , his brother Reg and father Pat. The remaining land was cleared in the 1970s. The current landuse is 2/3 cropping to 1/3 sheep.

The upper reaches of Twertup Creek originates in this property. The riparian zone of Twertup Creek wasn't cleared and is in near pristine condition, except where salinity is encroaching some of the vegetation and farmland.

Trevor and Reg Ross, with Claudia Hadlow from the Department of Agriculture, established a trial revegetation site on 'Pineplace' in the 1980s. This was one of the first revegetation efforts in the area. This first revegetation site paved the way for further revegetation throughout the property. Trevor and Allyson integrate seed collecting, tree planting and seeding into their farming system.

Waterway condition

Twertup Creek is a southerly flowing tributary of the Fitzgerald River. The upper reaches originate in 'Pineplace' and flows through three other properties before entering the Fitzgerald River National Park. Twertup Creek is a brackish-saline waterway. The vegetation in the channel supports this with the presence of salt tolerant species such as samphires. Salinisation has caused a small area of vegetation to die and this secondary salinity is encroaching a small area of farmland adjacent to the creek.

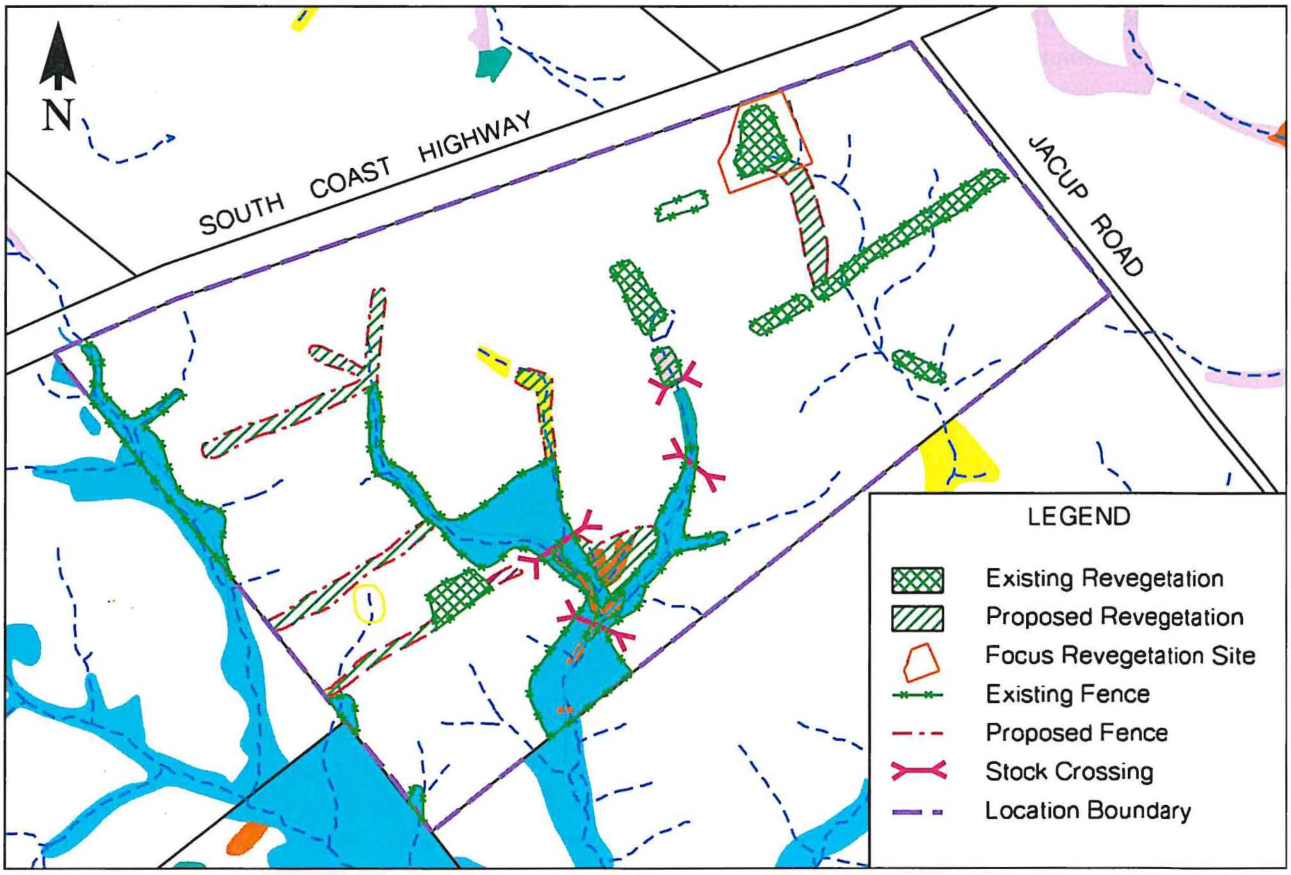


Figure 12. 'Pineplace' revegetation efforts

Twertup Creek was left vegetated and fenced since the farmland was cleared. The vegetation is a riverine vegetation community with high species diversity. Tree species include yate (*Eucalyptus occidentalis*), sheoak (*Allocasuarina campestrus*) and mallee (*Eucalyptus* spp.). Dead yates protrude from the existing vegetation canopy. These were killed in a fire in the 1970s. Except for the salt affected areas, the vegetation is in A grade foreshore condition.

The issue

The first revegetation trial site was carried out on an erosion prone site, not a waterway. A lot of water sits south of this site and it is definitely a recharge area for Twertup Creek but the primary reason for revegetating the site was to address wind erosion on a sandy soil site. Trevor and Allyson have now extended their revegetation works throughout the property. They have focused the development of shelterbelts to protect livestock from wind, tagasaste sites for sheep feed and to increase water use, and revegetation of waterways to re-establish riparian vegetation to prevent salinity, erosion and use water to address rising water tables.

The solution

In the 1980s Claudia Hadlow, Land Conservation Officer at the Jerramungup District Office, Department of Agriculture, approached Trevor and Reg.

