Government of **Western Australia**
Department of **Water**

Foreshore and channel assessment of Monjerducking Gully

Water resource management series
Looking after all our water needs

Report no. WRM 53
March 2009

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Department of Water

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- Kate Gole (Department of Water, Northam) for her assistance during the preparation of the survey, development of the Microsoft Access database, advice and report editing
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Cover photo: River reach, Monjerducking Gully

Unless otherwise stated, all photographs taken by Lucy Sands.

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The foreshore and channel assessment of Monjerducking Gully provides detailed information on the current condition of this waterway and highlights the issues and areas that require specific management.

Monjerducking Gully is a braided waterway which has intermittent peak flows, usually as a result of a large rainfall event. At other times it has minimal flow and is dry throughout the summer months, unless there is a summer storm. Typical of a braided waterway, it also has a high width to depth ratio and carries a high coarse sediment load, which lines the bed of the entire waterway and its tributaries.

This high coarse sediment load can be attributed to extensive catchment clearing. Catchment clearing has also increased the rate of salinisation in this catchment, although it is difficult to quantify the extent as little monitoring data exists for this waterway. However, extensive salt scalding, numerous tree deaths in the floodplain and reports from landowners all suggest the problem is becoming worse.

Some local landowners are obviously aware of the threats to this waterway and catchment and have been actively fencing and revegetating the waterway for more than 20 years. These sections were rated to be in the best condition and are a credit to their managers. There is also passion and commitment from newer landowners to improve the condition of their section of the waterway.

There are some sections of Monjerducking Gully that require immediate management to protect adjacent farmland from erosion and prevent downstream impacts. Rubbish was evident in some sections and could easily be washed downstream during peak flows. Lateral erosion of the channel is a severe problem in other sections and left untreated will continue to worsen and impact upon downstream landowners.

This report makes general and specific recommendations to improve the health of Monjerducking Gully, and it is hoped these will engage landowners' interest and stimulate action to protect this valuable asset.

1 Introduction

Foreshore and channel assessments have been completed for a number of waterways in the Avon River catchment, including the nearby Mackie River (Water and Rivers Commission, 2001). These assessments are designed to provide a consistent approach to collecting baseline information to assist in future management of these waterways.

The purpose of the assessment was to collect information on current condition, health, past and current management practices and disturbance factors relating to Monjerducking Gully; and to identify priority areas for management and provide landowners, the community and organisations including the Department of Water and the Avon Catchment Council with the information required to manage this waterway effectively.

2 Description of Monjerducking Gully

2.1 Location, land use and tenure

Monjerducking Gully is located approximately 20 km south-east of the town of Beverley, in the Avon River catchment, which is a significant subcatchment of the Avon River basin. Monjerducking Gully flows in a south-westerly direction towards its confluence with the Avon River, near the Yenyening Lakes Road, within the Shire of Beverley. Map 1 shows the location of Monjerducking Gully in relation to the Avon River catchment.

The main channel of Monjerducking Gully flows through privately owned land holdings, some of which are hobby farms. The majority of the catchment has been cleared for agricultural activities, including stock grazing and/or cropping. There are a number of properties around the middle reaches that have large plantations of sandalwood (*Santalum spicatum)* and jam (*Acacia acuminata*), which appears to be gaining popularity in the region.

2.2 Landform and soils

The Avon River catchment has three distinct drainage zones. Monjerducking Gully lies within the zone of rejuvenated drainage. This zone includes the land between the Darling Range to the west, and the Meckering Line to the east.

This zone is characterised by a more undulating landscape than the zone of ancient drainage (which encompasses much of the central and eastern Wheatbelt) with defined drainage lines that flow every winter. The average annual rainfall within the zone ranges from 375 mm in the east to 550 mm in the western part of the zone (Lantzke & Fulton, undated).

Monjerducking Gully is characterised by gently undulating hills and relatively broad valley floors, which narrow towards its headwaters.

2.3 Climate

The Monjerducking Gully catchment has a Mediterranean climate, characterised by hot, dry summers and cool, wet winters. The closest, most representative, weather station is located at Beverley, approximately 20 km north-west of the waterway.

At this station, average yearly rainfall is 420 mm, with June and July being the wettest months and December the driest (Table 1).

Table 1 Average monthly and annual rainfall for Beverley
(Australian Bureau of Meteorology, 2007)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
Average rainfall (mm)	12	13	16	24	54	80	78	60	36	24	15	10	420

2.4 Historical water monitoring

There is limited water quality data available for Monjerducking Gully as no stream gauging station exists on this waterway. Water quality data is limited to two snapshot samples taken in September 2006 and 2007 at Yenyening Lakes Road, which is approximately 900 metres upstream from its confluence with the Avon River. These results are provided in Table 2. These snapshot results indicate that, at the time of sampling, the water quality in Monjerducking Gully was highly saline (Table 3).

Table 2 Snapshot results for Monjerducking Gully
(Source: Department of Water, 2008a)

Year	pH	Electrical conductivity (mS/m)	Salinity classification	Total phosphorus (mg/L)	Phosphorus classification	Total nitrogen (mg/L)	Nitrogen classification
2006	8.32	3 616	Highly saline	0.96	Low	0.027	Low
2007	8.36	3 437	Highly saline	Not sampled	NA	Not sampled	NA

Table 3 Salinity classification table

Classification 1	mg/L 1	mS/m 2	grains/gallon 2
Fresh	0 – 500	0 – 91	0 – 35
Marginal	500 –1 000	91 – 182	35 – 70
Brackish	1 000 – 2 000	182 – 364	70 – 140
Moderately saline	2 000 – 5 000	364 – 909	140 – 350
Saline	5000 – 10 000	909 – 1 818	350 – 700
Highly saline	10 000 – 35 000	1 818 – 6 363	700 – 2 450
Brine	>35 000	>6 363	>2 450
Sea water	35 000	6 363	2 450

[1] *Mayer, Ruprecht, Bari, 2005*

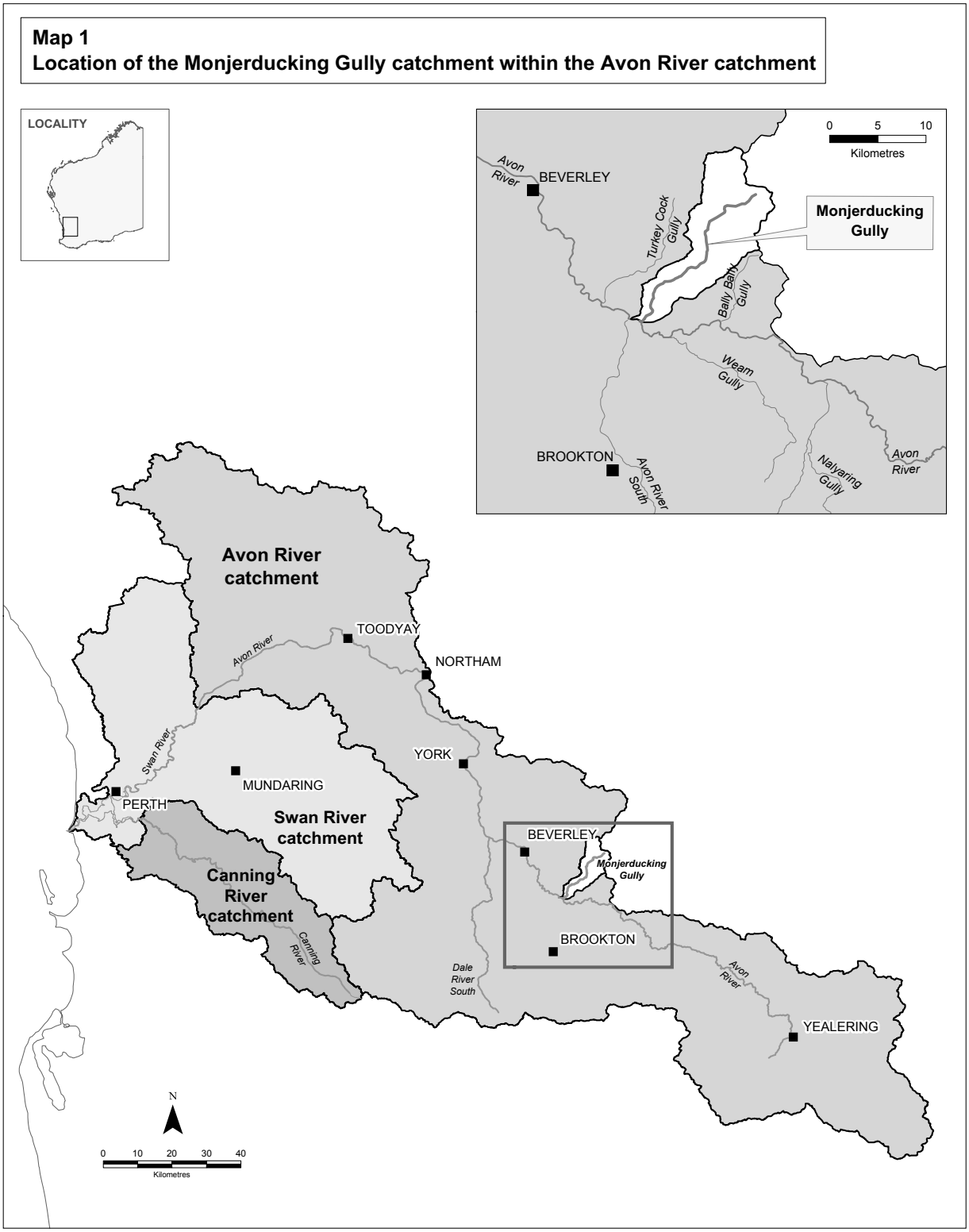
[2] *Department of Fisheries (2008)*

2.5 Tributaries

There are 19 tributaries flowing into Monjerducking Gully. Of these, eight are considered to be major tributaries. Major tributaries were determined initially from aerial photography based on their approximate catchment area. These preliminary observations were then confirmed by field observations of channel width and depth and flow discharge.

The remaining 11 are minor tributaries that flow intermittently during rainfall events, capturing overland flow. One of the major tributaries is known locally as Parson's Gully (MDTrib001).

Map 1
Location of the Monjerducking Gully catchment within the Avon River catchment



Legend

- Towns
- Watercourses
- Monjerducking catchment boundary

SOURCES

The Department acknowledges the following datasets and their Custodians in the production of this map:

Hydrography, Linear (heirarchy) - DOW - 2006
Hydrography, Linear (heirarchy) - WRC - 2003
Hydrography Subcatchments - DOW - 2007
Towns - DLI - 2001

Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50

Project Information
Requestee: Kate Gole
Map Author: Hamish Wallace
Task ID: 6951
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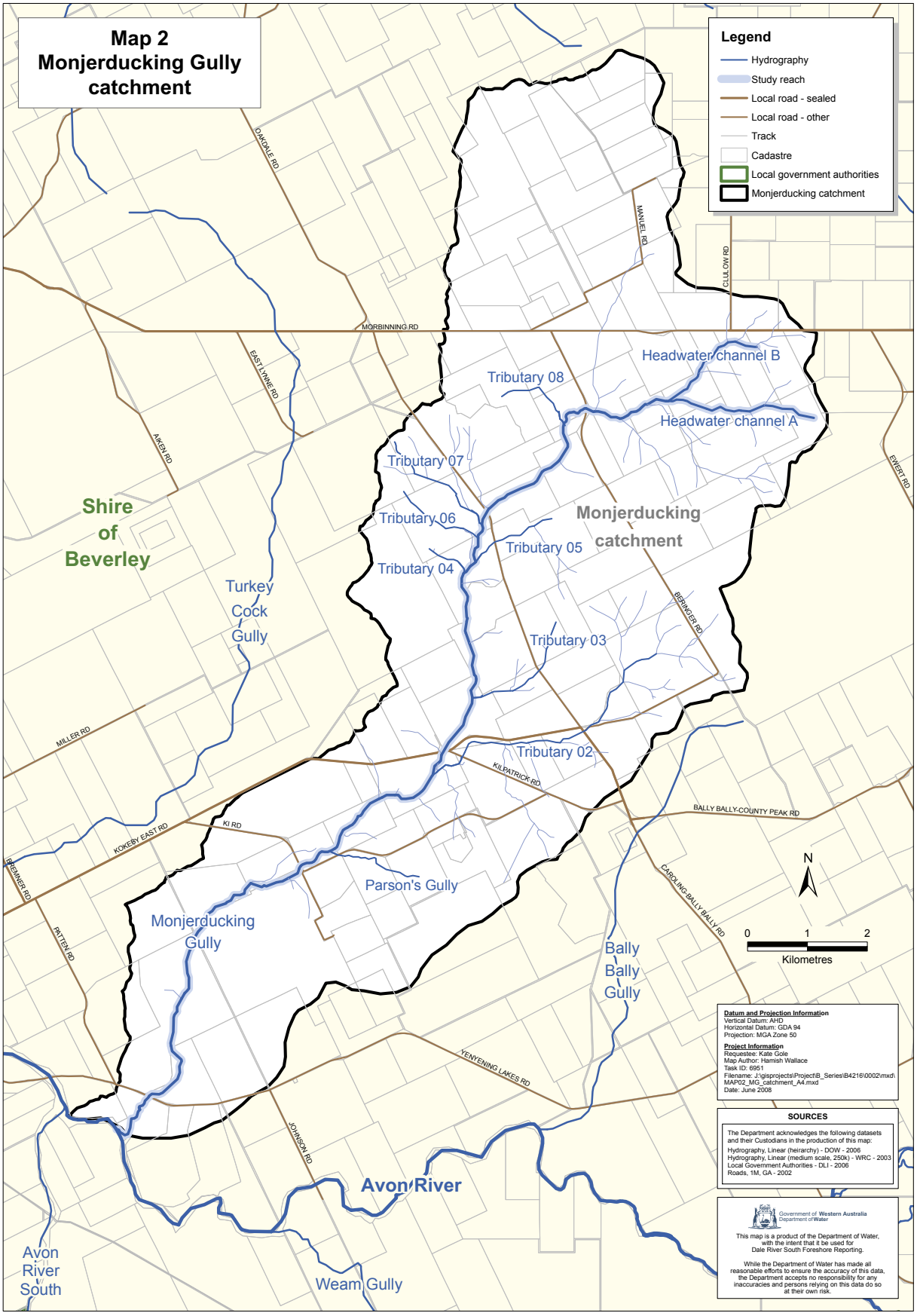
Date: June 2008

Government of Western Australia
Department of Water

This map is a product of the Department of Water, with the intent that it be used for Monjerducking Gully Foreshore Reporting.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.


Map 2
Monjerducking Gully catchment
Legend
Hydrography
Study reach
Local road - sealed
Local road - other
Track
Cadastre
Local government authorities
Monjerducking catchment
Shire of Beverley
Monjerducking catchment
Headwater channel B
Headwater channel A
Tributary 08
Tributary 07
Tributary 06
Tributary 05
Tributary 04
Tributary 03
Tributary 02
Turkey Cock Gully
Parson's Gully
Monjerducking Gully
Bally Bally Gully
Avon River
Avon River South
Weam Gully
MORBINNING RD
DAKOALE RD
EAST LYNNE RD
AMEN RD
MANUEL RD
CULLOW RD
EWERT RD
BERINGER RD
MILLER RD
KILPATRICK RD
KOKEBY EAST RD
KI RD
BREMNER RD
PATTEN RD
BALLY BALLY-COUNTY PEAK RD
CAROLING-BALLY BALLY RD
YENYENING LAKES RD
JOHNSON RD
N
0 1 2
Kilometres
Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
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Date: June 2008
SOURCES
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Hydrography, Linear (heirarchy) - DOW - 2006
Hydrography, Linear (medium scale, 250k) - WRC - 2003
Local Government Authorities - DLI - 2006
Roads, 1M, GA - 2002
Government of Western Australia
Department of Water
This map is a product of the Department of Water, with the intent that it be used for Dale River South Foreshore Reporting.
While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

3 Foreshore and channel assessment method

3.1 Focus of the foreshore and channel assessment

The assessment looked at the condition of the foreshore and channel areas of the Monjerducking Gully floodplain. Figure 1 shows a cross section of a typical waterway in the Avon River catchment and the terms used to describe it. Definitions of the floodplain, floodway and verge can be found in the glossary.

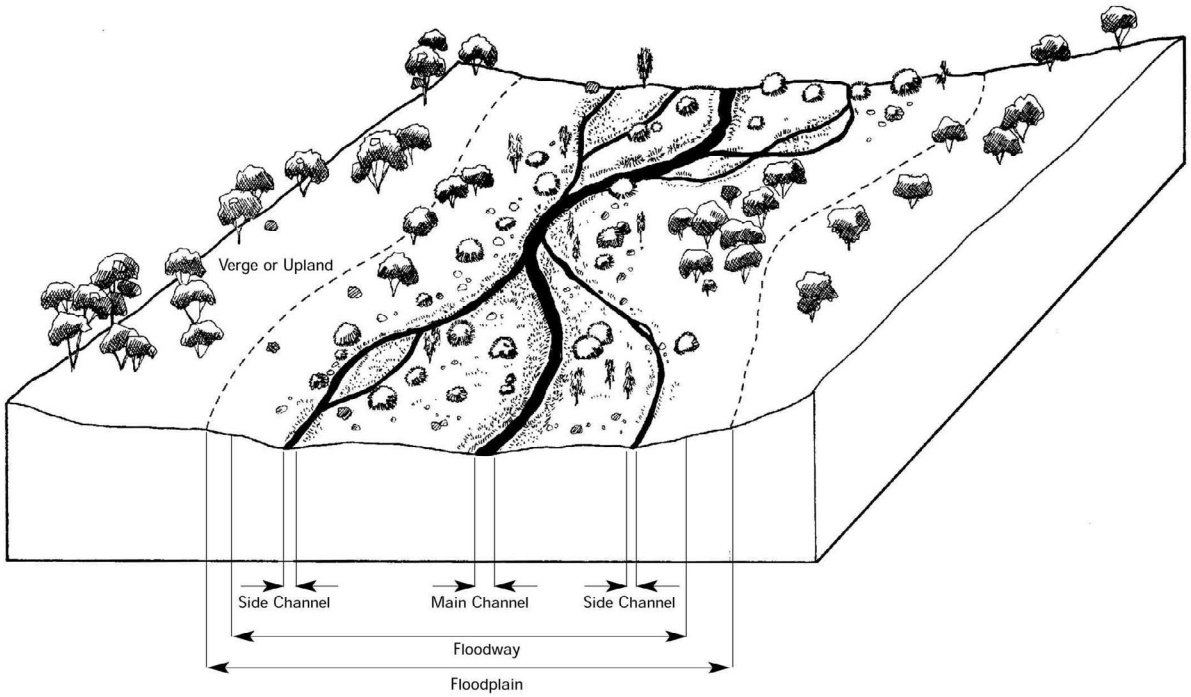


Figure 1 Cross sectional representation of a typical waterway of the Avon catchment (Water and Rivers Commission, 2003)

3.2 Survey preparation

Prior to undertaking the foreshore and channel assessment, a letter was sent to landowners along Monjerducking Gully explaining the purpose of the field assessment. Before the assessment, each landowner was contacted by phone to gain access to the waterway.

Landowners were invited to be present during the assessment to better understand the assessment process and provide information on historical recreational use, waterway features and past and current river management practices.

The foreshore and channel assessment was planned using 1:30 000 cadastre maps and 1:10 000 aerial photographs. These maps were used to identify roads, property boundaries, fence lines, tributaries and significant landforms that helped to plan approximate survey sections, which were later confirmed during the assessment.

3.3 Foreshore and channel assessment method

The current foreshore and channel assessment method used in the Avon River catchment has been adapted by the Department of Water from the *Stream foreshore assessment for farming areas* developed by Pen and Scott (1995). The method, as it was applied to Monjerducking Gully, is described below and it is also detailed in *Foreshore and channel assessment in the Avon River catchment* (Department of Water, 2007).

3.3.1 Definition of survey sections

The foreshore and channel assessment of Monjerducking Gully commenced at its confluence with the Avon River, walking towards its headwaters. Both banks were assessed and the left and right banks were determined by facing upstream.

The river was divided up into 26 sections, although section MD003 was unable to be assessed. The start and end points of each section were usually defined by paddock boundaries.

The headwaters of Monjerducking Gully split into two distinct branches, one extending to the south-east and the other to the north-east. These are referred to as headwater channel A and headwater channel B (Map 2).

In addition to the 25 sections assessed in the main channel, eight significant tributaries were also assessed (Map 2).

3.3.2 Foreshore and channel assessment form

To standardise the collection of field data for each survey section, the following information was recorded on the foreshore and channel assessment form (Appendix 1):

- bank stability and erosion (see section 3.3.3)
- waterway form and features (section 3.3.4)
- vegetation health, including identification of native and weed species (section 3.3.5)
- habitat quality and diversity, including identification of native and introduced fauna (section 3.3.6)
- water quality (section 3.3.7)

- fence condition and stock access (section 3.3.8)
- foreshore condition grade (section 3.3.9)
- overall stream health rating (section 3.3.10)
- management issues, evidence of management and management recommendations (section 3.3.11).

A photographic record was also taken during the assessment. Some of these photographs are included in this report. The remainder are on file at the Department of Water, Northam.

3.3.3 Bank stability

Erosion is a naturally occurring process even in pristine waterways. However, in waterways that are in good condition erosion is generally present only on meander bends. Badly eroded banks and sediment slugs indicate poor waterway condition and result from a lack of fringing vegetation to protect and stabilise banks, and trampling of banks by livestock.

During the survey, bank stability was assessed by observing the proportion of the banks within each survey section affected by erosional processes, including undercutting, firebreak and track washout, subsidence, gully erosion, sedimentation and slumping (Table 4).

Table 4 Rating system used to determine bank stability

Percentage of river bank affected	Rating
0–5%	Minimal
5–20%	Localised
20–50%	Significant
>50%	Severe

These processes are explained on following pages and some are illustrated by photos 1 and 2. Photo 1 shows a section of Monjerducking Gully where undercutting is occurring as a result of the channel incising (becoming deeper). Photo 2 shows the process of sedimentation, where weeds have colonised the unstable sand bar which has formed within the channel. In contrast, photo 3 shows a well-vegetated, stable channel on a downstream section of the gully.

Photo 1 Bank undercutting on Monjerducking Gully

Photo 2 Sediment bar colonised by weeds in the braided channel of Monjerducking Gully

*Photo 3 Stable banks well vegetated with samphire (*Halosarcia sp.*) on a downstream section of Monjerducking Gully*

Undercutting occurs on vertical banks where an increase in flow velocity causes the channel to incise. The scouring action of the water against the banks causes mobilisation of sediment, resulting in the banks becoming undercut. Eventually the undercut bank, with no support from below, will collapse. This process is called slumping. Subsidence is another form of bank collapse where flows saturate banks and cause them to collapse under the added weight of the water (Pen, 1999).

Washouts occur where sandy soils are exposed on the floodplain, usually along tracks and firebreaks. During floods these areas are scoured out and the scour grows in size with each successive flood. Washouts can also occur when the main channel becomes clogged with sediment and debris and flood flows are unable to move through the channel. Instead, flows move across the floodplain eroding vulnerable areas (Pen, 1999).

Gully erosion refers to the formation of a relatively deep channel (>30 cm) where once there was only a shallow depression. A common way gullies form is through headcutting. Headcutting is where a stream erodes upstream from a point and occurs where the slope of the channel suddenly increases. The flow velocity consequently increases, scouring the soil over the face of the slope (Pen, 1999).

Sedimentation is a process where sediments settle out of the water column in areas where the flow velocity decreases, such as on the inside of meander bends. Erosional processes cause sediments to become mobile in the water column; therefore, a waterway with unstable banks and significant erosion will often have a high level of sedimentation. Sediment can also be washed in from upstream sections, tributaries or can enter via overland flow.

3.3.4 Waterway form and features

The presence of waterway features such as deep pools, riffles, anabranches, large woody debris and wetlands provide an indication of waterway health. These waterway features provide a variety of habitats and a high occurrence indicates a generally healthy waterway. Features such as dams, sediment slugs, bridges and crossings are often present as a result of human use or disturbance and may relate to poor waterway health.

The presence of the following natural and constructed waterway features in each survey section were recorded:

- waterway form, including channel form, channel depth and width and the presence of vegetated islands and sediment slugs
- pools
- riffles
- large woody debris
- wetlands
- groundwater seeps
- tributaries
- constructed features such as dams, crossings and bridges.

Waterway form

Waterway form refers to the path the waterway makes over the landscape and takes into account floodplain form. Waterway form is determined by flow, sediment load, landscape gradient, soil types and vegetation.

Understanding form helps to recognise how a waterway behaves and, subsequently, how it is influenced by a variety of factors (i.e. land uses, climate change and restoration) and assists in river management (Water and Rivers Commission, 2002).

For each survey section a record was made of whether the channel was straight, braided or anabranching. As it is possible for waterway form to change within a survey section, for some sections more than one form may have been noted. Braided channels divide and rejoin around small, unstable sediment bars or islands. These small islands may be vegetated and during peak flows can be covered with water. Anabranching channels divide and converge around larger, stable islands that are inundated only during large flood events (Water and Rivers Commission, 2002).

As they are related to channel form, the presence of vegetated islands and sediment slugs within survey sections were also noted.

Pools and riffles

Pools and riffles are important waterway features, providing a variety of habitats and flow conditions within waterways. They often occur together in pool-riffle sequences, where pools form upstream and downstream of riffles.

Deep river pools provide a source of permanent water for aquatic and terrestrial fauna, particularly important in summer months when the remainder of the channel is dry.

Riffles are high points in the channel bed where water becomes turbulent as it passes over accumulated coarse material such as rocks, woody debris or pebbles. Riffles are an important waterway feature, as they provide important habitat for aquatic invertebrates and fish. Riffles also help oxygenate the water column, as the turbulent water increases its contact with the air, allowing oxygenation of the water (Pen, 1999).

The presence or absence of deep pools and natural and constructed riffles in each survey section was recorded.

Large woody debris

Large woody debris includes fallen trees, logs, branches and twigs and are also referred to as snags. Woody debris is essential to the functioning of waterways. It slows the flow of water and provides a range of flow conditions. It stabilises the bed and banks of waterways, offering protection from erosion and provides an energy source for instream food webs.

Waterways that have woody debris present are often found to have a greater number of river pools, which enable algae and submerged plants to grow. These in turn strip the water column of nutrients, thereby reducing the nutrient load being transported downstream (Water and Rivers Commission, 2000a).

The presence or absence of large woody debris in each survey section was recorded.

Wetlands/salt lakes

A wetland can be defined as an area of seasonally, intermittently or permanently inundated land and can be flowing or static and fresh, brackish or saline. Examples of wetlands include rivers, streams, lakes and swamps.

However, for the purposes of this assessment wetlands were referred to as salt lakes. Salt lakes are defined as seasonally or intermittently inundated depressions within the floodplain that tend to be connected to the main channel of Monjerducking Gully only during peak flow events, being covered with water during the peak flow and retaining water as flows subside. They also fill from local surface runoff and groundwater seeps.

Groundwater seeps

Groundwater seeps are areas where groundwater discharges at the surface. They can be located on hill slopes or in the lowest parts of the landscape – the valley floors. Where groundwater is relatively fresh, seeps can improve the quality (salinity) of streamflow; however, saline groundwater seeps can increase streamflow salinity. The presence of groundwater seeps was noted for each section.

Tributaries

Tributaries can influence downstream water quality. They can be a source of fresh or saline water and also sediment. Tributaries entering each survey section were noted.

Constructed features

The survey assessed the number of constructed features along the waterway, including dams, constructed riffles, crossings (stock and vehicle) and bridges.

3.3.5 Vegetation health

Vegetation health and structure is linked to waterway health and plays a key role in bank stability. Vegetation health and structure were assessed to identify sections of foreshore that may become unsupported in the future. A visual assessment of vegetation health was made and recorded as ‘healthy’, ‘some sick trees’, ‘many sick or dying trees’, ‘some dead trees’ or ‘many dead trees’. Vegetation structure was assessed by estimating the crown cover for each structural layer (overstorey, middlestorey and understorey). An estimation was made of the percentage of native species compared to weed species.

Native and weed species were identified. While a detailed flora survey was not undertaken, an effort was made to identify the common native and introduced species in each section to give an indication of the diversity of plant species in the riparian zone, provide a species list for future riparian revegetation projects and identify weed species impacting on riparian vegetation. Regeneration of native species was also noted.

3.3.6 Habitat quality and diversity

A wide range of aquatic and terrestrial habitats is necessary for waterways and riparian zones to support a diversity of flora and fauna species. Information was collected during the survey on whether different habitats were present, such as pools, instream rocks and logs, protected basking sites and a variety of vegetation types.

Signs and sighting of native and introduced fauna species were recorded. Recording the presence of introduced species, including sightings, tracks and scats, is undertaken to provide information for future management of the waterway. Recording of native fauna species was limited mostly to bird sightings and was undertaken to give an indication of the habitat value of the riparian vegetation along the brook.

3.3.7 Water quality

For each survey section water quality parameters, including pH, temperature and electrical conductivity (salinity) were tested using an MC81 meter. General observations were also made about turbidity (water clarity). Samples were collected at the start of each section and parameters measured immediately.

3.3.8 Fencing condition and stock access

Waterways provide stock with drinking water, shade and feed. However, stock can do enormous amounts of damage to fringing vegetation and banks and can foul water supplies. The control of livestock is the single most important management activity in the riparian zones of rural areas and the most effective way of achieving this is by fencing (Pen, 1999).

Fence condition and stock access to the riparian zone was recorded. Fence condition was recorded as follows:

- good – relatively new and expected to remain stock-proof with minor maintenance for >30 years
- moderate – fence is stock-proof but will need maintenance or replacement within 10–20 years
- poor – fence is barely stock-proof and will need to be replaced within five years
- no fence.

Photos in Appendix 2 show examples of good, moderate and poor fence condition.

Signs of stock or vehicle access, such as gates and/or stock tracks, were also recorded.

3.3.9 Foreshore condition grade

The foreshore condition grade indicates the level of waterway degradation by characterising the foreshore in terms of vegetation structure, the balance between native and weed species and bank stability. Both an overall rating and best and worst rating were recorded for each survey section.

The overall or general foreshore grade for each section was determined as the average grade along the length of the section and was recorded as A-grade (pristine) through to D-grade (eroding ditch). The best and worst grades were respectively the highest and lowest ratings determined within the section and were recorded as A1 (pristine) through to D3 (weed-infested drain). A description of each foreshore grade and sub-grade is provided below and a diagram of the four grades is presented in Appendix 3.

A-grade foreshore

For a section to be rated as A-grade, the riparian zone must be vegetated entirely with native species (Photo 4). Some weeds may be present but native species still dominate the understorey and there is little or no evidence of disturbance from human activities or introduced animals. This general rating is further divided to reflect the level of weed invasion and disturbance.

Rating	Key features
A1 Pristine	The river embankments and floodway are vegetated entirely with native species and there is no evidence of human presence or livestock damage
A2 Near pristine	Native vegetation dominates. Some introduced weeds may be present in the understorey but not as the dominant species. Otherwise, there is no evidence of human impact
A3 Slightly disturbed	Native vegetation dominates, but there are some areas of human disturbance where soil may be exposed and there are local weed infestations along tracks. Native vegetation would quickly recolonise if human disturbance declined

B-grade foreshore

A general B-grade foreshore rating is given to sections where the majority of the vegetation structure is intact, but where the understorey has been invaded by weeds (Photo 5). The sub-grades are divided based on the level of weed invasion and its effect on the regeneration of some shrubs and trees.

Rating	Key features
B1 Degraded – weed infested	Weeds have become a significant component of the understorey vegetation. Native species are still dominant but a few have been replaced by weeds
B2 Degraded – heavily weed infested	Understorey weeds are nearly as abundant as native species. The regeneration of trees and large shrubs may have declined
B3 Degraded – weed dominant	Weeds dominate the understorey, but many native species remain. Some trees and large shrubs may have disappeared

C-grade foreshore

A C-grade foreshore rating indicates that the foreshore supports only trees over weeds or pasture (Photo 6). As a result of the dominance of weeds in the understorey, bank erosion and subsidence occur in localised areas. The sub-grades for this rating are divided based on the amount of ground cover provided by weeds and the susceptibility of the banks to erosion.

Rating	Key features
C1 Erosion prone	Trees remain with some large shrubs and the understorey consists entirely of weeds (i.e. annual grasses). There is little or no evidence of regeneration of tree species. River embankment and floodway are vulnerable to erosion due to the shallow-rooted weedy understorey providing minimal soil stabilisation and support
C2 Soil exposed	Older trees remain but the ground is virtually bare. Annual grasses and other weeds have been removed by livestock grazing and trampling or through human use and activity. Low level soil erosion has begun
C3 Eroded	Soil is washed away from between tree roots. Trees are being undermined and unsupported embankments are subsiding into the river valley

D-grade foreshore

A D-grade foreshore rating indicates that there is not enough remaining vegetation to control erosion and the waterway is little more than an eroding ditch or weed-infested drain (Photo 7). Sub-grades are determined by the amount of vegetation present and the severity of erosion.

Rating	Key features
D1 Ditch – eroding	There is not enough fringing vegetation to control erosion. Remaining trees and shrubs act to impede erosion in some areas, but are doomed to be undermined eventually
D2 Ditch – freely eroding	No significant fringing vegetation remains and erosion is out of control. Undermined and subsided embankments are common. Large sediment plumes are visible along the river channel
D3 Drain – weed dominant	The highly eroded river valley has been fenced off, preventing control of weeds by stock. Perennial weeds have become established and the river has become a simple drain

Photo 4 An A-grade reach of a tributary of Christopher Brook in the Dale River catchment (note the well vegetated channel along the right hand side and an absence of weeds)

*Photo 5 A B-grade reach of Monjerducking Gully (note the high occurrence of native species, including samphire (*Halosarcia spp.*) but also the dominance of weeds in the understorey)*

Photo 6 A C-grade reach of Monjerducking Gully (weeds dominate the understorey and the exposed banks are susceptible to erosion)

Photo 7 A D-grade reach of Monjerducking Gully (very little vegetation remains and the banks are heavily eroded)

3.3.10 Overall environmental stream health rating

Each section was given an overall environmental stream health rating to give an indication of stream health based on an assessment of the quality and diversity of riparian zone habitats.

The overall environmental stream health rating for each section was based on an assessment of the following factors:

- floodway and bank vegetation
- verge vegetation
- stream cover
- bank stability and sedimentation
- habitat diversity
- surrounding land use.

Each of the factors (with the exception of land use) was rated from excellent to poor (Table 5) and a numerical score for each factor was determined. Scores were weighted to give more importance to those factors, such as shade and permanent water, which are more important to stream health. The overall environmental stream health rating was then derived from the summation of the individual scores (Appendix 4).

A rating of excellent indicates a healthy stream that has all three vegetation layers (understorey, middlestorey and upperstorey) present, providing a variety of habitat types, shade and protection to the banks from erosion. On the other end of the scale, a rating of ‘very poor’ indicates an unhealthy stream that is highly degraded, with little or no vegetation, little habitat value and continuous bank erosion and sedimentation.

Table 5 Scores for the stream health rating

Score	Rating
40–55	Excellent
30–39	Good
20–29	Moderate
10–19	Poor
0–9	Very poor

3.3.11 Management issues

Management issues, including fire risk, weed invasion, erosion, salinity, stock access and rubbish dumping, were identified for each survey section. These were prioritised (high, medium or low) for action. Any management undertaken by landowners, such as fencing and revegetation, were also noted and further management suggestions are given.

3.4 Information analysis

On completion of the assessment, the results were entered into a Microsoft Access database. The database has been designed and created by the Department of Water to record data from multiple foreshore and channel assessments for analysis and interpretation to assist in future river management.

Queries run in Microsoft Access were then analysed in Microsoft Excel to provide the results presented in chapter 4.

4 Findings from the Monjerducking Gully foreshore survey

This chapter presents the results from the foreshore survey and a discussion of their meaning.

4.1 Bank stability

Due to the mobile nature of sediment within Monjerducking Gully, sedimentation was rated as significant in 40 per cent and severe in 56 per cent of sections (Table 6). Although high levels of sedimentation are characteristic of braided systems, the Monjerducking Gully catchment has been extensively cleared, resulting in continual excess quantities of sediment being transported into this waterway from surrounding paddocks via overland flow and also from erosion in the main channel and tributaries.

The fringing vegetation along Monjerducking Gully has also been cleared or degraded by agricultural activities. Although there have been significant efforts by some landowners to revegetate sections, there are other sections that are completely void of fringing vegetation and continue to supply excess sediment and high-velocity flows to downstream reaches.

Pristine braided waterways typically have relatively unstable floodplains that change constantly (Water and Rivers Commission, 2002). The absence of fringing vegetation in these systems leads to significant lateral erosion, which in agricultural areas can consume adjacent farmland. This is evident in the middle reaches of Monjerducking Gully where the channel and floodplain appear to have been cleared for some time. In these sections, the channel is up to 80 metres wide. The sandy banks are constantly being eroded with every flow event and the floodplain has been consumed by the channel (Photo 8). Significant restoration management efforts are required to control this lateral erosion and reduce adverse impacts on downstream sections.

Undercutting, and to a lesser extent slumping, were the main forms of bank instability along Monjerducking Gully. Undercutting was evident in sections where there was little to no fringing vegetation and the banks were exposed to the erosive capacity of high, variable flows. Undercutting was localised in 64 per cent, significant in 20 per cent and severe in four per cent of sections in the main channel. Slumping was localised in 56 per cent and significant in 12 per cent of sections and occurred mainly where the banks had been undercut and eventually slumped into the channel, contributing more sediment to the channel.

The tributaries also had high sediment loads with 50 per cent having significant and 50 per cent severe sedimentation (Table 7). Undercutting was localised in 50 per cent and significant in 25 per cent of tributaries. Similarly to the main channel, this has been caused by a lack of fringing vegetation.

Photo 8 The absence of fringing vegetation has resulted in severe lateral erosion in the middle reaches of Monjerducking Gully. Unrestricted stock access is also evident in this photograph.

Table 6 Percentage (%) of sections rated under each bank stability rating in the main channel (total number of survey sections = 25)

Rating	Erosion process					
	Undercutting	Track washout	Subsidence	Gully erosion	Sedimentation	Slumping
Minimal	12	64	80	88		32
Localised	64	36	16	8	4	56
Significant	20		4		40	12
Severe	4				56	

** Refer to section 3.3.3 for descriptions of the bank stability ratings*

Table 7 Percentage (%) of sections rated under each bank stability rating in tributary sections (total number of survey sections = 8)

Rating	Erosion process					
	Undercutting	Track washout	Subsidence	Gully erosion	Sedimentation	Slumping
Minimal	25	75	75	88		38
Localised	50	25	25	12		50
Significant	25				50	12
Severe					50	

** Refer to section 3.3.3 for descriptions of the bank stability ratings*

4.2 Waterway form and features

A summary of the waterway features observed along Monjerducking Gully is provided in Table 8.

Table 8 Summary of waterway features for Monjerducking Gully and its tributaries

Waterway feature	**Percentage (%) of sections on main channel with feature present** (n=25*)	**Percentage (%) of sections on assessed tributaries with feature present** (n=8*)
Waterway form		
Single channel	76	100
Braided channel	48	13
Anabranch	24	0
Vegetated island	8	0
Sediment slugs	88	75
Natural features		
Deep pool	8	38
Natural riffle	12	13
Large woody debris	76	63
Salt lakes/wetlands	32	0
Groundwater seep	16	0
Tributary	44	13
Constructed features		
Constructed riffles	8	13
Crossing	32	38
Dam	8	13
Bridge	20	0

** n denotes total number of survey sections*

4.2.1 Waterway form

Monjerducking Gully is best described as a braided waterway. The dominant soil types in the area are coarse sands, so the waterway has an abundant supply of coarse sandy material that rolls along the bed. Sediment deposits in areas of low flow velocity to create bars or islands, which are often colonised by weeds or samphire (*Halosarcia sp.*)

Characteristic of braided systems, Monjerducking Gully has an intermittent (or flashy) flow regime with peak flows occurring after high rainfall events. Local landowners commented that the waterway flows actively after rainfall events but only for a short period, after which it subsides to a trickle.

Anabranches occur in 24 per cent of sections, although they are more common in the middle reaches (Photo 9). Many of these anabranches are still connected to the main channel, although they would only receive water during high flow events.

Anabranches that are connected to the main channel during high flow or flood events serve an important hydrological and ecological function. In drier months, these side channels are similar to the rest of the floodplain and are important for nutrient cycling and provision of habitat (Department of Water, 2006). Anabranches that are connected to the main channel provide an important source of carbon and energy from organic matter to the waterway during peak flow or flood events.

Photo 9 An anabranch in the middle reach of Monjerducking Gully

Monjerducking Gully has a high width to depth ratio, which is characteristic of braided systems. The majority of the channel was between 10 to 25 metres wide and less than one metre deep, with the exception of the upper reaches (sections MD21 to MD26), where the channel narrowed considerably.

4.2.2 Pools and riffles

Pools and riffles are important waterway features, providing a variety of habitats and flow conditions within waterways. However, due to their mobile sediment load and flashy flows, braided river systems do not exhibit the traditional pool-riffle sequence, which is common among waterways in the higher rainfall zones of the south-west of Western Australia.

Therefore, Monjerducking Gully has very few pools or riffles. In fact, during the time of the survey (November 2007), there was only one deep pool in the middle reaches which contained water. There were some smaller pools in the upper reaches where the channel narrows but these were dry, providing limited opportunities for aquatic habitat.

Although there are few pools and riffles found in this waterway, there are other important habitats present which are more typical of braided systems including well-vegetated areas of the floodplain, salt lakes and anabranches (refer to section 4.4.1).

4.2.3 Salt lakes

Salt lakes were found along 32 per cent of sections of the main channel of Monjerducking Gully, mostly in the lower to middle sections of the waterway. None were observed along the tributaries. These wetlands were referred to as salt lakes during the assessment.