Ross to establish a revegetation trial site on 'Pineplace'. The aim was to establish vegetation that would stop wind erosion on a sandy site. The site already had some pine trees established which were planted by the previous landholder but they were not stopping the wind erosion. Two species were planted, tagasaste and a species of *Acacia*. The revegetation was very successful with good stands of both species growing. Trevor uses the site for autumn sheep feed. Tagasaste is a nutritional, high protein sheep feed that supplements sheep diet. Both the Acacia and tagasaste have naturally regenerated through seed dispersal. Even the pine trees have regenerated. This site is used for a seed bank for further tagasaste establishment throughout the farm. Trevor collects the seed off the ground, (it just takes a couple of shovel fulls), and spreads it in the proposed site. This has proved successful in the establishment of tagasaste stands.

Since then, Trevor has seeded other sites. These include a shelterbelt, a waterway and a tagasaste site. Trevor and Allyson collect native seed, including local species and species from other areas. Trevor said "*the landscape has been altered and what used to grow here (native species) does not always grow well now.*" His aim is to establish vegetation. He believes in using native species but not particularly species indigenous to this area.

Site facts

These facts are for the focus revegetation site as shown in Figure 14. This was the first trial site established by Trevor and Reg Ross in partnership with the Department of Agriculture.

- *Size of area:* **14 ha**
- *Length of fencing:* **1.5 km**
- *Costs:* **50:50 with the Department of Agriculture**
- *Treatments:* **herbicide treatment before seeding**
- *Agency Involvement:* **Claudia Hadlow, Department of Agriculture Land Conservation Officer at the Jerramungup District Office in 1980?.**
- *Species:* **tagasaste**
  ***Acacia* spp.**
  Pine Trees already present

Cost savings

Erosion, sheep feed in autumn with the tagasaste and the trees use water (intercept and use rainfall which prevents water recharging groundwater and watertable rising.)

Outcomes and observations

The first trial was very successful and has been used for sheep feed in autumn and as a seed bank source for further tagasaste revegetation sites. As the photo shows, this project has been a very successful trial with natural regeneration of *Acacia* and tagasaste. The existing pines are also regenerating. The emphasis has been on revegetation using native vegetation that grows best in this area.