These salt lakes had high salinity levels, indicated by numerous tree stags (dead trees) and salt scalds on the surface.

4.2.4 Tributaries

The major tributaries of Monjerducking Gully were assessed as part of this survey and the results have been analysed and discussed in the relevant sections of this report. The locations of the surveyed tributaries are shown on maps 2, 3, 4 and 5. Table 9 summarises the significant threats and assets of these tributaries.

Table 9 Tributaries with significant threats or assets

Tributary	Threat(s)	Asset(s)/features
MDTrib001	• Limited fringing vegetation upstream of K1 Road • Significant weed infestation	

Tributary	Threat(s)	Asset(s)/features
MDTrib002	• Significantly eroded and channel becoming incised • Little to no fringing vegetation • Salt scalding evident in middle reaches • Catchment largely cleared	• Actively being revegetated where it runs parallel to East Kokeby Road • Longest tributary of Monjerducking Gully
MDTrib003	• Extensively cleared, minimal fringing vegetation remaining • Salt scalding evident in headwaters • Catchment largely cleared	
MDTrib004	• Salt scalding evident in headwaters	• Small tributary but is fenced as part of a 10 year old revegetated area
MDTrib005	• Salt scalding evident along most of the tributary • Catchment largely cleared	• 500m of the tributary is fenced and revegetated
MDTrib006	• Salt scalding evident in headwaters and adjacent paddocks • Catchment largely cleared	• Small tributary but lower reaches are in reasonable health due to being fenced as part of a 10 year old revegetated area • Small pool observed in revegetated area
MDTrib007	• Salt scalding evident in headwaters and adjacent paddocks • Catchment largely cleared	• Small tributary that is partially fenced as part of a 10 year old revegetated area
MDTrib008	• Significant salt scalding evident in lower to middle reaches • Catchment largely cleared	• Partially fenced and revegetated upstream of Morbining Road • Large tributary – headwaters include a large block of remnant vegetation

4.2.5 Large woody debris

Monjerducking Gully had a high percentage of sections in the main channel (76 per cent) and tributaries (63 per cent) with woody debris present. However, with the exception of the B-grade sections (MD01, MD04, MD14, MD25), the total amount of woody debris in these sections was limited to a few large branches or trees that have succumbed to erosion or salinisation and fallen into the channel.

There were no instances where woody debris was causing an increased flood risk.

4.2.6 Constructed features

The survey assessed the number of constructed features along the waterway including dams, constructed riffles, crossings and bridges.

There are five roads that cross Monjerducking Gully, including the only sealed road – Kokeby East Road. These roads are:

- Yenyening Lakes Road (six box-culverts)
- K1 Road (five box-culverts)
- Kokeby East Road (six pipe culverts)
- Caroling–Bally Bally Road (bridge)
- Beringer Road (three pipe culverts)
- farm access road (three pipe culverts).

In addition there are three farm crossings. Two of these crossings appear to be used infrequently by vehicles or farm machinery and are causing minimal erosion. The other is used frequently by stock and erosion of the bed and banks is evident.

The wide channel of Monjerducking Gully makes it generally unsuitable for constructed riffles. One landowner in the middle reaches has attempted to construct a riffle with coarse gravel and small rocks, but it has since been washed away, possibly as the material used was too fine. There is another constructed riffle in the headwaters, although it appears the boulders have shifted during peak flows and the riffle is doing little to trap sediment.

Dams were present in eight per cent of sections in the main channel and 13 per cent of tributaries. The dams have been constructed off-stream and do not appear to be causing any adverse impacts. The dams were probably constructed as stock watering points, but do not appear to be used anymore, due to increased salinity levels making them unsuitable for stock. A few landowners have soaks located in adjacent paddocks, away from the waterway which reportedly have lower salinity levels and are used for stock watering.

4.3 Vegetation assessment

Dense, healthy fringing vegetation is integral to waterway health. Fringing vegetation provides bank stability, habitat, instream shade and woody debris, which in turn provides carbon to the stream ecosystem and stabilises the bed and banks. It also filters sediment and nutrients, slows the velocity of flow and protects adjacent land from erosion, especially during flood events.

Fringing vegetation can be degraded by clearing, stock access, erosion, weed infestation, disease, pest attack, change to flow conditions and fire.

Information about vegetation health was also recorded as part of the stream environmental health rating (see section 4.7). These results are presented below, along with other information about vegetation structure, health and species composition collected during the survey.

4.3.1 Vegetation health and structure

A mixture of overstorey (trees), middlestorey (shrubs) and understorey plants (herbs, sedges and rushes) are important for bank stability and habitat diversity. A dense covering of native understorey plants such as sedges, rushes and herbs provide an excellent buffer to the banks during high flow events and have the ability to strip nutrients and sediment from instream and overland flows.

The stream health rating shows that the majority of floodway and bank vegetation along Monjerducking Gully was rated to be in poor (32 per cent) to very poor (28 per cent) condition. The majority of verge vegetation was also in poor (32 per cent) to very poor (28 per cent) condition. In these sections clearing and stock access has degraded fringing vegetation and weeds have proliferated. However, 36 per cent of sections had floodway and verge vegetation in moderate condition. In all but one of these sections the landowners have fenced and revegetated the waterway, which has improved the structure and function of the fringing vegetation.

During the survey, the proportion of native species in the overstorey, middlestorey and understorey was assessed. Along the main channel, the proportion of native species in the understorey was moderate, with 52 per cent of sections having more than 10 per cent of natives in the understorey. These sections also had minimal to localised bank undercutting or slumping (with the exception of one section), indicating that the natives in the understorey were protecting the banks.

In addition to the vegetation health information that contributes to the stream health rating, an assessment was made on the overall health of vegetation within the foreshore area. The presence of dead trees and/or foliage loss may be an indication of disease, insect attack, heat stress, waterlogging, salinity or stock pressures.

The vegetation appeared healthy in 20 per cent of sections in the main channel. In some sections the health of vegetation varied significantly, especially if that section contained a salt lake. In most instances, vegetation in and around the salt lakes was dead or in declining health (Photo 10) but vegetation away from the lakes tended to be healthy and was regenerating.

Photo 10 Dead trees were common in the salt lakes that are located in the Monjerducking Gully floodplain

4.3.2 Native plant species

There were 20 native plant species identified in the main channel of Monjerducking Gully. The overstorey was dominated by York gum (*Eucalyptus loxophelba*) and Salt River gum (*Eucalyptus sargentii*). The middlestorey was dominated by jam (*Acacia acuminata*) and swamp sheoak (*Casuarina obesa*). The understorey was dominated by salt-tolerant species, such as silver saltbush (*Atriplex bunburyana*), ruby saltbush (*Enchylaena tomenstosa*) and samphire (*Halosarcia spp*.).

There were two sections in the main channel that had the richest species diversity, both having 11 native plant species present at the time of the survey. Each of these sections has been extensively revegetated over the last 10–20 years by their current landowners. These sections are fenced to exclude stock.

4.3.3 Regeneration of native species

Regeneration of native species is critical to ensure there is adequate replacement of the species that die as a result of natural or human disturbances (i.e. disease, fire, erosion, grazing). Regeneration will only be successful if disturbances are limited during the plants critical growth period.

Regeneration was evident in 68 per cent of sections in the main channel and 38 per cent of tributaries. Regeneration was more frequent in areas with limited stock access and sections with no stock access usually had two or more species regenerating.

Dominant regenerating trees and shrubs included:

- jam (*Acacia acuminata*)
- golden wreath wattle (*Acacia saligna*)
- York gum (*Eucalyptus loxophelba*).

4.3.4 Weed invasion

Weeds are a problem in waterways because they do not provide suitable habitat for native animals, they lack the ability to effectively bind the banks as their roots are shallow, and they do not provide woody debris to the channel. Weeds can also quickly colonise disturbed areas or sediment deposits, altering the morphology of the channel and diverting flow into adjacent banks, causing lateral erosion. Their ability to propagate rapidly enables them to dominate and simplify natural ecosystems (Environmental Protection Authority, 2007).

Weeds also cause economic losses in agriculture as they reduce yields, contaminate crops, poison stock, reduce livestock carrying capacity and downgrade wool (Hussey et al., 1997).

Weeds were present in all sections of the main channel and tributaries. Dominant weeds included love grass (*Eragrostis spp*.), wild oats (*Avena fatua*), barley grass (*Hordeum leporinum*) and sharp rush (*Juncus acutus*), which were present in almost every section. Love grass (*Eragrostis spp*.) was the most dominant weed species and lined the banks of the main channel.

It should be noted that this was a snapshot of the weeds present at the time of the survey (November 2007) and it is likely that there are weed species present in the Monjerducking Gully floodplain that were not identified during the survey. A list of species identified during the survey can be found in Appendix 5.

4.4 Habitat diversity

The habitat requirements of aquatic and terrestrial animals vary greatly in a river system, with some being able to utilise the entire waterway and others being restricted to localised areas, such as pools or riffles.

Aquatic habitat diversity usually increases when there is a variety of waterway conditions and features, such as fast and slow moving water, shaded and exposed areas, sandy and rocky beds, shallow and deep water and inundated floodplains or anabranches.

Terrestrial habitat diversity is directly related to the species diversity of riparian vegetation, a variety of under, mid and upper storey species providing a variety of micro habitats for birds, reptiles, frogs and mammals.

4.4.1 Aquatic habitat and animals

In the main channel, aquatic habitats (Table 10) were dominated by instream logs, observed in 80 per cent of sections. The number of instream logs in each section was not recorded; however, it was noted than many of these logs are the remains of trees that have died because of salinisation. Instream habitats were also dominated by meanders and pools, observed in 72 per cent of sections, although most of these pools were shallow and filled with sediment, providing little aquatic habitat.

Monjerducking Gully has intermittent flows, which subside quickly after rainfall events. This variability of flow and a lack of river pools due to the high sediment load mean that there is an unreliable supply of water for many aquatic animals. Monjerducking is also saline and there are few aquatic animals that can tolerate continually high salinities.

There were no aquatic species observed during the survey, even in the only pool that contained water, as there was no flow during the survey. Although no aquatic species were seen, aquatic species may have been present, as an adult dragonfly (sub order *Anisoptera*) was observed near the pool. This was an interesting observation as dragonflies are usually quite sensitive to salinity. It could be that some terrestrial invertebrates, such as the dragonfly rely on a nearby source of fresh or brackish water (such as a dam or soak) for survival of their larval stages.

Table 10 Aquatic habitat diversity recorded on Monjerducking Gully

Aquatic habitat	**Percentage of sections along the main channel** (n=25*)	**Percentage of sections along the tributaries** (n=8*)
Aquatic invertebrates, reptiles and fish		
Riffles	20	13
Meanders, pools	72	50
Instream rocks, boulders	28	–
Instream logs	80	24
Variety of instream and bank vegetation	4	–
Frogs		
Emergent plants (frogs)	8	13

** n denotes total number of survey sections*

4.4.2 Terrestrial habitat and animals

Trees and shrubs were the dominant terrestrial habitat (see Table 11), with 96 per cent of sections in the main channel having trees and 72 per cent of sections having shrubs present. Protected basking sites for reptiles were also common, occurring in 80 per cent of sections, although some of these sites were relatively localised and consisted of hollows in dead trees.

Birds were the dominant terrestrial animal identified during the survey. Along the main channel, 23 different bird species were identified. The most common bird species identified included Australian ringneck (*Barnardius zonarius*), Australian magpie-lark (*Grallina cyanoleuca*), weebill (*Smicronis brevirostris race occidentalis*) and willie wagtail (*Rhipidura leucophrys*). A list of bird species found during the survey can be found in Appendix 5.

Western grey kangaroos (*Macropus fuliginosus*) were observed in 48 per cent of sections in the main channel. There was also one fence skink (*Acritoscincus trilineatum*) and one dragonfly (sub order *Anisoptera*) observed in section MD010. No native species were observed along the tributaries. It should be noted that the temperature was very hot during the first two days of the survey (maximum 46ºC), which may have reduced the activity of many species.

Table 11 Terrestrial habitat diversity recorded on Monjerducking Gully

Terrestrial habitat	**Percentage of sections along the main channel** (n=25*)	**Percentage of sections along the tributaries (n=8*)**
Terrestrial invertebrates		
Variety of vegetation types	8	–
Protected basking sites	56	38
Birds		
Trees	96	63
Shrubs	72	63
Rushes	8	–
Reptiles		
Variety of vegetation types	24	25
Protected basking/nesting sites	80	63
Mammals		
Dense protective vegetation	20	13
Frogs		
Dense fringing vegetation	8	–

** n denotes total number of survey sections*

4.4.3 Introduced animals

Introduced animals can be a nuisance to landowners and place additional pressures on fringing vegetation and native animals. European red foxes (*Vulpes vulpes)* were observed in 32 per cent of sections of the main channel.

European wild rabbits (*Oryctolagus cuniculus*) were observed in 20 per cent of sections, mostly in the lower to middle reaches of the waterway. There was one section (MD007) where rabbit warrens were numerous and contributing to bank instability.

Feral cats (*Felis catus*) were observed in 12 per cent of sections, mostly in the lower reaches.

4.5 Water quality

No water quality sampling was undertaken as there was no flow in Monjerducking Gully during the survey.

Long-term water quality data is unavailable for Monjerducking Gully. Snapshot samples were taken by Department of Water in 2006 and 2007, the results of which are presented in section 2.4.

The presence of numerous dead trees and salt scalds in the floodplain and adjacent paddocks indicates salinity levels are rising in Monjerducking Gully, although in the absence of long-term water quality data it is difficult to ascertain by how much.

Salt scalds (also referred to as salt crusts) occur when local water tables rise (due to land clearing) and the salt stores are brought to the surface. Salt scalds were observed in the floodplain, salt lakes and adjacent paddocks of Monjerducking Gully. It is expected that the first major flow event after summer, or a large summer storm, would flush the concentrated salt store from these areas downstream and eventually into the Avon River. The salinity (electrical conductivity) during these first flow events is expected to be considerably higher than observed during the snapshot in September 2006 and 2007.

4.6 Foreshore condition

4.6.1 General foreshore condition

The general foreshore condition for each section was determined as the average rating along the whole length of the surveyed section of the Monjerducking Gully. Of the approximately 20 km of the main channel of Monjerducking Gully that was

surveyed, 45 per cent was rated as C-grade foreshore (Table 12). A C-grade rating is indicative of a waterway with native trees over a weedy understorey that has localised bank erosion or subsidence. C-grade foreshores are common in agricultural areas where unrestricted stock access has an adverse impact on the condition and regeneration of native fringing vegetation.

The condition of the remainder of the waterway was varied. A B-grade rating was given to 23 per cent of the waterway. These sections had stable banks and, although weeds had invaded the understorey, native species were still dominant. These sections were fenced with little to no stock access.

A D-grade rating was allocated to 25 per cent of the waterway. D-grade sections were either significantly or severely eroded with little to no fringing vegetation remaining to protect the banks. None of the sections along Monjerducking Gully were rated as A-grade foreshore. One section was not assessed, although it is likely it would have been rated as C or D-grade foreshore (based on observations noted from adjacent properties).

The assessed tributaries were also given a general foreshore condition rating (Table 13). Fifty per cent of the length of the assessed tributaries was rated as D-grade foreshore, while 38 per cent were rated as C-grade. A B-grade rating was given to 12 per cent of the length, which was part of a large revegetated area. No tributaries were rated as A-grade.

Table 12 General foreshore condition of the main channel of Monjerducking Gully

Grade	**Total length (km)**	**Percentage (%) of sections** (n=25*)
A-grade foreshore	–	–
B-grade foreshore	5.0	23
C-grade foreshore	9.5	45
D-grade foreshore	5.0	25
Unassessed	1.5	7
Total	21	100

** n denotes total number of survey sections*

Table 13 General foreshore condition of the assessed tributaries of Monjerducking Gully

Grade	Total length (km)	Percentage (%) of sections (n=8*)
A-grade foreshore	–	–
B-grade foreshore	0.5	12
C-grade foreshore	1.0	38
D-grade foreshore	1.5	50
Total	3.0	100

** n denotes total number of survey sections*

4.6.2 Best and poorest condition

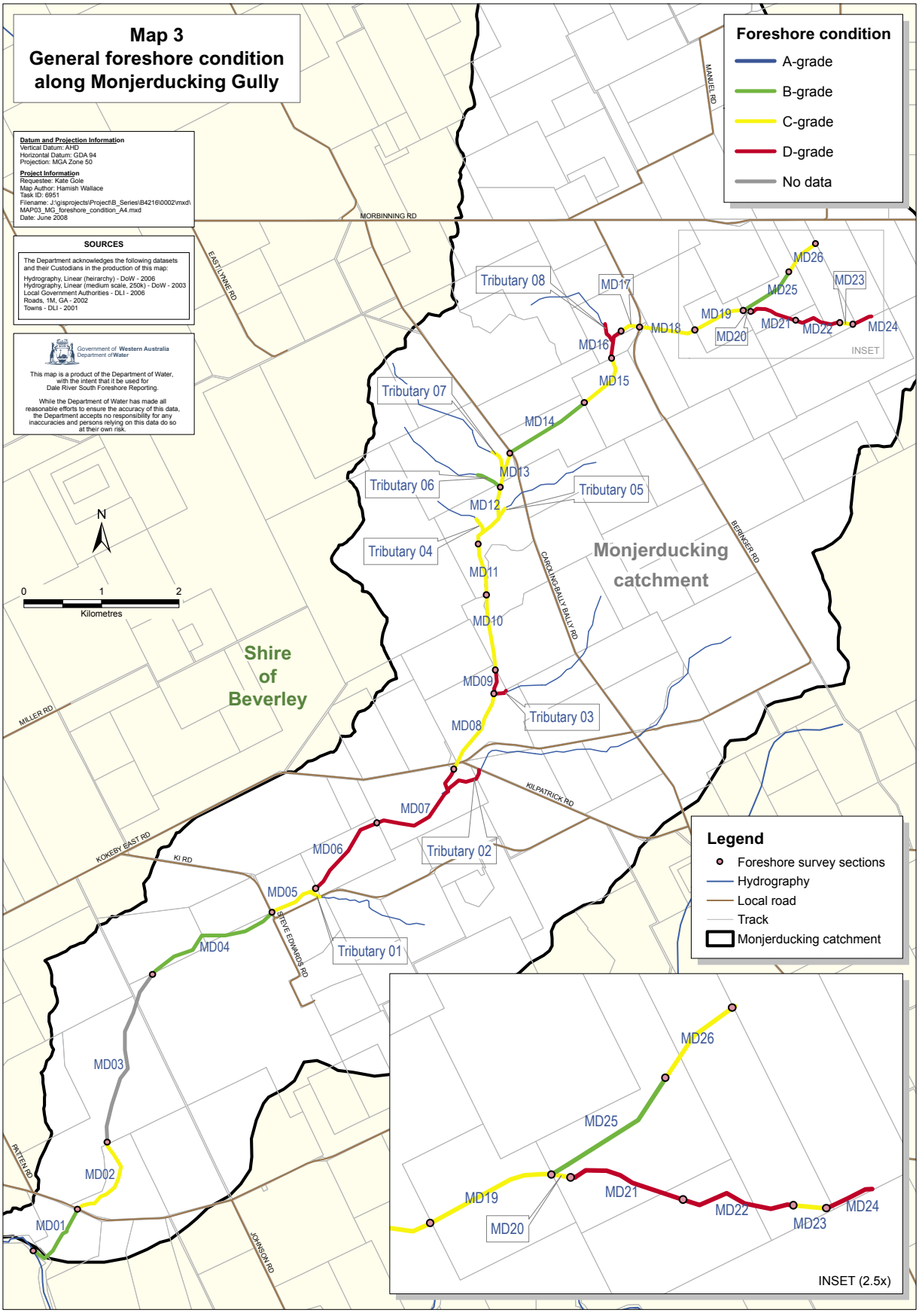
The best foreshore rating is the highest possible rating within each section and may be limited to part of the section. In the main channel, the best foreshore rating recorded was B2, allocated to 12 per cent of sections. In these areas, the overstorey was healthy and consequently there was good bank stability, but there was also significant weed infestation. The next best rating was B3, which was allocated to 16 per cent of sections of the main channel. These sections were in reasonable health, but weeds dominated the understorey.

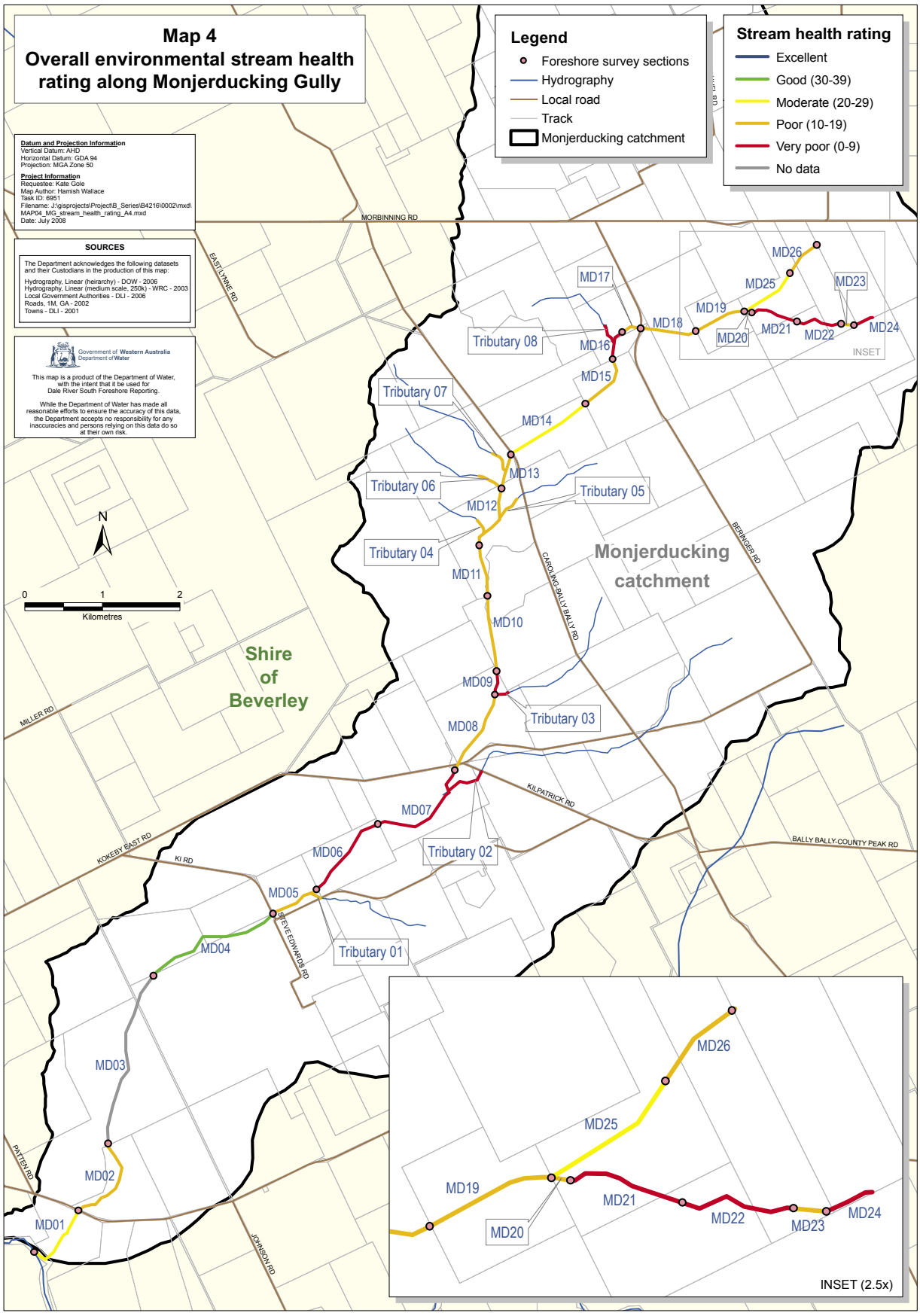
The poorest foreshore rating is the lowest rating within each section. In the main channel the poorest rating recorded was D3, given to four per cent of sections. In these areas, there was no fringing vegetation remaining to support the banks and the banks were being consumed by erosion.

4.7 Overall stream environmental health rating

Along the main channel of Monjerducking Gully, there were no sections rated in excellent health (Map 4). There was one section (MD004) which was rated to be in good health (Table 14). This section has been fenced from stock for more than 20 years and as a result has healthy, regenerating fringing vegetation and a diversity of habitats. The fringing vegetation is effectively stabilising the banks in this section, resulting in only localised erosion points, such as on meander bends.

The majority of the main channel was assessed to be in poor environmental health, with 9.5km (45 per cent) of the waterway falling into this category. This was due primarily to the lack of healthy, dense fringing vegetation, the presence of weeds and a level of erosion which was further degrading the existing vegetation.


Map 3
General foreshore condition along Monjerducking Gully
Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50
Project Information
Requestee: Kate Gole
Map Author: Hamish Wallace
Task ID: 6951
Filename: J:\gisprojects\Project\B_Series\B4216\0002\mxd\MAP03_MG_foreshore_condition_A4.mxd
Date: June 2008
SOURCES
The Department acknowledges the following datasets and their Custodians in the production of this map:
Hydrography, Linear (heirarchy) - DoW - 2006
Hydrography, Linear (medium scale, 250k) - DoW - 2003
Local Government Authorities - DLI - 2006
Roads, 1M, GA - 2002
Towns - DLI - 2001
Government of Western Australia
Department of Water
This map is a product of the Department of Water, with the intent that it be used for Dale River South Foreshore Reporting.
While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.
N
0
1
2
Kilometres
Foreshore condition
A-grade
B-grade
C-grade
D-grade
No data
MORBINNING RD
MANJELRD
EASTLYNNE RD
Tributary 08
MD17
MD18
MD19
MD20
MD21
MD22
MD23
MD24
MD25
MD26
INSET
MD16
MD15
Tributary 07
MD14
MD13
Tributary 06
Tributary 05
MD12
Tributary 04
MD11
MD10
MD09
MD08
Tributary 03
Monjerducking catchment
BERRIDGER RD
CAROLINE BALLY BALLY RD
Shire of Beverley
MILLER RD
KILPATRICK RD
MD07
KOKEBY EAST RD
KI RD
MD06
Tributary 02
MD05
STEVE EDWARDS RD
MD04
Tributary 01
MD03
PATTEN RD
MD02
MD01
JOHNSON RD
Legend
Foreshore survey sections
Hydrography
Local road
Track
Monjerducking catchment
INSET (2.5x)


Map 4
Overall environmental stream health rating along Monjerducking Gully
Legend
Foreshore survey sections
Hydrography
Local road
Track
Monjerducking catchment
Stream health rating
Excellent
Good (30-39)
Moderate (20-29)
Poor (10-19)
Very poor (0-9)
No data
Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50
Project Information
Requestee: Kate Gole
Map Author: Hamish Wallace
Task ID: 6951
Filename: J:\gisprojects\Project\B_Series\B4216\0002\mxd\MAP04_MG_stream_health_rating_A4.mxd
Date: July 2008
SOURCES
The Department acknowledges the following datasets and their Custodians in the production of this map:
Hydrography, Linear (heirarchy) - DOW - 2006
Hydrography, Linear (medium scale, 250k) - WRC - 2003
Local Government Authorities - DLI - 2006
Roads, 1M, GA - 2002
Towns - DLI - 2001
Government of Western Australia
Department of Water
This map is a product of the Department of Water, with the intent that it be used for Dale River South Foreshore Reporting.
While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the Department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.
N
0 1 2
Kilometres
Shire of Beverley
Monjerducking catchment
MORBINNING RD
EASTLYNNE RD
BERINGER RD
CAROLING-BALLY BALLY RD
KILPATRICK RD
BALLY BALLY-COUNTY PEAK RD
KOKEBY EAST RD
KI RD
MILLER RD
STEVE EDWARDS RD
PATTEN RD
JOHNSON RD
MD01
MD02
MD03
MD04
MD05
MD06
MD07
MD08
MD09
MD10
MD11
MD12
MD13
MD14
MD15
MD16
MD17
MD18
MD19
MD20
MD21
MD22
MD23
MD24
MD25
MD26
Tributary 01
Tributary 02
Tributary 03
Tributary 04
Tributary 05
Tributary 06
Tributary 07
Tributary 08
INSET
INSET (2.5x)

Three kilometres (14 per cent) of the main channel was assessed to be in moderate environmental health with good vegetation cover providing a variety of instream and terrestrial habitats, although there was some erosion and weed invasion in these sections.

The health of the assessed tributaries was rated to be in either poor or very poor environmental health (Table 15). Many of the tributaries had limited fringing vegetation and significant weed infestation. Those that had fringing vegetation had narrow verges and limited natural regeneration, resulting in limited terrestrial habitat. All of the assessed tributaries had significant or severe sedimentation and little to no instream habitat.

Table 14 Overall stream environmental health rating along the main channel of Monjerducking Gully

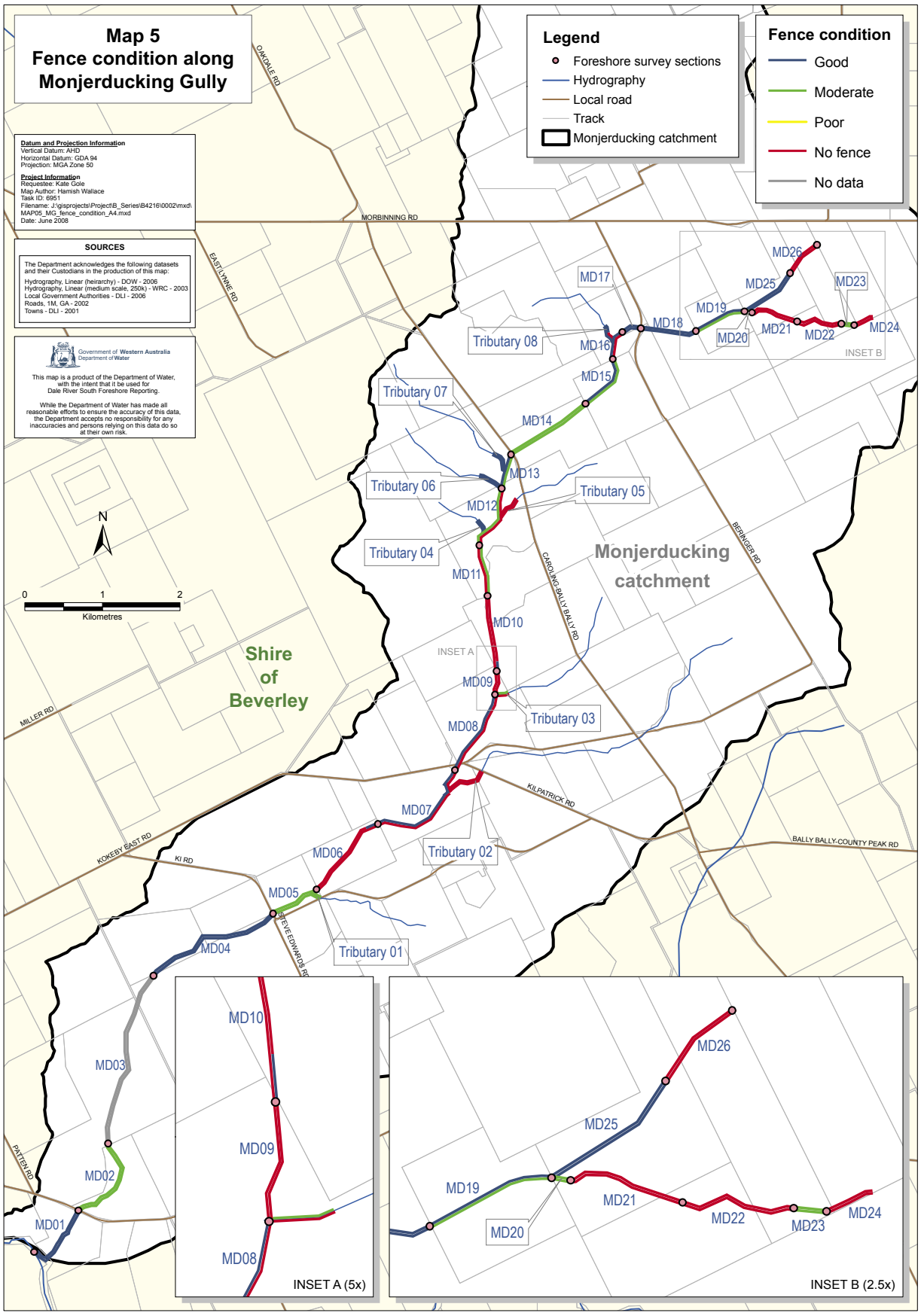
Rating	**Length (km)**	**Percentage (%) of sections** (n=25*)
Excellent	0.0	–
Good	2.0	9.0
Moderate	3.0	14.0
Poor	9.5	45.0
Very poor	5.0	25.0
Unassessed	1.5	7.0
Total	21.0	100

** n denotes total number of survey sections*

Table 15 Overall environmental stream health rating along the assessed tributaries of Monjerducking Gully

Rating	**Length (km)**	**Percentage (%) of sections** (n=8*)
Excellent	0.0	0.0
Good	0.0	0.0
Moderate	0.0	0.0
Poor	1.5	50.0
Very poor	1.5	50.0
Total	3.0	100

** n denotes total number of survey sections*


Map 5
Fence condition along
Monjerducking Gully
Datum and Projection Information
Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA Zone 50
Project Information
Requestee: Kate Gole
Map Author: Hamish Wallace
Task ID: 6951
Filename: J:\gisprojects\Project\B_Series\B4216\0002\mxd\MAP05_MG_fence_condition_A4.mxd
Date: June 2008
SOURCES
The Department acknowledges the following datasets and their Custodians in the production of this map:
Hydrography, Linear (heirarchy) - DOW - 2006
Hydrography, Linear (medium scale, 250k) - WRC - 2003
Local Government Authorities - DLI - 2006
Roads, 1M, GA - 2002
Towns - DLI - 2001
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N
0
1
2
Kilometres
Legend
Foreshore survey sections
Hydrography
Local road
Track
Monjerducking catchment
Fence condition
Good
Moderate
Poor
No fence
No data
OAKDALE RD
MORBINNING RD
EASTLYNNE RD
MILLER RD
KOKEBY EAST RD
KI RD
PATTEN RD
STEVE EDWARDS RD
KILPATRICK RD
CAROLING-BALLY BALLY RD
BERINGER RD
BALLY BALLY-COUNTY PEAK RD
Shire of Beverley
Monjerducking catchment
Tributary 08
Tributary 07
Tributary 06
Tributary 05
Tributary 04
Tributary 03
Tributary 02
Tributary 01
MD01
MD02
MD03
MD04
MD05
MD06
MD07
MD08
MD09
MD10
MD11
MD12
MD13
MD14
MD15
MD16
MD17
MD18
MD19
MD20
MD21
MD22
MD23
MD24
MD25
MD26
INSET A
INSET B
INSET A (5x)
INSET B (2.5x)

4.8 Fencing and access to the channel

4.8.1 Presence and condition of fencing

Waterways provide stock with drinking water, shade and feed. However, stock can do enormous amounts of damage to fringing vegetation and banks and can foul water supplies. The control of livestock is the single most important management activity in the riparian zones of rural areas and the most effective way of achieving this is by fencing (Pen, 1999).

During the survey, the presence and condition of fencing was assessed along both banks in each section (Map 5). A considerable number of landowners have fenced the waterway either to exclude or limit stock access. Some of this fencing has been in place for 10–20 years and in these sections the waterway is in good health. One landowner commented that fencing Monjerducking Gully is a necessity rather than an option due to rising salinity levels and identified a need for fence lines to incorporate the salt lakes in the floodplain.

Monjerducking Gully has a relatively high proportion of fencing (Table 16). Approximately 20 km of the main channel was surveyed, of which 14.5 km (73 per cent) of the left bank and 11.5 km (58 per cent) of the right bank are fenced. A total of 10.5 km (53 per cent) is fenced on both sides (see Appendix 6). Fences are located more than 20 metres away from the main channel in all but 16 per cent of sections. In eight per cent of sections the fences are located up to 220 metres away from the main channel to incorporate salt lakes.

Approximately 2.5 km of tributaries were assessed (Table 17). Sixty per cent of the left bank and 35 per cent of the right bank of the tributaries are fenced, with 35 per cent being fenced on both sides. In most cases the fence line for the main channel incorporates any tributaries that occur in that section.

The condition of the fencing varies. Condition was recorded as:

- good – relatively new and expected to remain stock-proof with minor maintenance for >30 years
- moderate – fence is stock-proof but will need maintenance or replacement within 10–20 years
- poor – fence is barely stock-proof and will need to be replaced within five years.

Photos in Appendix 2 show examples of good, moderate and poor fence condition.

All of the fencing was in moderate to good condition and is not expected to require replacement for over five years.

Landowners interested in fencing Monjerducking Gully or its tributaries may be eligible to receive fencing materials through the Avon Fencing Project. For more information see section 5.3.

Table 16 Presence of fencing along the main channel

	Length fenced (km)	**Percentage (%) fenced** (n=25*)
Left bank only	14.5	73
Right bank only	11.5	58
Both sides	10.5	53
Total length assessed	20.0	
Unassessed	1.5	

** n denotes total number of survey sections*

Table 17 Presence of fencing along tributary sections

	Length fenced (km)	**Percentage (%) fenced** (n=8*)
Left bank only	1.6	62
Right bank only	0.9	35
Both sides	0.9	35
Total length surveyed	2.6	

** n denotes total number of survey sections*

4.8.2 Access to the foreshore

Stock and vehicle access was recorded during the survey. Forty per cent of the main channel and 38 per cent of tributary sections are accessible by stock. Stock access in some of these sections is well managed and there is minimal damage to the riparian zone from stock. However, some sections are heavily stocked and have been for some time.

These sections have no fringing vegetation and the sandy soils along the banks and floodway have been significantly eroded, resulting in the transport of sediment

downstream. There is also high flow velocity through these sections, as there is no fringing vegetation to slow the flow. This is resulting in localised channel incision in downstream sections, some of which are in good to moderate health and could be degraded by continual excessive sediment loads and high velocity flows.

Vehicle access is limited along Monjerducking Gully. The coarse sand that lines the bed of the waterway is soft, making vehicle access difficult. Only 20 per cent of sections in the main channel have vehicle access and only one tributary has vehicle access. There are three farm crossings on Monjerducking Gully. Only one of these is used frequently by stock and will require management to protect the banks from further erosion.

4.9 Management issues

Erosion and sedimentation, weed invasion and salinity were identified as priority management issues in most survey sections on both the main channel and tributaries.

Erosion, sedimentation and weed invasion are the result of catchment clearing, unrestricted stock access and the surrounding agricultural land use. Salinity problems are the result of widespread catchment clearing that has changed the catchment water balance, resulting in the water table rising and salts being brought to the surface.

These management issues are discussed further in chapter 5. Descriptions of each survey section, including specific management recommendations, are included in Appendix 7.

4.10 Summary of findings

The main findings from the foreshore and channel assessment of Monjerducking Gully and its tributaries are summarised below.

4.10.1 Main channel

The main findings for the main channel of the waterway are as follows:

- The general foreshore condition rating varied between B-grade and D-grade, with the largest percentage of the waterway (45 per cent) being rated as C-grade.
- Monjerducking Gully is a braided waterway that has high levels of coarse sediment and an intermittent flow pattern, resulting in limited aquatic habitat.
- The management issues identified as a high priority were erosion, sedimentation, salinity and weeds.

- Unmanaged stock access has lead to the degradation of fringing vegetation, which has resulted in severe lateral erosion in some sections.
- There is a high proportion of fencing and revegetation, with over half of the channel being fenced.
- Salinisation appears to be an increasing threat, especially in the middle to upper reaches of the catchment. Salt lakes are numerous along the waterway and contain many dead trees and salt scalds.
- There were 20 native plant species identified.
- There were 23 bird species identified.

4.10.2 Tributaries

The main findings for the tributaries are as follows:

- The general foreshore condition rating varied between B-grade and D-grade.
- The overall environmental stream health rating for all of the tributaries was poor to very poor.
- The management issues identified as a high priority were erosion, sedimentation, salinity and weeds.
- Tributaries varied in length and condition. Two tributaries had extensive, cleared catchments and were in very poor health. The remaining tributaries had small catchments, most with extensive areas of salt scalding and erosion.
- There were 13 native plant species identified along the tributary sections.
- There were 10 bird species identified along the tributary sections.

5 Management advice for Monjerducking Gully

A number of management issues were identified during the survey. This section provides some information on the most appropriate way in which to manage them. Waterways management advice is also available by contacting the Department of Water's Northam office on (08) 9690 2600.

The waterways of the Avon River catchment have been significantly modified since European settlement. Extensive clearing for agriculture has increased runoff and sediment loads into Monjerducking Gully.

Salinisation is also a threat in this catchment. Visual observations of salt scalding in the paddocks and the floodplain, snapshot water quality samples, aerial photography and comments from long-term landowners all indicate that the rate of salinisation in the catchment is increasing. Catchment-scale management of this threat is required.

There is a high proportion of fencing along Monjerducking Gully and many of these fenced areas have been revegetated, providing multiple benefits including provision of habitat and erosion control. These areas should be regarded as local assets and a model to strive towards for other local landowners.

It is not envisaged that Monjerducking Gully could be returned to a pristine or pre-European state. However, the results of this survey will assist landowners and river managers to understand the main threats to this waterway and how to manage them. This will help to ensure Monjerducking Gully is more resilient and able to recover from potential threats and disturbances it may face in the future.

5.1 General management advice

While each issue of concern is discussed separately, Table 18 gives some general management suggestions for each general foreshore rating. Appendix 7 provides a description and specific management recommendations for each survey section.

Additional information and practical advice on waterways management can be found in the *Field guide to managing waterways in the Avon Wheatbelt* available from the Department of Water, Northam (Department of Water, 2008b).