Future action

Trevor has proposed revegetation for shelterbelts and on the upper tributaries of Twertup Creek. Many of these will be implemented within the next two years in conjunction with the FRCG NHT project.

4.4.5 TJ & LM Lee, 'South Uberin' - protection of the Sussetta River

Background

Terry and Linda Lee moved to 'South Uberin' in 1992 after leaving 'Uberin Farms' in Dowerin. The previous landholders cropped very little of the property, with Terry and Linda changing the farming system to a 50:50 crop to pasture ratio.

The farm is dissected by the middle reaches of the Sussetta River, a southerly flowing tributary of the Fitzgerald River. The northern section of the tributary was cleared of native vegetation, with the southern section left to native vegetation.

The Sussetta River is a naturally brackish to saline tributary. The upper Sussetta River is sparsely vegetated and has become degraded through salinisation. Secondary salinity is encroaching both the river system and the farmland.

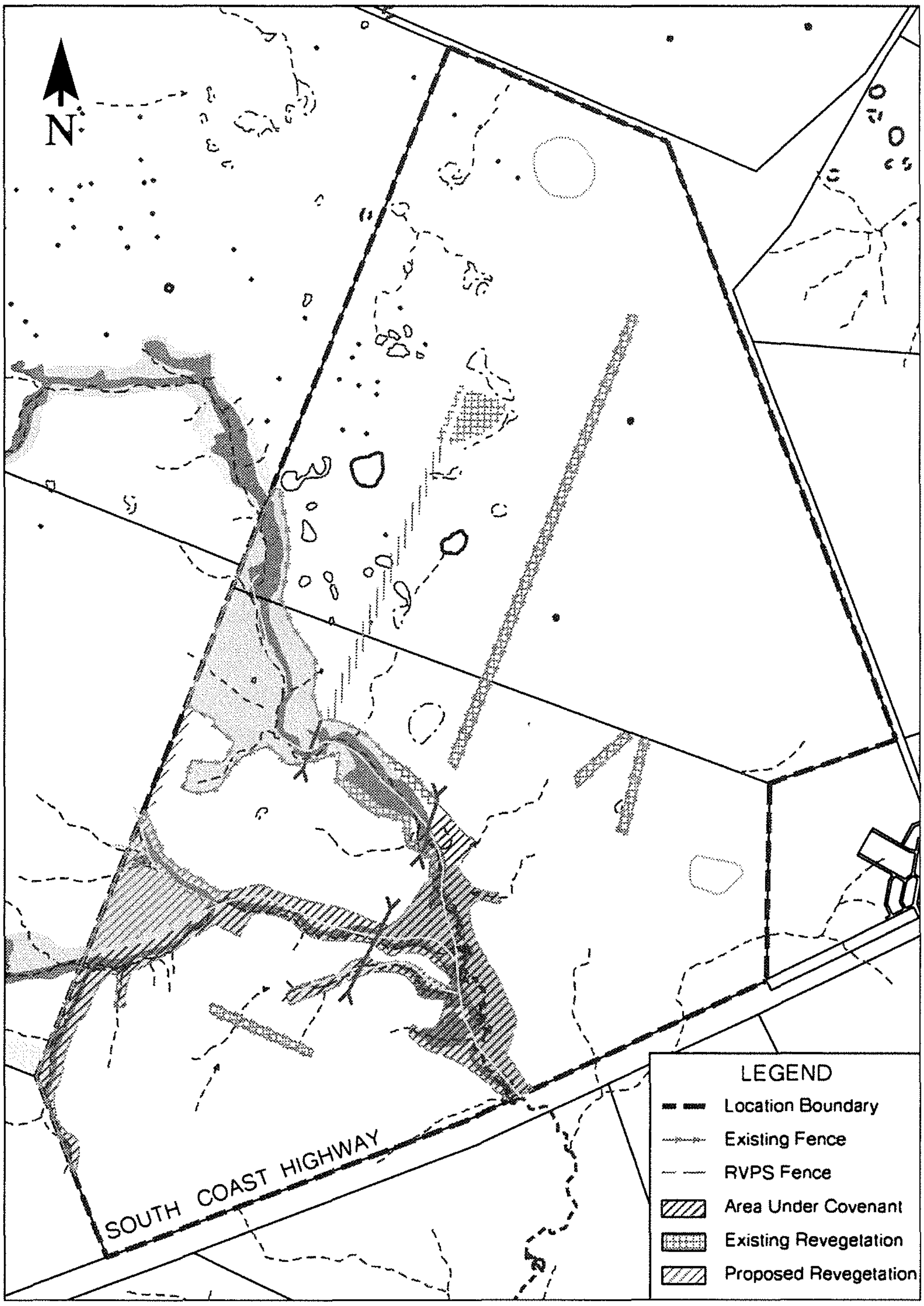


Figure 13. Areas protected by fencing and covenant under the Remnant Vegetation Protection Scheme, and areas of existing and proposed revegetation on the Sussetta River within 'South Uberin', Location 1640 and

Terry and Linda have quickly addressed the issue, fencing the entire area under the Remnant Vegetation Protection Scheme and placing it under a 30-year covenant. They are also revegetating areas with seedlings.

Waterway condition

The Sussetta River is a southerly flowing tributary that joins the Fitzgerald River in the Fitzgerald River National Park. The upper Sussetta River was cleared of native vegetation. Removal of the riparian vegetation, and the consequential rise of watertables, has impacted on the river significantly. Erosion and sedimentation have widened the river channel causing it to encroach onto farmland. Secondary salinity is scalding areas within the channel and farmland. On 'South Uberin' the northern section of the Sussetta River is in D grade foreshore condition, with little to no native vegetation. The southern section is vegetated and is in B grade foreshore condition except for salt affected areas.

The issue