Table 18 General management suggestions for each foreshore rating
(adapted from Water and Rivers Commission, 2001)

A-grade – pristine to slightly disturbed	A-grade foreshores require minimal management such as: • removal or realignment of large woody debris where it is causing localised erosion • removal of isolated occurrences of weeds • fence maintenance to exclude livestock • control of feral animals • establishment and maintenance of fire breaks and access tracks
B-grade – weed infested to weed dominant	Management of B-grade foreshores requires a greater effort than for A-grade rated foreshores and includes: • removal of minor weed invasions and ongoing control of widespread weed problems • removal or realignment of large woody debris where it is causing localised erosion • managing stock access to control weeds without damaging native vegetation and streambanks
C-grade – erosion prone to eroded	Management activities for C-grade foreshores are more difficult due to the higher degree of degradation. However, the following activities can help maintain and restore value to the river section: • use of large woody debris to protect banks from erosion • revegetation with local native species to stabilise banks and provide habitat • stabilisation of sediment slugs with local native species • management of stock access and stocking rates to jointly control widespread grassy weeds and maintain vegetation on streambanks to protect them from erosion
D-grade – eroding ditch to simple drain	It is very costly to restore D-grade foreshore areas. Priorities for management include: • revegetation in localised areas initially using fast-growing species, then in-filling with slower growing plants • implementing strategies to slow water flow, for example using large woody debris and riffles • undertaking localised weed control in and around revegetation areas • managing stock access and stocking rates to jointly control widespread grassy weeds and maintain sufficient vegetation cover on streambanks to protect them from erosion

5.2 Catchment and farm management

Good catchment management is paramount to the health of the waterway and has benefits to landowners. *Farming for the future* is a program run by the Department of Agriculture and Food that promotes sustainable farming practices. The program

supports individuals and industry groups to develop sustainable farm practices and includes the following areas:

- farm economic and social sustainability (e.g. business plans)
- natural resource sustainability (e.g. salinity management, soil and land management)
- biosecurity (e.g. pest and weed management) (Department of Agriculture and Food, 2008).

More information on Farming for the Future, including a self-assessment tool, can be found on the Department of Agriculture and Food's website link <www.agric.wa.gov.au/content/SUST/f4fhomepage.htm#why>.

5.3 Stock control and fencing

Monjerducking Gully has a relatively high proportion of fencing that is located a reasonable distance from the channel. Discussions with some local landowners revealed a good understanding of the need to fence and exclude stock from this waterway and its floodplain. Rising salinity levels and erosion were common factors that have influenced landowners to fence and revegetate their sections of the waterway.

However, there are some sections that are not fenced and are either accessible to stock or have been accessible to stock in the past. This, coupled with other stresses such as drought and salinity, has resulted in the degradation of fringing vegetation and severe bank erosion. The loss of fringing vegetation has exposed soil along the banks and floodway to erosion, resulting in sediment being transported downstream during peak flows.

It is not necessary to totally exclude stock from the channel and floodway, unless the aim is to protect remnant bushland or A-grade river sections. However, it is important to be able to restrict stock access, which is only possible by fencing.

Landowners are often concerned about fencing riparian zones, with the most frequent comments being that the area will become weed infested and present a significant fire risk. Some landowners also feel that the area provides good grazing and is the only source of water for stock. Although valid, these concerns can be overcome and fencing the riparian zone has a number of benefits both to landowners and the environment including:

- reduced stock losses from flooding
- improved bank stability from protected fringing vegetation
- reduced land lost to erosion

- provision of a windbreak for stock
- improved water quality
- improved property appearance and resale value
- improved habitat for native fauna (Department of Water, 2006).

Landowners are encouraged to fence the riparian zone and restrict stock access except for crash grazing to control weeds and the subsequent fire risk. Crash grazing is where stock are allowed to graze in riparian zones for short periods to suppress the weed mass. They are removed before they start to damage native vegetation. The following guidelines should be followed if fenced riparian zones are to be grazed:

- only graze riparian areas when soil is relatively dry and the bulk of the vegetation is dormant
- avoid grazing during the growing, flowering and germination seasons of native vegetation, which typically means spring and summer
- adjust stocking rates and frequency of grazing to suit the sensitive nature of the land (Department of Water, 2006).

Landowners interested in fencing Monjerducking Gully or its tributaries may be eligible to receive fencing materials through the Avon Fencing Project. The Avon Fencing Project, funded by the Avon Catchment Council and the Department of Water, provides ringlock wire, posts and strainers to fence priority riparian areas. Materials are limited. Contact the Department of Water, Northam on (08) 9690 2600 to register your interest.

5.3.1 Location of fences

The placement of fencing is an important factor that must be considered carefully. Incorrect placement of fencing may lead to the fence, and your investment, being washed away. When determining fence placement, you need to know a little about the potential flood level and flood frequency of your waterway.

Fences can be constructed to resist flood damage by constructing them with the lowest height that gives adequate stock control. Posts should also be located as close together as possible and placed into the ground as firmly as possible. Fences crossing waterways also require regular maintenance to prevent damage from accumulating woody debris (Department of Environment, 2006).

Monjerducking Gully has a broad river valley. Figure 2 indicates the most appropriate location of fencing in these waterways. It is important to fence the channel and floodway, but it is acknowledged that due to the large floodplains of broad waterways it is often difficult to fence the entire valley. However, where there are salt lakes or salt scalds in the floodplain, these should be incorporated in the fenced area.

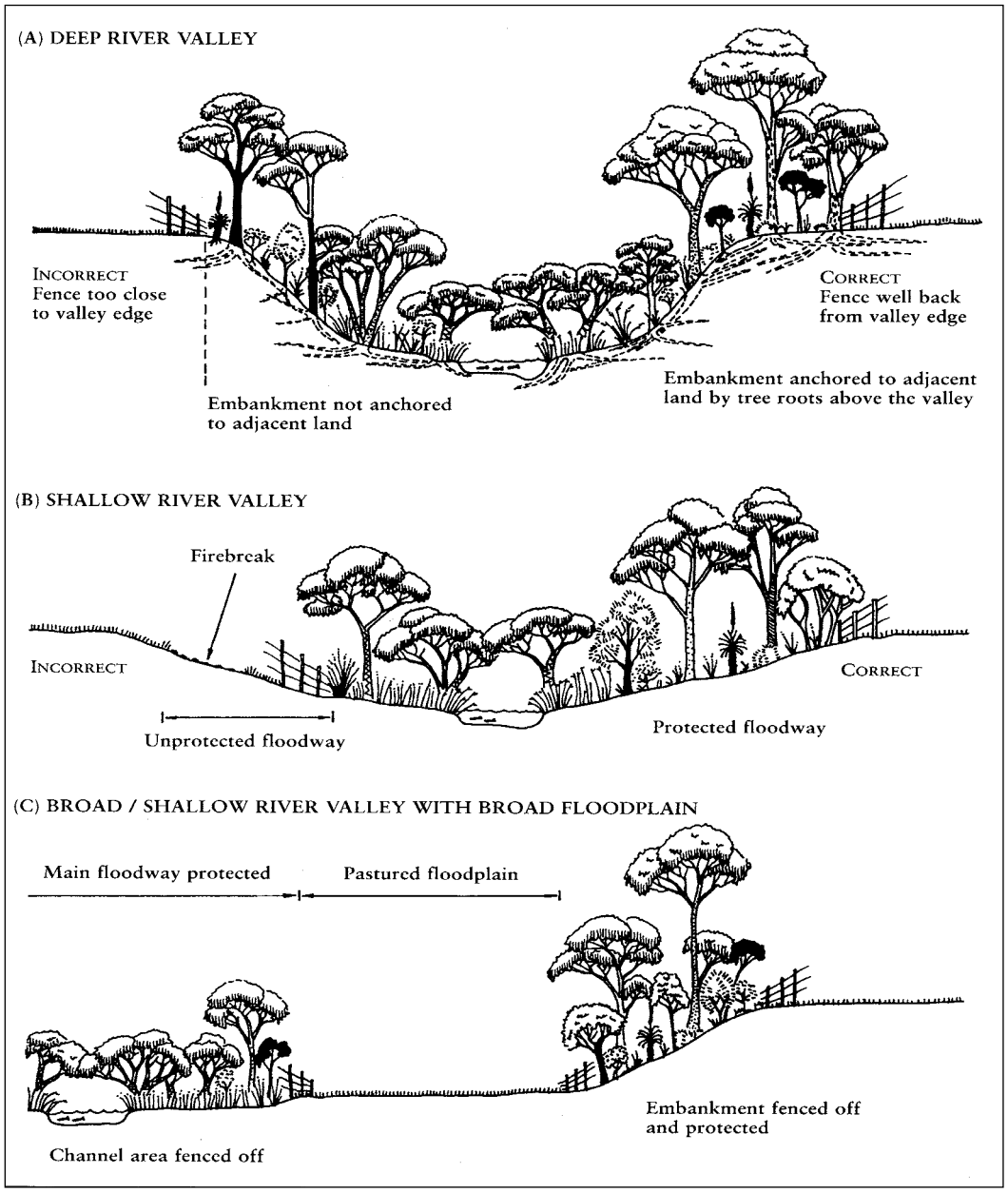

Figure 2 Ideal fence placement along river floodways
(Source: Pen, 1999)

This land is often unusable for farming practices, and fencing and revegetating the area may slow the rate of salinisation in adjacent paddocks.

5.3.2 Stock crossings

Although Monjerducking Gully is not used as a stock watering source, stock are still required to cross the waterway in some sections to access adjacent banks and paddocks.

The correct placement of crossing points is important to minimise erosion, protect fringing vegetation and also protect stock. Crossing points should be located on a

straight stretch of the waterway, where the bed is naturally high and the banks are not too steep. If the bed is soft, it should be hardened up with rock or field stone (not gravel, as this will be washed away). This rocky crossing will also act as a riffle and help to trap sediment and provide a habitat for aquatic fauna. Figure 3 illustrates the correct placement of crossings and fences on waterways.

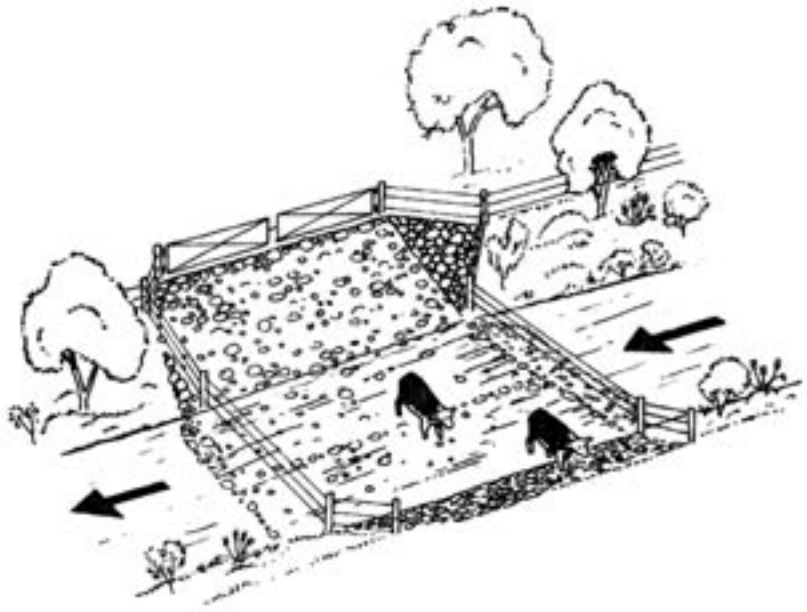

Figure 3 Basic geometry of a livestock crossing
(Source: Water and Rivers Commission, 2000b)

5.4 Erosion and sediment control

There are some sections of Monjerducking Gully where the level of erosion should be of concern to landowners. Lateral erosion caused by the removal of fringing vegetation is consuming valuable farmland and, if left untreated, the problem will worsen and cause adverse impacts downstream. Failure to manage erosion may require landowners to fence off much larger areas of valuable farmland in the future in an effort to protect cropping and grazing land.

The principal forms of erosion and sedimentation along Monjerducking Gully and its tributaries stem from unrestricted stock access and an extensively cleared catchment. Unrestricted stock access has led to the decline of fringing vegetation, especially native understorey species, whose roots effectively bind and protect the banks from erosion. Catchment clearing has led to increased runoff and flow velocity, bringing with it increased sediment loads.

An effective means of slowing and preventing further erosion and sedimentation of Monjerducking Gully is to restrict stock access by fencing the areas that are currently unfenced. This will enable the bed and banks in these areas to recover from disturbance and allow natural regeneration to occur. In some sections that

have severe erosion, the use of appropriately placed large woody debris can offer protection to exposed banks. Logs should be installed against the outer bank, pointing downstream at an angle of approximately 30º. The butt of the log should be buried up to one metre into the bank to secure it against high flows (Water and Rivers Commission, 2000c).

Once an area is fenced, landowners may need to manage the weed burden, recommendations for which are made in section 5.6. Some sections will also require assistance in re-establishing native vegetation as there may be minimal vegetation to enable natural regeneration and the current seed store may be unviable (see section 5.5).

A worthwhile reference for anyone interested in bank stabilisation is *Stream stabilisation* (Water and Rivers Commission, 2000c). Assistance in undertaking bed and bank stabilisation works is available through the Department of Water's Northam office on (08) 9690 2600.

5.5 Revegetation of the riparian zone

Healthy waterways are a valuable asset to landowners and are worth managing and protecting. The fenced and revegetated sections of Monjerducking Gully support a diversity of trees and shrubs, providing bank stability and habitat. Improving the diversity and quality of this fringing vegetation, especially the understorey, has a number of benefits to landowners and the environment including:

- improved bed and bank stability
- improved water quality
- aesthetic and recreational benefits
- provision of shade and shelter for stock
- provision of fodder during times of drought (with careful management of stock numbers)
- trapping sediment and nutrients
- localised lowering of water tables which may reduce the movement of salt into the waterway
- shading streams and providing improved aquatic habitat
- enhancement of biodiversity and provision of aquatic and terrestrial habitat (Price, et al., 2005).

Revegetating the riparian zone is only worthwhile if the area has been restricted

to stock (see section 5.3). Planning your revegetation project is also important to maximise success. Assistance in planning and undertaking riparian revegetation projects can be sought from the Department of Water, Northam by contacting (08) 9690 2600.

Steps to consider when planning your revegetation project:

- Determine which area requires attention first. The general rule of thumb is to protect the best areas first and work towards the more degraded areas.
- Consider areas where there is potential for natural regeneration. It is much easier to protect existing native vegetation than to replant it. Where native species remain and are healthy enough to flower and produce viable seed, natural regeneration is the best, and cheapest, way to revegetate.
- Determine if site preparation is required, such as erosion control or weed removal, which are usually best undertaken during drier months.
- If the area is quite degraded (i.e. D-grade rating), then initial plantings should consist of fast growing species, which could be followed up with slower growing species in subsequent years.
- Choose your species wisely. Your choice of species depends on the purpose for which you are revegetating and site conditions. For example, you would choose different species to control erosion than you would choose to increase biodiversity. Salt and waterlogging tolerant species should also be considered, as there are areas of Monjerducking Gully where these threats are apparent (Price, et al., 2005, Department of Environment, 2006).

Native species that have proved popular in revegetation projects and/or have naturally regenerated along Monjerducking Gully include swamp sheoak (*Casuarina obesa)*, jam wattle (*Acacia acuminata)*, golden wreath wattle (*Acacia saligna)*, flat-topped yate (*Eucalyptus occidentalis*), saltbush (*Atriplex spp*.) and samphire (*Halosarcia spp*.). See Appendix 8 for revegetation tips using these and other species.

A worthwhile reference for anyone interested in revegetation is *Riparian plants of the Avon catchment; a field guide*, available from the Department of Water, Northam on (08) 9690 2600.

5.6 Weed control

Annual agricultural weeds are dominant in the understorey along many rural waterways and Monjerducking Gully is no exception. Weeds often have shallow roots and are unable to provide bank stability in the same way as deep rooted native species. Weeds reduce habitat diversity for native animals, pose a significant fire risk and reduce the regeneration of native species.

Weed control can be a daunting task, but prevention is the key. It is easier to manage a small scale weed problem than a significant infestation. Common methods of weed control include chemical control, stock grazing, mechanical removal and hand removal.

The type of weed control you use will depend on the location, type of weeds, time of year and existing vegetation. It is typically best to target smaller infestations first. Sometimes a number of techniques can be the most effective way of eliminating significant infestations. Some examples are listed in Table 19.

Table 19 Possible control methods for weed removal

Method	Techniques	Advantages	Disadvantages	Things to consider
Hand removal	Pulling or digging weeds by hand	Erosion is localised and kept to a minimum	Labour intensive	Best done when the soil is damp
Mechanical	Brushcutters, chainsaws, tractor slashers, mowers	Can be suitable for large areas	Inappropriate use can lead to erosion	
Chemical		Can cover large areas Very effective for some species	Risk of contamination to the waterway	Always read instructions on the label and wear protective clothing Chemicals can harm aquatic animals and pollute waterways; choose a suitable chemical that will not harm aquatic ecosystems or choose another control method
Grazing	Allowing stock to periodically graze the fenced riparian zone	Reduces weed biomass Source of feed during drought	Unsuitable for high quality bushland/ riparian areas Stock can easily damage native vegetation and erode banks	Maintain low stocking rates for short periods during late spring and summer Avoid stocking riparian areas when native species are flowering and regenerating
Solarisation	Plastic sheeting	Effective for small areas	Difficult to use if there is native vegetation among weeds Need to leave plastic on for 2–3 weeks, which is difficult in some areas	This technique uses plastic sheeting to kill the weed mass. Plastic should be in direct sunlight and the soil should be damp

Landowners also have an obligation to remove weeds that are declared under the *Biosecurity and Agriculture Management Act 2007* (WA). During the survey, one declared plant species, one-leaf cape tulip (*Homeria flaccida*) was found in six sections of the waterway. This species is declared as Priority 1 throughout Western Australia, which prohibits the movement of plants or their seeds within the state.

5.6.1 Control of sharp rush (*Juncus acutus*)

A particularly invasive species, sharp rush (*Juncus acutus*) was identified during the survey. Although this not a declared plant species in Western Australia, it is in other Australian states, due to its invasive nature and ability to colonise large areas of valuable farmland.

This species has been mistaken for a native rush by many landowners and as such, has been left untreated. Photos 11 and 12 illustrate the growth form and seed heads of sharp rush (*Juncus acutus*).

Sharp rush is tolerant of saline and waterlogged conditions and once established it covers large areas and eliminates almost all other vegetation. Infestations can become impenetrable to livestock and humans, preventing access to water. Their sharp spines can be dangerous to children (as they are at eye level) and if the spines penetrate the skin it can cause adverse reactions in some people.

Infestations can also provide an effective shelter to introduced animals, and when growing in channels, can seriously obstruct water flow, causing flooding (Department of Primary Industries, 2008).

Removal of sharp rush is usually more successful if using a variety of methods including mechanical removal and chemical control. However, before carrying out any control, consideration should be given to potential soil erosion as the rhizomatous root mat of this species can cover large areas. If you require advice, or would like assistance in developing a weed removal plan for a large infestation of sharp rush, contact the Department of Water, Northam (08) 9690 2600.

5.7 Salinity and nutrient management

The cause and impacts of dryland salinisation are well known throughout the Wheatbelt. Everyday in Western Australia the equivalent of 19 football ovals of land are lost to dryland salinity (Environmental Protection Authority, 2007).

Management of dryland salinisation requires an integrated approach and the most appropriate management techniques are often site specific. Plant-based solutions can be effective but need to be carefully considered. Research has shown that trees should be planted in high recharge areas of the catchment and in suitable soils (i.e.

*Photo 11 Sharp rush (*Juncus acutus*) in the floodway of Monjerducking Gully*

*Photo 12 Sharp rush (*Juncus acutus*) seed head (Photo: Kate Gole, Department of Water)*

deep sand) (Department of Agriculture, 2005). It is therefore important to understand the local hydrogeology before making significant investments in tree planting to manage salinity.

Other plant-based solutions include plantations of economic tree crops. Salinity management often requires large areas of the catchment to be planted with trees and this is not always economically feasible. However, if the area was planted with an economic crop, this could lower groundwater tables and reduce runoff and erosion, improving the hydrological balance of the catchment. Around the middle reaches of Monjerducking Gully there are some sandalwood (*Santalum spicatum)* plantations, which have a growing local market.

Engineering solutions are also used to manage salinisation, but their use and application should be carefully considered. The attraction of using engineering solutions such as deep drainage as a quick fix for agricultural production may have unintended long-term consequences for the environment. Drainage water discharged into natural waterways and wetlands has the potential to severely impact on the health of the receiving ecosystem through addition of water, salt, nutrients, sediment, heavy metals and acidity (Environmental Protection Authority, 2007). If you are considering engineering solutions, contact appropriate authorities for advice and assistance.

There were isolated occurrences of rubbish dumping along Monjerducking Gully. Rubbish consisted of farm and household refuse and appeared to be inert; a detailed inspection of rubbish was not carried out. Dumping rubbish in waterways or floodplains was a common occurrence historically, but there is now a good understanding about its social and environmental impacts. However, isolated instances still occur and should be discouraged.

While there were no point sources of pollution and/or nutrients observed along Monjerducking Gully, agricultural land uses dominate the catchment. Fertiliser and pesticide runoff commonly enter waterways in agricultural areas. Unrestricted stock access along much of the waterway also means that stock foul the water with their wastes.

Restricting stock access to the riparian zone will not only prevent stock from fouling the water, it will also allow fringing vegetation to recover and regenerate. A well-vegetated riparian zone can remove sediment and nutrients from overland runoff and flow within the stream.

5.8 Fire management

Fire is an important natural feature that shapes the Australian landscape. However, along many waterways the structure of plant communities has changed considerably and the understorey is often dominated by annual agricultural weeds that add to the fuel load.

In the rural landscape, riparian vegetation along waterways often represents a significant proportion of the remaining remnant native vegetation. Therefore, frequent and uncontrolled fires in riparian zones can significantly damage fringing vegetation, (resulting in the loss of fire-sensitive species), destroy habitat, impact on food supplies for native animals and expose the area to erosion and weed infestation. Fires can also pose a risk to stock and cause damage to fences and other farm infrastructure.

Although intense fires are damaging, fire can be a useful management tool in appropriate circumstances. For example, some native plants require smoke, intense heat or ash to germinate and carefully controlled fires can be useful in stimulating the germination of these species. Fire can also be useful in reducing the weed burden, especially in heavily infested areas. However, extreme care should be taken when undertaking controlled burns in riparian zones and the use of fire should be considered in consultation with the relevant fire authority and the Department of Water, Northam.

Firebreaks and access to the riparian zone are important in river management. When fencing the riparian zone, firebreaks should be located on the river side of the fence, allowing easy access to the area and preventing stock from pushing through fences to graze the riparian zone (Department of Environment, 2006).

The Avon Waterways Committee has developed a fire policy that outlines objectives for fire management along the Avon River and its tributaries (Appendix 9).

5.9 Introduced animal control

There were three introduced animals observed along Monjerducking Gully, namely the European red fox (*Vulpes vulpes),* European wild rabbit (*Oryctolagus cuniculus*) and feral cat (*Felis catus*).

The European red fox (*Vulpes vulpes)* has played a major role in the decline of a number of native animals, including ground-nesting birds, reptiles, small to medium-sized mammals and some threatened species since their introduction in the 1800s. They also prey on newborn lambs, posing an economic threat to sheep farmers *(*Department of the Environment and Heritage, 2004a).

European wild rabbits (*Oryctolagus cuniculus*) compete with native wildlife, damage vegetation and degrade the land. They affect the success of revegetation projects, eat seedlings and their warrens can cause erosion along waterways.

The most effective methods of fox and rabbit control appear to be baiting, fencing and shooting. Biological control of rabbits has proved effective in some areas of Australia, although it seems to be more effective when followed up with more traditional methods such as baiting or digging up warrens (Department of the Environment and Heritage, 2004b). However, care should be taken when digging up warrens near waterways, to limit the potential of erosion.

Table 20 summarises the problems caused by introduced animals and the possible methods of control.

Table 20 Problems and control of introduced animals
(Department of Environment and Heritage, 2004a-d)

Feral animal	Problems	Control methods
European wild rabbit (*Oryctolagus cuniculus*)	• Ringbarks trees • Prevents regeneration of native plants • Competes with stock and native fauna for food	• Destroying warrens • Shooting • Poisoning • Trapping • Biological control using myxoma virus or calicivirus
European red fox (*Vulpes vulpes*)	• Preys on native fauna • Preys on livestock including lambs and poultry	• Shooting • Baiting
Feral cat (*Felis catus*)	• Preys on native fauna • Preys on livestock such as poultry • Carry infectious diseases	• Control is difficult as feral cats do not readily take baits or approach traps. • They are difficult to shoot as they are wary of humans

Glossary

Acid(ic)	See pH.
Alkaline	See pH.
Anabranching channel	Diverging and converging channel separated by relatively large, stable islands that are only inundated in flood events.
Alluvium	Sediment deposited by flowing water.
Aquifer	A layer of rock or soil capable of receiving, storing and transmitting quantities of water.
Braided channel	Diverging and converging channel separated by relatively small, unstable bars or sediment slugs which are frequently covered by in-channel flows.
Catchment	The area of land which intercepts rainfall and contributes the collected water to a common point through surface and groundwater.
Confluence	Flowing together or intermingling, for example where a tributary joins the main river channel.
Channel incision	Where the bed of the channel is eroded downwards, creating a deeper channel and steep banks.
Debris	Loose and unconsolidated material resulting from the disintegration of rocks, soil, vegetation or other material transported and deposited during erosion.
Discharge	Volumetric outflow rate of water, typically measured in cubic meters per second. Applies to both groundwater and surface water.
Discharge area or zone	Area where groundwater discharges to the surface.
Ecosystem	A biological community of interacting organisms and their physical environment.
Electrical conductivity	A measure of salinity. The higher the electrical conductivity of soil or water the greater the salinity.
Erosion	The subsequent removal of soil or rock particles from one location and their deposition in another location.
Floodplain	A broad, flat, low-lying area of land within the valley floor, the boundary of which is defined by the water level during a 100-year flood. Includes the floodfringe and floodway.
Flood – 100 year	The 100-year flood has a statistical probability of occurring, on average, once every 100 years. The 100-year flood level is the contour to which this flood will rise.

Floodfringe	The area of the floodplain, outside of the floodway, that is affected by flooding.
Floodway	The river channel and portion of the floodplain which forms the main flow path for flood waters once the main channel has overflowed.
Foreshore	Area of land next to a waterway.
Groundwater	Water which occupies the pores and crevices of rock or soil.
Groundwater seep	Seeps occur where the groundwater meets the surface. This can be the result of a bedrock high (where the bedrock is close to the surface), dolerite dyke, at the base of a sand rise or where the slope changes.
Habitat	The physical and biological environment on which a particular species depends for its survival.
Hydrogeology	The study of the occurrence and movement of groundwater in the soil and rocks of the earth's crust.
Hydrology	The study of water, its properties, distribution and utilisation, above, on and below the earth’s surface.
Introduced species	A general term used to describe species that are not native to an area.
Large woody debris	A branch, tree or root system that has fallen into or is immersed (totally or partially) in a waterway.
Macroinvertebrates	Aquatic invertebrates (animals without backbones) that are retained on a 0.25 mm mesh net and therefore big enough to be seen with the naked eye.
Natural resource management	The ecologically sustainable management of the land, water, air and biodiversity resources for the benefit of existing and future generations.
Nutrient load	The amount of nutrient (usually nitrogen and/or phosphorus) reaching a waterway over a given time period from its catchment area.
pH	The concentration of hydrogen ions in solution that indicates the acidity or alkalinity in water. A pH value of 7 is neutral, above 7 is alkaline and below 7 is acidic.
Recharge	Volumetric inflow rate of water to an aquifer, typically measured in cubic meters per second.
Recharge area or zone	An area through which water percolates to replenish (recharge) an aquifer. Unconfined aquifers are recharged through rainfall. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.

Remnant vegetation	An area of vegetation remaining after a major disturbance, such as land clearing.
Riffle	High points in the channel represented by bedrock bars, accumulations of rock or woody debris.
Riparian zone	The riparian zone includes the floodplain and adjacent verge. The width of the riparian zone varies greatly, from 10s of metres to kilometres, depending on the type of waterway and its catchment.
Riparian vegetation	Vegetation growing within the riparian zone.
River basin	The area drained by a waterway and its tributaries (see Catchment).
Runoff	Water that flows over the soil surface when rainfall is greater than the infiltration capacity of the soil. Flow in waterways results from rainfall runoff.
Salinity	A measure of the total soluble (dissolved) salts in water. Commonly measured in terms of total dissolved salts (TDS) in milligrams per litre (mg/L), or electrical conductivity, in millisiemens per metre (mS/m) or millisiemens per centimetre (mS/cm). Water resources are classified as fresh, marginal, brackish or saline on the basis of salinity.
Salinisation	An increase in the concentration of soluble salts in soil or water.
Salt lake	A shallow depression in the floodplain that intermittently fills with saline water and is generally covered with a salt crust when dry.
Sediment	Sand, clay, silt, pebbles and organic matter carried and deposited by wind or water.
Sedimentation	The process by which sediment is deposited, for example in waterways.
Sediment load	The amount of sediment reaching a waterway over a given time period from its catchment area. Also refers to the amount of sediment being transported by a waterway.
Sediment slug	An accumulation of sediment within a waterway formed where the flow velocity slows to the point where there is not enough energy to continue to carry the sediment suspended in the water column; for example, on meander bends and river pools.
Slumping	The process by which undercut, unsupported banks collapse. The result of the undercutting.
Subsidence	Another form of bank collapse where flows saturate banks and they collapse under the added weight of the water.

Surface water	Water flowing or held in waterways such as creeks, rivers and wetlands.
Terrestrial	Relating to land (as opposed to water).
Turbidity	A measure of how cloudy water is. Turbid water is caused by sediment or other pollutants.
Tributary	A waterway that flows into a larger waterway.
Undercutting	Occurs on vertical banks where streamflow scours sediment from the toe (bottom) of the bank.
Verge	Upland area adjacent to the floodplain.
Water quality	The physical, chemical and biological measures of water.
Waterlogging	Excess water close to the soil surface.
Watertable	Saturated level of unconfined groundwater. Wetlands in low-lying areas may be surface expressions of groundwater.
Waterway	Surface water bodies, including streams, rivers, lakes, wetlands, estuaries, coastal lagoons and inlets. Can be seasonally or permanently inundated.

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Appendix 1 Foreshore and channel assessment form

For property and paddock scale surveys

General details

Recorder's name: …… Survey date:……..

Tributary name: …… Section number: CB…….

Catchment name: Avon River Length of section: ……

Sub-catchment name…….. Shire……

GPS (start of survey section – left bank) E:…… N: ……

GPS (end of survey section – left bank) E:…… N: ……

Landholder contacted: Yes ☐ No ☐ Bank(s) surveyed (facing upstream)

Landholder consent obtained: Yes ☐ No ☐ Left ☐ Right ☐ Both ☐

Landholder present during survey: Yes ☐ No ☐

Landholder: ……..

Contact Number: ……

Property address: ……

Bank stability

Proportion of bank affected (% of survey area)	Undercutting	Firebreak/track washouts	Subsidence (sinking of soil)	Gully erosion	Sedimentation	Slumping (mass movement)
0–5% Minimal						
5–20% Localised						
20–50% Significant						
>50% Severe						

Are the banks subject to any artificial stabilisation? ☐ Yes ☐ No

Give details……

……

Waterways features

☐ Single channel ☐ Anabranch ☐ Crossing

☐ Braided channel ☐ Tributary ☐ Dam

☐ Deep pool ☐ Large woody debris ☐ Bridge

☐ Wetlands ☐ Vegetated island Other

☐ Groundwater seep ☐ Constructed riffles ……

☐ Natural riffle ☐ Sediment slug ……

Channel width (m)…….. Channel depth (m) ……

Vegetation health

☐ Looks healthy ☐ Some sick trees (some foliage loss) ☐ Many sick or dying trees ☐ Some dead trees ☐ Many dead trees

Are there any tree seedlings or saplings present? ☐ Yes ☐ No
Species: ……

Leaf litter: ☐ Absent ☐ Minimal cover ☐ Good cover ☐ Deep cover

Bare ground: % cover: …….

Native vegetation: ☐ Abundant ☐ Frequent ☐ Occasional ☐ Rare ☐ Absent

Exotic vegetation: ☐ Abundant ☐ Frequent ☐ Occasional ☐ Rare ☐ Absent

Instream cover: ☐ Leaf litter/detritus ☐ Rocks ☐ Branches ☐ Vegetation

Vegetation cover (native and weeds)

Proportion cover	Overstorey	Middlestorey	Understorey
> 80% Continuous			
20–80% Patchy			
< 20% Sparse			
0% Absent			

Proportion of native species

	Proportion (%) of native species
Overstorey	
Middlestorey	
Understorey	

Habitats

Aquatic invertebrates, reptiles and fish

- ☐ Cascades, rapids, riffles
- ☐ Meanders, pools
- ☐ Instream cobbles, rocks
- ☐ Instream logs
- ☐ Variety of instream and bank vegetation types

Terrestrial invertebrates

- ☐ Variety of vegetation types
- ☐ Protected basking sites (tree bark, leaf litter)

Birds (roosting/nesting sites)

- ☐ Trees
- ☐ Shrubs
- ☐ Rushes

Frogs

- ☐ Dense fringing vegetation
- ☐ Emergent plants/soft substrate for eggs

Reptiles

- ☐ Variety of vegetation types
- ☐ Protected basking/nesting sites (leaf litter, logs)

Mammals

- ☐ Dense protective vegetation

Water quality

pH……..

Salinity (ms/m)……

Temperature (ºC)……

Comments on water quality:

Fencing status

Fence section 1

Start……E Start……..N End……..……E End……..N

Left bank ☐ Right bank ☐

Fence condition: ☐Good ☐Moderate ☐Poor ☐No fence

Fence style: ☐ Barbed wire ☐ Electric ☐ Fabricated ☐ Ringlock ☐ Plain wire

Approximate distance [m] from main channel: ☐ <10m ☐ 10–20m ☐20–30m ☐ >30m

Fence section 2

Start……E Start……..N End……..……E End……..N

Left bank ☐ Right bank ☐

Fence condition: ☐Good ☐Moderate ☐Poor ☐No fence

Fence style: ☐ Barbed wire ☐ Electric ☐ Fabricated ☐ Ringlock ☐ Plain wire

Approximate distance [m] from main channel: ☐ <10m ☐ 10–20m ☐ 20–30m ☐ >30m

Fence section 3

Start……E Start……..N End……..……E End……..N

Left bank ☐ Right bank ☐

Fence condition: ☐ Good ☐ Moderate ☐ Poor ☐ No fence

Fence style: ☐ Barbed wire ☐ Electric ☐ Fabricated ☐ Ringlock ☐ Plain wire

Approximate distance [m] from main channel: ☐ <10m ☐ 10–20m ☐ 20–30m ☐ >30m

Fence section 4

Start……E Start……..N End……..……E End……..N

Left bank ☐ Right bank ☐

Fence condition: ☐ Good ☐ Moderate ☐ Poor ☐ No fence

Fence style: ☐ Barbed wire ☐ Electric ☐ Fabricated ☐ Ringlock ☐ Plain wire

Approximate distance [m] from main channel: ☐ <10m ☐ 10–20m ☐ 20–30m ☐ >30m

Stock access to foreshore: ☐ Yes ☐ No Vehicle access to foreshore: ☐ Yes ☐ No

Crossing point: ☐ Yes ☐ No

Foreshore condition rating

A Grade Foreshore	B Grade Foreshore	C Grade Foreshore	D Grade Foreshore
A1 Pristine	B1 Degraded – weed infested	C1 Erosion prone	D1 Ditch – eroding
A2 Near pristine	B2 Degraded – heavily weed infested	C2 Soil exposed	D2 Ditch – freely eroding
A3 Slightly disturbed	B3 Degraded – weed dominant	C3 Eroded	D3 Drain – weed dominant

(Choose one of the above. Use Grades A, B, C or D for general condition and use sub-grades for best and poorest ratings i.e. A1 through to D3)

General:…… Best: …… Poorest: ……...

Overall stream environmental health rating

Rating	Floodway & bank vegetation	Verge vegetation	Stream Cover	Bank stability & sediment	Habitat diversity
Excellent	15	8	8	8	6
Good	12	6	6	6	4
Moderate	6	4	4	4	2
Poor	3	2	2	2	1
Very poor	0	0	0	0	0

Surrounding landuse:

Conservation reserve (8) Urban (2) Agricultural (2)

Rural residential (4) Remnant bush (6) Commercial/industrial (1)

Total score = ☐

Score	40–55	30–39	20–29	10–19	0–9
Rating	Excellent	Good	Moderate	Poor	Very poor

Tributary assessment

Tributary survey section number: ……..

GPS (start of survey section – left bank) E:…….. N:……

GPS (end of survey section – left bank) E:…….. N:……

General foreshore rating: ……..

Comments:

Evidence of management

Tick the appropriate boxes:

- ☐ Prescribed burning
- ☐ Firebreak control
- ☐ Fencing
- ☐ Weed control
- ☐ Revegetation
- ☐ Erosion control
- ☐ Sediment management
- ☐ Other:……

Management issues

Tick the appropriate priority box for each management issue. If the issue does not exist along this section of the waterway it can be crossed out.

Issue	Priority		
	High	Medium	Low
Fire			
Disease			
Weeds			
Erosion			
Salinity			
Sediment			
Stock access			
Vehicle access			
Rubbish			
Pollution			

Issue	Priority		
	High	Medium	Low
Recreation			
Service corridors (roads)			
Crossing point			
Feral animals			
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Cultural features			
Other			

Ideas for management

Tick the appropriate boxes:

- ☐ Firebreak control
- ☐ Fencing
- ☐ Erosion control
- ☐ Stock/vehicle crossing
- ☐ Revegetation
- ☐ Weed control
- ☐ Riffles
- ☐ Sediment management
- ☐ Other:……

Native plant list

Introduced plant list

Native fauna list

Introduced fauna list

GPS coordinates

Coordinate	Description

Photos

Photo number	Description

Appendix 2 Examples of fence condition ratings

Fence in poor condition

Fence in moderate condition

Fence in good condition

(Photos: K. Gole, Department of Water)

Appendix 3 Foreshore grading system

A-Grade: *Foreshore has healthy native bush (i.e. similar to that found in nature reserves, state forests and national parks):*

A1. Pristine: The river embankments and floodway are entirely vegetated with native species and there is no evidence of human presence or livestock damage.

A2. Near Pristine: Native vegetation dominates. Some introduced weeds may be present in the understorey but not as the dominant species. Otherwise, there is no evidence of human impact.

A3. Slightly Disturbed: Native vegetation dominates, but there are some areas of human disturbance where soil may be exposed and weeds are relatively dense (i.e. local weed infestations along tracks). Native vegetation would quickly recolonise if human disturbance declined.

B-Grade: *The foreshore vegetation had been invaded by weeds, mainly grasses, and looks similar to typical roadside vegetation:*

B1. Degraded: Weed infested: Weeds have become a significant component of the understorey vegetation. Native species are still dominant but a few have been replace by weeds.

B2. Degraded: Heavily weed infested: Understorey weeds are nearly as abundant as native species. The regeneration of trees and large shrubs may have declined.

B3. Degraded: Weed dominant: Weeds dominate the understorey, but many native species remain. Some trees and large shrubs may have disappeared.

C-Grade: *The foreshore supports only trees over weeds or pasture. Bank erosion and subsidence may occur in localised areas:*

C1. Erosion prone: Trees remain with some large shrubs or tree grasses and the understorey consists entirely of weeds (i.e. annual grasses). There is little or no evidence of regeneration of tree species. River embankment and floodway are vulnerable to erosion due to the shallow-rooted weedy understorey providing minimal soil stabilisation and support.

C2. Soil exposed: Surface erosion. Older trees remain but the ground is virtually bare. Annual grasses and other weeds have been removed by livestock grazing and trampling or through human use and activity. Low level soil erosion has begun.