The Sussetta River is a degraded river system due to removal of native riparian vegetation, erosion, sedimentation and salinisation. Prior to Terry and Linda owning 'South Uberin', the Sussetta River was unfenced and livestock had access. This was causing further degradation such as:

- weed invasion: sheep graze low, removing any germinating native vegetation and reducing competition for weeds;
- reducing natural regeneration: as for weed invasion, sheep eat any germinating native vegetation before it can become established, thus reducing the regenerating capabilities of native riparian vegetation;
- compaction of soils: sheep hooves compact the soil which restricts rainfall infiltration and increases surface water runoff;
- erosion: livestock trample the riverbanks causing erosion and increase sediment load; and
- poor water quality: livestock faeces and urine pollute the water and reduce the water quality.

The solution

Terry and Linda have fenced the entire Sussetta River that flows within their property boundaries. A total of 15 km of this fencing was funded through the Remnant Vegetation Protection Scheme and a 30-year convenant placed on 155.3 ha. A further 250 ha is protected from livestock but is not under covenant. The fencing that was not done through the RVPS was paid for by Terry and Linda.

To compliment the fencing effort, Linda has attempted revegetation within the riparian zone using seedlings. Many of the seedlings died but the remaining trees are now at different heights, with shrubs and 2–3m trees. Revegetation has also been done around salt scald on the farmland, on sandy erosion prone areas and on paddock boundaries or laneways to create shelterbelts for livestock protection.

Site facts

- Area under RVPS Covenant: 155.3 ha
- Total area fenced: 405.3 ha (approx)
- Length of RVPS Fencing: 15 kms
- Covenant ends: 1 June 2024

Outcomes and observations

Since fencing the area five years ago, regeneration of native vegetation has occurred. The area was fenced quite wide in areas, including farmland with good pasture but Linda is aware that in other areas they fenced too close to the channel and secondary salinity has encroached from within the fenced area into the farmland.

Future actions

Terry and Linda have proposed revegetation within the protected areas of the Sussetta River. Other revegetation sites include shelterbelts for livestock protection along paddock boundaries.