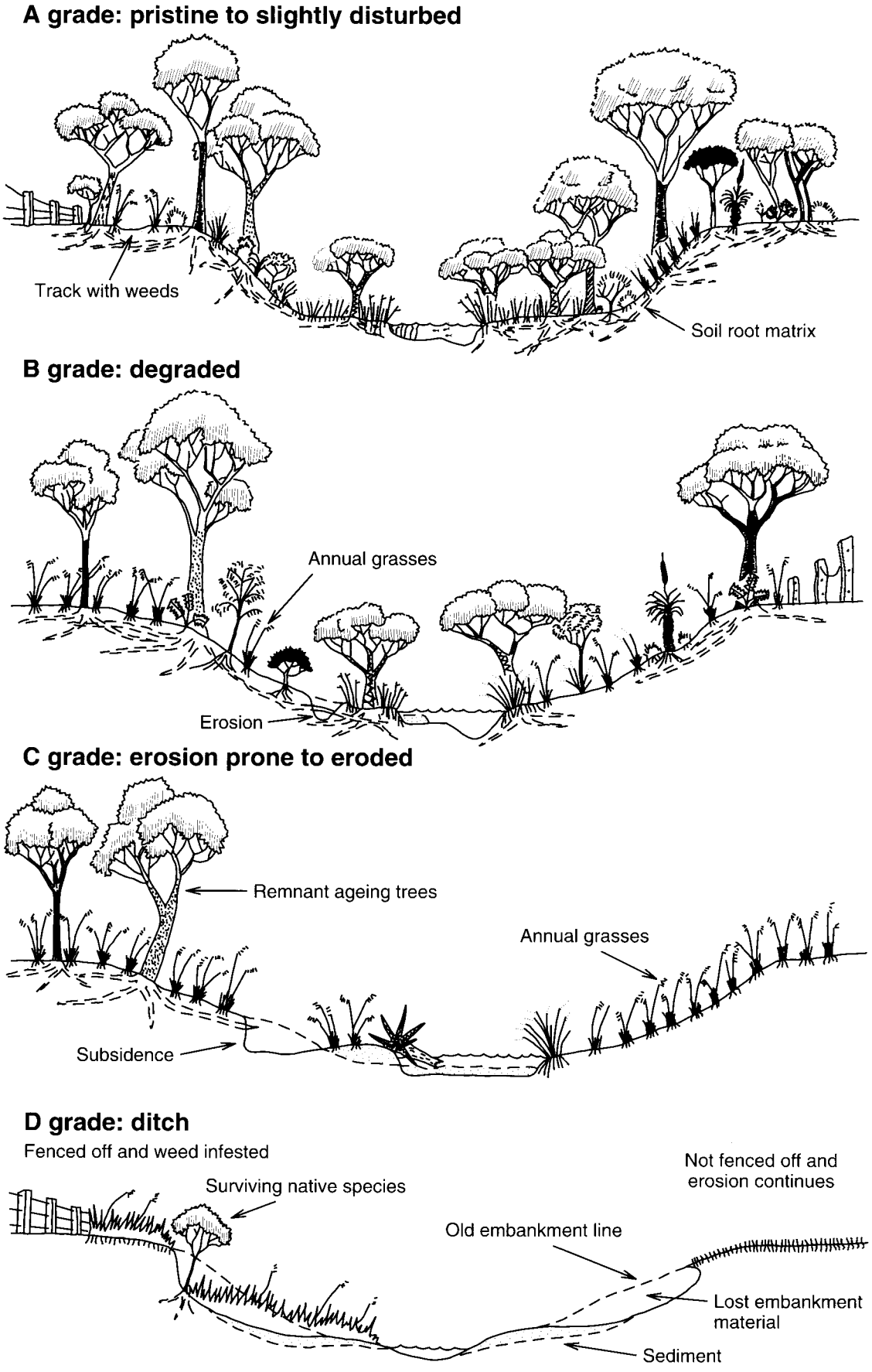
C3. Eroded: Soil is washed away from between tree roots. Trees are being undermined and unsupported embankments are subsiding into the river valley.

D-Grade: *The stream is little more than an eroding ditch or a weed infested drain:*

D1. Ditch – eroding: There is not enough fringing vegetation to control erosion. Remaining trees and shrubs act to impede erosion in some areas, but are doomed to be undermined eventually.

D2. Ditch – freely eroding: No significant fringing vegetation remains and erosion is out of control. Undermined and subsided embankments are common. Large sediment plumes are visible along the river channel.

D3. Drain – weed dominant: The highly eroded river valley has been fenced off, preventing control of weeds by stock. Perennial weeds have become established and the river has become a simple drain.



Adapted from Water and Rivers Commission, 1999

Appendix 4 Factors and scoring for determining the stream health rating

	Floodway and bank vegetation	Verge vegetation	Stream cover	Bank stability and sedimentation	Habitat diversity
Excellent	Healthy undisturbed native vegetation. Virtually no weeds. No disturbance. **(15 points)**	Healthy undisturbed vegetation. Verges more than 20 m wide. **(8 points)**	Abundant cover: shade, overhanging vegetation, snags, leaf litter, rocks and/or aquatic vegetation. **(8 points)**	No erosion, subsidence or sediment deposits. Dense vegetation cover of banks and verge. No disturbance. **(8 points)**	3 or more habitat zones. Some permanent water. **(6 points)**
Good	Mainly healthy undisturbed native vegetation. Some weeds. No recent disturbance. **(12 points)**	Mainly healthy undisturbed native vegetation. Verges less than 20 m wide. **(6 points)**	Abundant shade and overhanging vegetation. Some instream cover. **(6 points)**	No significant erosion, subsidence or sediment deposits in floodway or on lower banks. May be some soil exposure and vegetation thinning on upper bank and verge. **(6 points)**	2 habitat zones. Some permanent water. **(4 points)**
Moderate	Good vegetation cover, but mixture of native and exotic species. Localised clearing. Little recent disturbance. **(6 points)**	Good vegetation cover, but mixture of native and exotic species. Verges 20 m or more. **(4 points)**	Some permanent shade and overhanging vegetation. Some instream cover. **(4 points)**	Good vegetation cover. Localised erosion, bank collapse and sediment heaps only. Verges may have sparse vegetation cover. **(4 points)**	Mainly 1 habitat type with permanent water. OR Range of habitats with no permanent water. **(2 points)**
Poor	Mainly exotic groundcover. Obvious site disturbance. **(3 points)**	Narrow verges only (< 20 m wide). Mainly exotic vegetation. **(2 points)**	Channel mainly clear. Little permanent shade or instream cover. **(2 points)**	Extensive active erosion and sediment heaps. Bare banks and verges common. Banks may be collapsing. **(2 points)**	Mainly 1 habitat type with no permanent water. **(1 point)**
Very poor	Mostly bare ground or exotic groundcovers (i.e. pasture, gardens or weed infestations, but no trees). **(0 points)**	Mostly bare ground or exotic groundcovers (i.e. pasture, gardens or weed infestations, but no trees). **(0 points)**	Virtually no shade or instream cover. **(0 points)**	Almost continuous erosion. Over 50% of banks collapsing. Sediment heaps line or fill much of the floodway. Little or no vegetation cover. **(0 points)**	Stream channellised. **(0 points)**

Scores for surrounding landuse:

Conservation reserve	**(8 points)**	Rural residential	**(4 points)**	Agricultural	**(2 points)**
Remnant bush	**(6 points)**	Urban	**(2 points)**	Commercial/ industrial	**(2 points)**

Adapted from Water and Rivers Commission 1999, Planning and Management: Foreshore condition assessment in farming areas of south-west Western Australia, River Restoration Report No. RR3.

Appendix 5 Plants and animals identified during the Monjerducking Gully survey

Table A.5.1 Native plants identified during the survey

Common name	Scientific name
Tree	
Flat-topped yate	*Eucalyptus occidentalis*
Flooded gum	*Eucalyptus rudis*
Red morrell	*Eucalyptus longicornis*
Salt River gum	*Eucalyptus sargentii*
Swamp sheoak	*Casuarina obesa*
Wandoo	*Eucalyptus wandoo*
York gum	*Eucalyptus loxophleba sub. loxophleba*
Shrub	
Bluebush	*Maireana spp.*
Golden wreath wattle	*Acacia saligna*
Jam	*Acacia acuminata*
Lesser bottlebrush	*Callistemon phoeniceus*
Mohan	*Melaleuca viminea sub. viminea*
Ruby saltbush	*Enchylaena tomentosa*
Samphire	*Halosarcia spp.*
Silver saltbush	*Atriplex bunburyana*
Wavy-leafed saltbush	*Atriplex undulata*
Herb	
Everlastings	*Helichrysum spp.*
Rushes and sedges	
Native bulrush	*Typha domingensis*
Pale rush	*Juncus pallidus*
Grass	
Mallee lovegrass	*Eragrostis dielsii*

Table A.5.2 Introduced plants identified during the survey

Common name	Scientific name
Herb	
Cape tulip	*Homeria spp.*
Capeweed	*Arctotheca calendula*
Flatweed	*Hypochaeris spp.*
Narrowleaf lupin	*Lupinus angustifolius*
Onion weed	*Asphodelus fistulosus*
Pie melon	*Citrullus lanatus*
Waterbuttons	*Cotula coronopifolia*
Grass	
Barley grass	*Hordeum leporinum*
Love grass	*Eragrostis spp.*
Rye grass	*Lolium sp.*
Salt-water couch	*Paspalum vaginatum*
Wild oats	*Avena fatua*
Rushes and sedges	
Sharp rush	*Juncus acutus*

Table A.5.3 Animals identified during the survey

Common name	Scientific name
Native mammals	
Western grey kangaroo	*Macropus fuliginosus*
Reptiles	
Fence skink	*Acritoscincus trilineatum*
Introduced mammals	
European red fox	*Vulpes vulpes*
European wild rabbit	*Oryctolagus cuniculus*
Feral cat	*Felis catus*

Table A.5.4 Bird species identified during the survey

Common name	Scientific name	Habitat type*	Conservation status*
Bird species			
Australian magpie	*Gymnorhina tibicen*	Woodland	Farmland
Australian magpie-lark	*Grallina cyanoleuca*	Woodland	Farmland
Australian raven	*Corvus coronoides*	Farmland	Farmland
Australian ringneck	*Barnardius zonarius*	Farmland	Farmland
Black-shouldered kite	*Elanus notatus*		
Brown falcon	*Falco berigora*		
Common bronzewing	*Phaps chalcoptera*		
Crested pigeon	*Ocyphaps lophotes*	Farmland	Farmland
Elegant parrot	*Neophema elegans*		
Galah	*Eolophus roseicapilla*	Woodland	Farmland
Golden whistler	*Pachycephala pectoralis*		
Grey fantail	*Rhipidura fuliginosa*	Woodland	Remnant Dependent
Inland thornbill	*Acanthiza pursilla*	Shrubland	Priority
Laughing turtledove	*Streptopelia senegalensis*		
Pacific black duck	*Anas superciliosa*		
Red-tailed black cockatoo	*Calyptorhynchus banksii*		
Rufous whistler	*Pachycephala rufiventris*	Woodland	Priority
Striated pardalote	*Pardalotus striatus*		
Weebill	*Smicronis brevirostris race occidentalis*	Woodland	Remnant Dependent
Western gerygone	*Gerygone fusca*	Farmland	Remnant Dependent
Western thornbill	*Acanthiza inornata*		
White-faced heron	*Egretta novaehollandiae*	Farmland	Farmland
Willie wagtail	*Rhipidura leucophrys*	Woodland	Farmland

* Greening Australia Western Australia 1994

Appendix 6 Fencing information for surveyed sections of Monjerducking Gully

Length and condition of fencing for each surveyed section

Section	**Left bank fence** (m)	**Right bank fence** (m)	**Length of section** (m)
Main Channel			
MD001	920 (G)	920 (G)	920
MD002	1 170 (M)	1 170 (M)	1 170
MD003	Not assessed	Not assessed	1 600
MD004	1 900 (G)	1900 (G)	1 900
MD005	800 (M)	800 (M)	800
MD006	200 (G)		1 200
MD007	1 620 (G)		1 620
MD008	1 070 (G)		1 070
MD009			250
MD010		250 (G)	950
MD011		650 (M)	650
MD012	750 (M)		750
MD013	500 (G)	500 (M)	500
MD014	1 250 (M)	1 250 (M)	1 250
MD015	750 (G)	750 (G)	750
MD016	180 (G)		470
MD017	370 (G)	370 (G)	370
MD018	850 (G)	850 (G)	850
MD019	750 (G)	750 (M)	750
MD020	100 (M)	100 (M)	100
MD021			670
MD022			650
MD023	220 (M)	220 (M)	220
MD024			370
MD025	850 (G)	850 (G)	850
MD026			550
Total	**14 250**	**11 330**	**21 230**

Section	**Left bank fence** (m)	**Right bank fence** (m)	**Length of section** (m)
Tributaries			
MDTrib001	150 (M)	150 (M)	150
MDTrib002			600
MDTrib003	400 (M)		400
MDTrib004	150 (G)	150 (G)	150
MDTrib005			420
MDTrib006	300 (G)	300 (G)	300
MDTrib007	300 (G)	300 (G)	300
MDTrib008	250 (G)		250
Total	**1 550**	**900**	**2 570**

Fence condition: (G) = good, (M) = moderate, (P) = Poor

Appendix 7 Description and management options for each surveyed section

Table A.7.1 Description and management options for each surveyed section of Monjerducking Gully

Section	General foreshore grade	OSEHR	Section description	Management options
MD001	B-grade	Moderate	This section begins at the confluence with the Avon River. There is a significant 90º meander within the first 150 m, which has considerable bank erosion (photo MJ001 05). Other than this small patch of erosion, the remainder of the channel is well vegetated with samphire (*Halosarcia* spp.), silver saltbush (*Atriplex bunburyana*) and a variety of mid and overstorey species. Although there are some stags (dead trees) in the adjoining salt lakes, the majority of species are healthy and regenerating. Weeds are dominant in this section, although they are helping to stabilise the banks. There is an old crossing point mid-way through the section which is no longer used. The current landowner has worked actively to restore and improve the condition of this section. This section was rated to be in moderate condition.	• The current landowners should be commended for their efforts to improve this section. Little management is required to maintain the current condition.
MD002	C-grade	Poor	There were a number of salt lakes either side of the main channel and an anabranch occurred at the end of the section, which flows in from approximately 300 m upstream. The channel widened considerably in this section. The fringing vegetation has a diverse mixture of native species, although weeds such as lovegrass (*Eragrostis* spp.) and barley grass (*Hordeum leporinum*) dominate the understorey. One individual sharp rush (*Juncus acutus*) was observed close to Yenyening Lakes Rd. Piles of farm rubbish, including emptied plastic herbicide and sheep wormer containers, were observed. The section is fenced from stock and the previous landowner has undertaken some revegetation.	• Remove sharp rush (*Juncus acutus*). • Remove rubbish to prevent it from being washed downstream.

Section	General foreshore grade	OSEHR	Section description	Management options
MD003			This section was not included in the survey. Observations from neighbouring properties and aerial photography indicate that this section appears to be fenced and revegetated for the first 300 m, although during the survey stock were observed in this fenced area. Beyond the fenced area, the gully appears to be largely cleared and consequently the banks are eroding and the channel is eroding into the adjoining farm land (Photo MJ004 01).	
MD004	B-grade	Good	The channel narrows in this section and has one significant meander, which has localised erosion. The channel has some incision, possibly due to high velocity flows received from cleared upstream sections. Salt lakes extend along the second half of the left bank, although they would only be connected to the main channel during flood events. This section has been fenced for approximately 20 years. The verges are up to 300 m wide along the left bank and 100 m wide on the right bank. As a result, the fringing vegetation is diverse, with little weed invasion, although some sharp rush (*Juncus acutus*) is present. A number of species are actively regenerating but there are stags in the main channel and the salt lakes, as a result of recent salinisation and waterlogging. This section was rated to be in good condition.	• The current landowners should be commended for their efforts to improve the condition of this section. Little management is required to maintain the current condition, other than the removal of sharp rush (*Juncus acutus*) and erosion control on the meander bend.

Section	General foreshore grade	OSEHR	Section description	Management options
MD005	C-grade	Poor	This is a relatively short section, which is part of a smaller land holding. There is some braiding of the channel and the confluence to the first major tributary is found at the upstream end of this section. This section is fenced and has been revegetated with jam (*Acacia acuminata*), swamp sheoak (*Casuarina obesa*) and a diversity of *Eucalypt* species. The understorey is dominated by weeds, including sharp rush (*Juncus acutus*). There is a significant amount of undercutting and sedimentation along the channel. This is possibly caused by the significant velocity of flow received from immediately upstream where the channel is cleared for approximately 2.5 km. Consequently, this section was rated to be in poor condition, although the condition could easily be improved by revegetating the banks using salt-tolerant shrubs and groundcovers. MDTrib001 – Known as 'Parson's Gully' to locals, this tributary drains a small, mostly cleared sub-catchment to the south-east of the main channel. At its confluence with Monjerducking Gully, the channel of this tributary is broad (40 m) and dominated with lovegrass (*Eragrostis* spp.). The start of the tributary is in the same small fenced paddock as section MJ005. After about 150 m, the tributary crosses K1 Road and then splits into two channels. This section is also revegetated. This tributary was rated as C-grade.	• Remove sharp rush (*Juncus acutus*). • Stabilise the banks using salt-tolerant shrubs and groundcovers.
MD006	D-grade	Very poor	This section was rated to be in very poor condition. Lateral erosion is consuming the surrounding farmland with the channel extending up to 100 m across, incorporating the floodway and part of the floodplain. There is no fringing vegetation left to support the banks, other than a small patch at the end of the section which is at risk of eventually being consumed by the widening channel. Salt scalds are evident along the channel and in the paddocks.	• This section should be fenced and stock excluded for up to 5 years to allow the gully to recover. • Revegetation using ripping and direct seeding or seedlings would greatly assist this area, as the soil is compacted and the current seed store is too limited to enable natural regeneration.

Section	General foreshore grade	OSEHR	Section description	Management options
MD007	D-grade	Very poor	This section was also rated to be in very poor condition. Lateral erosion and undercutting were significant but not as severe as in the previous section. The left bank is fenced, although the gully forms part of a stocked paddock. Fringing vegetation consists of a single York gum (*Eucalyptus loxophleba subsp. loxophleba*) and a variety of annual agricultural weeds. There are a large number of rabbit warrens (>20) at the start of this section, causing additional erosion and bank instability. MDTrib002 – the start of this tributary is in similar condition to the main channel. The channel is suffering from lateral erosion, due to the absence of fringing vegetation. Further upstream, some sections of the tributary have been revegetated. This tributary is the longest of Monjerducking Gully, extending beyond Beringer Road. It was rated as D-grade.	• This section should be fenced and stock excluded for up to 5 years to allow the gully to recover. • Revegetation using ripping and direct seeding or seedlings would greatly assist this area, as the soil is compacted and the current seed store is too limited to enable natural regeneration.
MD008	C-grade	Poor	The channel narrows considerably compared to the downstream section. A small dam exists near the start of the section, and although the wall of the dam forms part of the bank, it does not appear to be causing any impact. Fringing vegetation consists of York gum (*Eucalyptus loxophleba subsp. loxophleba*), Salt River gum (*Eucalyptus sargentii subsp. sargentii*) and swamp sheoak (*Casuarina obesa*) with a variety of annual agricultural weeds dominating the understorey. This section was rated to be in poor condition, mostly due to the lack of native, mid and understorey vegetation, especially toward the end of the section. Some household and farm rubbish is located in a small farm dam toward the end of the section. MDTrib003 – This tributary is cleared for almost its entire length and the section surveyed at the start is representative of its condition. Local landowners are concerned over the level of salinisation along this tributary, which is particularly evident where it crosses the Caroling–Bally Bally Road. This tributary was rated as D-grade.	• Although stock access appears to be managed, fencing the right bank so that the waterway is not part of a paddock would enable it to recover. Stock could still be allowed access to suppress weeds and the fire risk, so long as access to the channel was carefully managed. • Remove rubbish to prevent downstream impacts.

Section	General foreshore grade	OSEHR	Section description	Management options
MD009	D-grade	Very poor	This is a short section that is heavily stocked. Fringing vegetation is sparse and is limited to a few York gums (*Eucalyptus loxophleba subsp. loxophleba*) and Salt River gums (*Eucalyptus sargentii subsp. sargentii*) at the end of the section. Exposed calcrete starts to occur in this section, which is common in the middle section of this catchment. Sharp rush (*Juncus acutus*) is dominant and regenerating. This section was rated to be in very poor condition.	• Stock should be excluded from this paddock for a few years to enable the waterway to stabilise and encourage natural regeneration. After this time, stock access should be limited to enable weed suppression. • Sharp rush should be removed (*Juncus acutus*).
MD010	C-grade	Poor	There has been an attempt at revegetating this section by previous landowners, although the current owner mentioned many of the seedlings planted were heavily grazed. The current landowner has excluded stock from the waterway and is actively revegetating the section. The overstorey is sparse and the banks are dominated with weeds, including sharp rush (*Juncus acutus*). A small soak exists towards the end of the section, which provides some breeding habitat for birdlife. Disused piggery sheds have partially collapsed into the channel. This section was rated to be in poor condition.	• Remove sharp rush (*Juncus acutus*). • Remove piggery sheds. • Continue with revegetation, using species tolerant to salinity and waterlogging.
MD011	C-grade	Poor	This section is similar to the previous section and was rated to be in poor condition. The banks were dominated by annual agricultural weeds and sharp rush (*Juncus acutus*), which is regenerating. There has been some revegetation in the past but this seems to have been compromised by weed infestation or possibly stock grazing by the previous landowner. A seepage exists toward the end of the section and along the right bank beyond the property boundary (<50 m) is a large plantation of jam (*Acacia acuminata*) and sandalwood (*Santalum* sp.).	• Remove sharp rush (*Juncus acutus*). • Limit future stock access and revegetate with local native species to reduce bank erosion and improve condition.

Section	General foreshore grade	OSEHR	Section description	Management options
MD012	C-grade	Poor	This section is in a broad valley and a number of major and minor tributaries drain in at this point. This results in flow surges when there is significant rainfall which, according to the current landowner, quickly subsides. The banks are dominated by an understorey of weeds, including sharp rush (*Juncus acutus*) and some erosion is evident along the banks. This section was rated to be in poor condition. MDTrib004 – This is a relatively short tributary (~1.2 km), which carries a large volume of flow from its relatively small catchment. Approximately 100 m upstream, the tributary is fenced and flows through an extensive area of revegetation, which joins the revegetated area in section MD013. Salt scalds exist in the upper reaches of this sub-catchment. Approximately 600 m of the tributary is fenced and revegetated upstream of Caroling–Bally Bally Road and revegetated, but many of the planted trees are too far away from the channel to provide erosion control or shade and many have been lost to salinisation. MDTrib005 – The channel of this tributary is broad and flat in its lower reaches but with a more defined channel in the middle reaches. Dead trees and salt scald along the channel and the verges indicate this tributary is affected by salinisation, although some regeneration is occurring.	• Remove sharp rush (*Juncus acutus*). • Limit future stock access and revegetate with local native species to reduce bank erosion and improve condition.