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Appendix 1
Macroinvertebrate species sampled as part of the AUSRIS National Rivers Health Program

Site	Date	Habitat	Taxa
ALB04	13/09/1994	CHANNEL	Branchipodidae
ALB04	13/09/1994	CHANNEL	Ceratopogonidae
ALB04	13/09/1994	CHANNEL	Chironominae *
ALB04	13/09/1994	CHANNEL	Dytiscidae
ALB04	13/09/1994	CHANNEL	Hydrophilidae
ALB04	13/09/1994	POOL ROCKS	Ceratopogonidae
ALB04	13/09/1994	POOL ROCKS	Chironominae *
ALB04	13/09/1994	POOL ROCKS	Dytiscidae
ALB04	13/09/1994	POOL ROCKS	Ephydridae
ALB04	13/09/1994	POOL ROCKS	Hydraenidae
ALB04	13/09/1994	POOL ROCKS	Hydrophilidae
ALB04	13/09/1994	POOL ROCKS	Orthocladiinae *
ALB04	04/01/1995	CHANNEL	Branchipodidae
ALB04	04/01/1995	CHANNEL	Ceratopogonidae
ALB04	04/01/1995	CHANNEL	Dytiscidae
ALB04	08/08/1995	CHANNEL	Branchipodidae
ALB04	08/08/1995	CHANNEL	Ceratopogonidae
ALB04	08/08/1995	CHANNEL	Chironominae *
ALB04	08/08/1995	CHANNEL	Dytiscidae
ALB04	08/08/1995	CHANNEL	Hydrophilidae
ALB04	08/08/1995	CHANNEL	Orthocladiinae *
ALB04	08/08/1995	POOL ROCKS	Branchipodidae
ALB04	08/08/1995	POOL ROCKS	Ceratopogonidae
ALB04	08/08/1995	POOL ROCKS	Dytiscidae
ALB04	08/08/1995	POOL ROCKS	Ephydridae
ALB04	08/08/1995	POOL ROCKS	Orthocladiinae *
ALB04	07/12/1995	CHANNEL	Branchipodidae
ALB04	07/12/1995	CHANNEL	Ceratopogonidae
ALB05	13/09/1994	CHANNEL	Chironominae *
ALB05	13/09/1994	CHANNEL	Dytiscidae
ALB05	13/09/1994	CHANNEL	Hydrophilidae
ALB05	13/09/1994	CHANNEL	Leptoceridae
ALB05	13/09/1994	POOL ROCKS	Chironominae *
ALB05	13/09/1994	POOL ROCKS	Culicidae
ALB05	13/09/1994	POOL ROCKS	Dytiscidae
ALB05	13/09/1994	POOL ROCKS	Ephydridae
ALB05	13/09/1994	POOL ROCKS	Hydrobiidae
ALB05	13/09/1994	POOL ROCKS	Hydrophilidae
ALB05	13/09/1994	POOL ROCKS	Leptoceridae
ALB05	08/08/1995	CHANNEL	Branchipodidae

Site	Date	Habitat	Taxa
ALB05	08/08/1995	CHANNEL	Ceratopogonidae
ALB05	08/08/1995	CHANNEL	Chironominae *
ALB05	08/08/1995	CHANNEL	Culicidae
ALB05	08/08/1995	CHANNEL	Dytiscidae
ALB05	08/08/1995	CHANNEL	Ephydridae
ALB05	08/08/1995	CHANNEL	Hydrophilidae
ALB05	08/08/1995	CHANNEL	Orthocladiinae *
ALB05	08/08/1995	POOL ROCKS	Chironominae *
ALB05	08/08/1995	POOL ROCKS	Culicidae
ALB05	08/08/1995	POOL ROCKS	Dytiscidae
ALB05	08/08/1995	POOL ROCKS	Ephydridae
ALB05	08/08/1995	POOL ROCKS	Hydrobiidae
ALB05	08/08/1995	POOL ROCKS	Hydrophilidae
ALB05	08/08/1995	POOL ROCKS	Orthocladiinae *
ALB05	07/12/1995	CHANNEL	Chironominae *
ALB05	07/12/1995	CHANNEL	Dytiscidae
ALB05	07/12/1995	CHANNEL	Hydrophilidae
ALB05	07/12/1995	CHANNEL	Oniscidae
ALB12	07/01/1995	CHANNEL	Ceinidae
ALB12	07/01/1995	CHANNEL	Chironominae *
ALB12	07/01/1995	CHANNEL	Coenagrionidae
ALB12	07/01/1995	CHANNEL	Dytiscidae
ALB12	07/01/1995	CHANNEL	Hydrobiidae
ALB12	07/01/1995	CHANNEL	Hydrophilidae
ALB12	07/01/1995	CHANNEL	Leptoceridae
ALB12	07/01/1995	CHANNEL	Lestidae
ALB12	07/01/1995	CHANNEL	Palaemonidae
ALB12	07/01/1995	CHANNEL	Stratiomyidae
ALB12	07/01/1995	CHANNEL	Tanypodinae *
ALB12	07/01/1995	CHANNEL	Oligochaete indeterm.
ALB12	07/08/1995	CHANNEL	Ceinidae
ALB12	07/08/1995	CHANNEL	Chironominae *
ALB12	07/08/1995	CHANNEL	Culicidae
ALB12	07/08/1995	CHANNEL	Dytiscidae
ALB12	07/08/1995	CHANNEL	Hydrophilidae
ALB12	07/08/1995	CHANNEL	Leptoceridae
ALB12	07/08/1995	CHANNEL	Tanypodinae *

Site	Date	Habitat	Taxa
ALB12	07/08/1995	RIFFLE	Ceinidae
ALB12	07/08/1995	RIFFLE	Ceratopogonidae
ALB12	07/08/1995	RIFFLE	Chironominae *
ALB12	07/08/1995	RIFFLE	Dytiscidae
ALB12	07/08/1995	RIFFLE	Palaemonidae
ALB12	07/12/1995	CHANNEL	Chironominae *
ALB12	07/12/1995	CHANNEL	Dytiscidae
ALB12	07/12/1995	CHANNEL	Hydrophilidae
ALB12	07/12/1995	CHANNEL	Leptoceridae
ALB12	07/12/1995	CHANNEL	Stratiomyidae
ALB12	07/12/1995	CHANNEL	Tanypodinae *
ALB12	07/12/1995	CHANNEL	Oligochaete indeterm.
ALB12	16/10/1997	CHANNEL	Ceinidae
ALB12	16/10/1997	CHANNEL	Chironominae *
ALB12	16/10/1997	CHANNEL	Dytiscidae
ALB12	16/10/1997	CHANNEL	Ephydridae
ALB12	16/10/1997	CHANNEL	Hydrophilidae
ALB12	16/10/1997	CHANNEL	Leptoceridae
ALB12	16/10/1997	CHANNEL	Stratiomyidae
ALB12	16/10/1997	CHANNEL	Tanypodinae *
ALB12	16/10/1997	CHANNEL	Oligochaete indeterm.
ALB23	15/10/1997	CHANNEL	Chironominae *
ALB23	15/10/1997	CHANNEL	Coenagrionidae
ALB23	15/10/1997	CHANNEL	Dytiscidae
ALB23	15/10/1997	CHANNEL	Leptoceridae
ALB23	15/10/1997	CHANNEL	Pyralidae
ALB23	15/10/1997	CHANNEL	Acarina indeterminate
ALB23	15/10/1997	CHANNEL	Oligochaete indeterm.
ALB24	16/10/1997	CHANNEL	Ceratopogonidae
ALB24	16/10/1997	CHANNEL	Chironominae *
ALB24	16/10/1997	CHANNEL	Culicidae
ALB24	16/10/1997	CHANNEL	Dolichopodidae
ALB24	16/10/1997	CHANNEL	Dytiscidae
ALB24	16/10/1997	CHANNEL	Hydraenidae
ALB24	16/10/1997	CHANNEL	Hydrophilidae
ALB24	16/10/1997	CHANNEL	Stratiomyidae
ALB24	16/10/1997	CHANNEL	Tanypodinae *
ALB24	16/10/1997	CHANNEL	Tipulidae

Appendix 2

Useful references on weed management

(Source: Hussey et al, 1997)

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Land and Water Resources Research and Development Corporation, Canberra.

District Agriculture Protection Officer located at Agriculture Western Australia, Jerramungup.