Section	General foreshore grade	OSEHR	Section description	Management options
MD013	C-grade	Poor	This section has been fenced and revegetated for 10–15 years. Consequently, the verges are well vegetated with a diversity of native species. There is little weed invasion, other than isolated occurrences of sharp rush (*Juncus acutus*). A small anabranch flows along the right bank. This section drains two major tributaries, resulting in quite 'flashy' flows, similar to the previous section. This has resulted in some lateral erosion of the channel, which extends up to 50 m across in some parts. This section was rated to be in poor condition, mostly due to the instability of the banks and lack of stream cover. This will progressively improve as the planted trees grow larger, shading the channel and as the understorey regenerates. There is a small amount of farm rubbish (E 508371 N 6443951) in the channel. There is a small pile of gravel on the both sides of the bank (E 508443 N 6444066) where the landowner has tried to construct either a crossing or riffle but the material used was too fine and the gravel has been washed away. Neither the rubbish nor the gravel are causing any adverse impacts. MDTrib006 – This tributary enters the main channel where there is a large amount of exposed calcrete and salt scalding, resulting in extensive areas of bare ground. However, the condition of the tributary changes rapidly and 70 m upstream the channel narrows and the verges are well vegetated with a diversity of native species. There is some localised undercutting where a log is deflecting flow into the left bank. MDTrib007 – This tributary has a small sub-catchment and the channel is broad and flat with extensive sedimentation. The channel is fenced for approximately 500 metres and in this fenced area there is another smaller tributary which runs parallel to this tributary. The banks in the lower reaches are exposed and suffering from bank slumping.	• Remove farm rubbish. • Now that overstorey species have been established in the revegetated area, consider revegetation of the understorey using salt-tolerant shrubs, especially along Trib007. • Remove sharp rush (*Juncus acutus*).

Section	General foreshore grade	OSEHR	Section description	Management options
MD014	B-grade	Moderate	This section was rated to be in moderate condition. The channel runs along the southern edge of a large revegetated section, which is up to 500 m wide and runs the length of the section. The area was revegetated in the 1980s. The banks along this section are stable, although the understorey is dominated by lovegrass (Eragrostis sp.). Minimal erosion is occurring on a meander towards the end of the section. A large salt lake runs along the left bank, which has a number of stags, although at this stage it does not appear to be affecting the revegetated area.	• The current landowners should be commended for their efforts to improve this section. Little management is required to maintain the current condition.
MD015	C-grade	Poor	This section is being slowly degraded by the effects of salinisation and, as a result, was rated to be in poor condition. At the start of the section, the right bank has an extensive salt scald. There have been attempts to revegetate the right bank, although it appears many trees have been lost, especially around the salt scalds. A large salt lake runs along the majority of the left bank. Very few living trees remain in this section with most having been lost to salinisation. Wandoo (*Eucalyptus wandoo*) and jam (Acacia acuminata) are regenerating at the start and end of this section. Considerable birdlife was observed in this section (13 species).	• Continue revegetation attempts using salt-tolerant species, including shrubs.

Section	General foreshore grade	OSEHR	Section description	Management options
MD016	D-grade	Very poor	A tight meander bend occurs in this section, and at the confluence of the eighth tributary (MDTrib008). A small salt scald occurs on the left bank of the meander. Two small dams exist on the left bank. This section was cropped at the time of the survey but also appears to be used for stock grazing. Few native trees remain to support the banks and consequently, the banks are eroding. This section was rated to be in very poor condition. MDTrib008 – This is a large tributary that extends north past Morbining Road and has major tributaries of its own. However, this tributary is in very poor condition, suffering from the effects of salinisation. The valley is broad and salt scald is evident in the channel, verges and adjacent paddocks almost the entire length of the tributary. Dead trees are scattered along the channel and sedimentation and erosion are severe. There has been some recent revegetation along the right bank and in the middle and upstream sections (north and south of Morbining Road).	• Fencing to limit stock access would enable the waterway to stabilise and encourage natural regeneration. • Natural regeneration should be aided with revegetation using salt-tolerant native species.
MD017	C-grade	Poor	An anabranch runs parallel to the left bank for the length of this section. The anabranch has extensive salt scalds on the left bank. This section is fenced and has been revegetated in the past, although survival rates are better on the right bank, which has no scalding. The understorey is dominated by annual agricultural weeds. This section was rated to be in poor condition.	• Continue revegetation attempts using salt-tolerant species, including shrubs.

Section	General foreshore grade	OSEHR	Section description	Management options
MD018	C-grade	Poor	The channel was narrow (6–15 m) at the start of this section and as the valley floor broadened, so did the channel, extending up to 80 m across. The section has been fenced and revegetated, although there was a high occurrence of dead jam (*Acacia acuminata*) and golden wreath wattle (*Acacia saligna*). Salinisation is evident along the valley floor. At the end of the section the entire channel exhibits a white salt crust, which extends along a minor tributary and throughout the next section. The minor tributary at the end of the section has also been fenced and recently revegetated. This section was rated to be in poor condition.	• Continue revegetation attempts using salt-tolerant species, including shrubs.
MD019		Poor	This section is similar to the previous section, although the channel is more defined and narrow at the end of the section. Rip lines exist in the channel, which run at 90º to the channel from bank to bank, and are located approximately 20–30 m apart. The purpose of these lines is unclear. Sharp rush (*Juncus acutus*) occurs at the end of this section. This section was rated to be in poor condition.	• Continue revegetation attempts using salt-tolerant species, including shrubs. • Remove sharp rush (*Juncus acutus*).
MD020	C-grade	Poor	This was a short section where the channel splits into two to form the headwaters of Monjerducking Gully. This section is fenced and has been revegetated. Sharp rush (*Juncus acutus*) is dominant and actively regenerating along the banks. Downstream from where the two channels meet, the left bank is eroding and subsiding into the channel, because it is unable to cope with the volume of flow received from the convergence of the headwaters. This section was rated to be in poor condition.	• Remove sharp rush (*Juncus acutus*). • Continue revegetation attempts using salt-tolerant species, including shrubs.

Section	General foreshore grade	OSEHR	Section description	Management options
MD021	D-grade	Very poor	This section was largely cleared and the few remaining native species that exist along the bank are at risk of collapsing into the channel. Due to the absence of fringing vegetation to support the banks, the banks are actively eroding and the channel is incised. Sharp rush (*Juncus acutus*) exists in this section. A large granite outcrop exists at the end of this section and there is some seepage at the base of this outcrop. This section was rated to be in very poor condition.	• Fencing to limit stock access would enable the waterway to stabilise and encourage natural regeneration. • Natural regeneration should be aided with revegetation using salt-tolerant native species. • Remove sharp rush (*Juncus acutus*).
MD022	D-grade	Very poor	The river valley is steeper in this section as the channel meanders towards the top of the catchment. This section consists of a series of granite outcrops, which are acting as cascades and riffles. This section is largely cleared, and the remaining vegetation is at risk of collapsing into the channel. There are two small fenced blocks that have been revegetated approximately 30–40 m away from the channel about mid-way through this section. There are a number of seeps in this section. The majority of the channel is crusted with salt. Sharp rush (*Juncus acutus*) exists in this section. This section was rated to be in very poor condition.	• Fencing to limit stock access would enable the waterway to stabilise and encourage natural regeneration. • Natural regeneration should be aided with revegetation using salt-tolerant native species. • Remove sharp rush (*Juncus acutus*).
MD023	C-grade	Poor	This is a short, revegetated and fenced section. The channel bed through this section was gravelly and lateritic and is suffering from localised incision. Salinisation is evident through this section with the channel and verges being encrusted with salt. However, salt-tolerant species including (*Casuarina obesa, Eucalyptus sargentii subsp. sargentii and Eucalyptus occidentalis*) were chosen when revegetating this area, all of which are healthy and some were regenerating. Sharp rush (*Juncus acutus*) infestation occurs at the start of this section. This section was rated to be in poor condition.	• Remove sharp rush (*Juncus acutus*). • Continue revegetation attempts using salt-tolerant species, including shrubs.

Section	General foreshore grade	OSEHR	Section description	Management options
MD024	D-grade	Very poor	This was the final section of one of the headwater channels of Monjerducking Gully (Channel A). The waterway drains overland flow from a large, cleared paddock and only forms a defined channel at the start of the section. This section was rated to be in very poor condition as there was no native vegetation and the channel was actively eroding.	• Manage stocking rates in this paddock and consider fencing the channel and revegetating with local native salt-tolerant species.
MD025	B-grade	Moderate	This section commenced at the end of section MJ020, where the main channel splits into two to form its headwaters. This channel drains the north-eastern portion of the headwaters. This section has been fenced and revegetated with salt-tolerant species, including wavy-leafed saltbush (*Atriplex undulata*), jam (*Acacia acuminata*), bluebush (*Maireana spp.*), swamp sheoak (*Casuarina obesa*) and a variety of Eucalyptus species, all of which were thriving. There is some localised bank erosion in the first half of this section and some sharp rush (*Juncus acutus*) occurs toward the end of the section. A minor tributary flows in mid-way through the section, forming part of the headwaters. This section was rated to be in moderate condition.	• Remove sharp rush (*Juncus acutus*). • Continue revegetation attempts using salt-tolerant species, including shrubs.
MD026	C-grade	Poor	This was the final section of the most northern headwater channel. York gums (*Eucalyptus loxophleba subsp. loxophleba*) were the only native species found in this section, many of which were dead or at risk of collapsing into the channel due to undercutting or in one case, gully erosion. Bank erosion was significant in this section until after the point where the gully erosion occurred. Upstream of this point the channel was broad and poorly defined. Sharp rush (*Juncus acutus*) exists in this section. This section was rated to be in poor condition.	• Fencing to limit stock access would enable the waterway to stabilise and encourage natural regeneration. • Natural regeneration should be aided with revegetation using salt-tolerant native species. • Remove sharp rush (*Juncus acutus*).

Appendix 8 Plant species suitable for revegetation

Native species suitable for revegetation along Monjerducking Gully and its tributaries

(Oversby, 2004; Water and Rivers Commission, 1997a; Water and Rivers Commission, 1997b)

Species	Preferred site and soil conditions and propagation information
Rushes and sedges	
Coast saw sedge (*Garnia trifida*)	Occurs on most soils types on fresh to saline floodways. Moderately tolerant to water logging and very salt tolerant. Propagated from creeping stems.
Finger rush (*Juncus subsecundus*)	Grows on moist and seasonally wet floodway soils. Can be direct seeded.
Jointed twigrush (*Baumea articulata*)	Suitable for heavy and sandy soils on streambanks and floodways. Can withstand prolonged inundation up to 1 m. Transplant using creeping stems.
Shore rush (*Juncus krausii*)	Suitable for streambanks, seeps and floodways. Very tolerant to waterlogging and salinity. Easily propagated by seed and by transplanting creeping stems.
Spiny flat sedge (*Cyperus gymnocaulo*s)	Suitable for most soil types on streambanks and seeps, especially in disturbed areas or waterways with high nutrient levels. Moderately salt tolerant but does not tolerate inundation for very long.
Ground cover	
Creeping saltbush/ berry saltbush (*Atriplex semibaccata*)	Suitable for a wide variety of fresh to slightly saline soils across the landscape including floodfringes and floodways. Slightly waterlogging and salt tolerant. Can be grown from tubestock or direct seeded.
Sea heath (*Frankenia pauciflora*)	Grows in sands and lighter soils in floodways and winter-wet areas. Very salt and waterlogging tolerant. Can be grown from tubestock.
Grasses	
Kerosene grass (*Aristida holathera*)	Grows on sands, loams and gravels on floodfringes and the drier parts of floodways. Does not tolerate waterlogging but is slightly salt tolerant. Can be grown from tubestock or direct seeded.
Native marine couch (*Sporobolus virginicus*)	Suitable for lighter soils on streambanks and floodways. Very tolerant to waterlogging and moderately salt tolerant. Easily propagated by transplanting creeping stems.
Shrubs	
Astartea (*Astartea fascicularis*)	Grows on alkaline sands near watercourses, wetlands and seasonally wet depressions. Can be grown from cuttings taken in autumn or direct seeded.
Golden wreath wattle (*Acacia saligna*)	Grows on a variety of soil types on floodfringes and floodways. Can be planted from tubestock or direct seeded. Seed needs scarification and heat treatment for uniform germination.
Jam wattle (*Acacia acuminata*)	Grows on a variety of soil types, especially red loams, on floodfringes and drier floodways. Slightly waterlogging and salt tolerant. Plant as tubestock or direct seed. Seed needs scarification and heat treatment for uniform germination.

Manna gum (*Acacia microbotrya*)	Occurs on a wide range of soil types on floodways and floodfringes. Slightly waterlogging and salt tolerant. Plant from tubestock or direct seed. Seed needs scarification and heat treatment for uniform germination.
Mohan (*Melaleuca viminea sub .viminea*)	Grows in a variety of soil types in floodways. Moderately salt and waterlogging tolerant. Can be grown from tubestock or direct seeded.
Robin redbreast bush (*Melaleuca lateritia*)	Grows on floodway soils. Can be grown from cuttings and direct seeded.
Swamp banksia (*Banksia littoralis*)	Grows within floodfringes but is not tolerant of prolonged waterlogging and inundation. Can be grown readily from seed collected in autumn and late winter and direct seeded.
Swamp paperbark (*Melaleuca rhaphiophylla*)	Suitable for a variety of floodway soils. Extremely tolerant of waterlogging and mildly salt tolerant. Plant tubestock or direct seed.
Swamp sheoak (*Casuarina obesa*)	Suitable for a variety of floodway soils. Very salt and waterlogging tolerant. Plant tubestock or direct seed.
Trees	
York gum (*Eucalyptus loxophelba sub. loxophelba*)	Suitable for a variety of soil types including floodfringes and the drier parts of floodways. Does not tolerate waterlogging but some provenances are moderately salt tolerant. Plant tubestock or direct seed.
Flooded gum (*Eucalyptus rudis*)	Suitable for most soil types in winter-wet depressions, floodways and floodfringes. Very tolerant of waterlogging and moderately salt tolerant. Plant tubestock or direct seed.

Appendix 9 Recovery Statement Number 1: Fire

Introduction

The *Avon Waterways Committee* (AWC) is an organisation formed to assist the community and government agencies to sustainably manage the waterways within the Avon River Basin, within a framework of natural resource management. It has a mandate to continue the progression of the *Avon River Management Programme*, developed by its predecessor, the *Avon River Management Authority* (ARMA).

It has resolved to evolve the policies developed by ARMA as a statutory authority into more 'user friendly' position statements, called ***Recovery Statements***, and to develop new statements for issues as they arise.

The AWC, in developing these documents, have agreed that the *'Principles of River Management'* written by the late Jim Masters OA, and other sound scientific principals will underpin each Statement. Further, they recognise that each document must be consistent with the Avon Catchment Council's *Natural Resource Management Strategy for the Avon River Basin*.

The following document is a draft *Recovery Statement* on '***FIRE***.'

Objectives

The long-term objective of Avon Waterways Committee is to restore the natural functioning and vegetation of the Avon River and its major tributaries. Arising out of this aim, the Committee has four objectives related to fire:

- To protect riverine ecosystems from the damaging effects of uncontrolled fire:
- To use controlled fire for regeneration in accordance with management plans;
- To manage the fire hazard along the river, so as to minimise the threat of wildfire's to adjoining assets and property, and;
- To work cooperatively with Local Governments, Fire Brigades and neighbours with respect to fire management and development of Fire Management Plans.

Background

Fire is a natural factor in most Australian ecosystems. It can be started by lightning as well as by humans. The native bush is adapted to occasional fire; plants and animals either survive the fire, or regenerate following it. Many native plant species regenerate best after fire (although along the Avon River, regeneration events are also associated with floods).

Different types of native bush are adapted to different fire regimes. We have no knowledge of the "natural" fire regime that would have occurred in the Avon valley before agricultural development, but it can be inferred from the presence of fire-tender species such as Swamp Sheoak (*Casuarina obesa*) that fires may not have naturally occurred more frequently than every 15 or 20 years.

However, the strip of bush along the Avon River and its tributaries is no longer in its natural state. The surrounding country has been largely cleared and converted to crop land, pasture and urban development, limiting opportunity for recolonisation of burnt areas by native birds and animals.

Many weeds (especially exotic annual grasses) are thickly established in the bush, while in some places the native herbivores have been displaced by sheep.

Whilst fire is a natural factor in the bush, it can be a damaging agency in degraded bush. In particular, frequent fires enhance further weed development that in turn leads to higher annual fire hazards. Fire is a useful (indeed often essential) agent for bushland regeneration, but if it occurs too frequently, it can eliminate some native species and if it is too intense, it can burn down valuable habitat trees and accelerate erosion along the river banks.

Uncontrolled summer fires are also a threat to human values. Along the Avon River are several towns, minor settlements, farms businesses, bridges, powerlines, railways, tourist sites and historic buildings. These assets need to be protected from bushfires, including fires that may start in the river system.

The AWC has no significant resources at this stage to carry out fire management programs or to fight fires. We are therefore dependent upon the assistance of local Bushfire brigades and neighbours; equally they are dependent upon us to ensure our policies and river management plans are practical as well as visionary.

Strategies

In order to achieve its objectives, AWC will:

1. Undertake a Wildfire Threat Analysis of the river system. This will be done in conjunction with Local Authorities and experienced Bushfire personnel in each district. The purpose will be to identify all the important values that are potentially threatened by a fire starting in the river system.

2. Develop fire management plans to cover the areas of the river adjacent to identified high value sites and adjacent land as necessary. These plans will deal with issues such as access, firebreaks, fire suppression plans and hazard reduction, and will set out the various responsibilities for decision-making by those involved in doing the work which is prescribed. All plans will be undertaken with full community involvement. Final plans must be submitted to the AWC for consideration, and a recommendation will be made to the Department of Water for endorsement if appropriate.

3. Aim to keep fire permanently out of as much of the riverine system as possible, except where fire is used for hazard reduction, regeneration or control of weeds or feral animals under the terms of an approved management plan.

4. Allow the use of controlled fire, or selective herbicides to control annual grass fuels in areas where hazard reduction is approved to protect a high value site. In the case of controlled burning, a prescription must be prepared which specifies season and intensity of fire, the measure to be taken to ensure the fire is made safe, and that mopping up and patrolling is undertaken to protect old trees, hollow logs etc. In the case of herbicide spraying, a prescription must be prepared which specifies the frequency, chemical to be used, the rate and time of application and the measures to be taken to protect non-target species or guard against off-site effects.

   All controlled burning must be in accordance with the Bush Fires Act and meet Local Government requirements, and all prescriptions must be submitted to the AWC for consideration, and a recommendation will be made to the Department of Water for endorsement if appropriate.

5. Uncontrolled grazing by sheep, cattle, goats, pigs or horses will not be permitted in the river system in areas controlled by Department of Water. Some limited controlled grazing may be approved during an interim periods in which other hazard reduction measures are being developed. Proposals to graze Department of Water-controlled land must be submitted to the AWC for consideration, and a recommendation will be made to the Department of Water for endorsement if appropriate.

   Owners of riverine vegetation will be encouraged to phase out or limit grazing on their lands in favour of less destructive measures of hazard reduction.

   New weed invasion will be minimised by minimising all forms of soil disturbance along the river. This especially applies to roads and firebreaks, off-road vehicle use and urban development, none of which may take place along the river without approval of the Department of Water.

6. Permit the mowing or slashing of weeds in some areas close to towns, buildings or other constructions so as to break down a tall grassy fire hazard. Prescriptions covering the proposed work must be submitted to the Department of Water for approval.

7. Encourage neighbours to the river to make their own properties fire-safe, rather than rely on fire hazard reduction along the river. This will be achieved through education campaigns, including detailed discussion with property owners and the involvement of neighbours in the preparation of fire management plans for the river system.

   AWC will also support measures promoted by Landcare groups to minimise stubble burning on farmlands adjacent to the waterways.

8. Encourage research to be undertaken on the management of fire and on fire ecology along the Avon River. AWC wishes to recover the full suite of native plants and animals that once occurred in the bush in this area, but at the same time we wish to ensure neighbouring assets are protected. AWC will assist scientists from government agencies and universities who are prepared to work on research projects that help to achieve this aim.

9. Monitor all areas burnt. Where good regeneration of desirable species has occurred, areas will be set aside from prescribed burning for a sufficient period to enable the young plants to establish, flower and seed.

10. AWC will strongly support volunteer Fire Brigades located along the river, to ensure they are properly equipped and organised. This support will take the form of collaborative submissions to Local Authorities and the Bush Fires Service, until we are in a position to provide direct financial support.

11. Potential sources of fire in or adjacent to the river system will be identified. Where there are obvious problem sites (eg, smouldering rubbish tips) the site-manager will be approached to fix the problem. If necessary AWC will ask Local Authorities or the Bush Fire Service to enforce the Bush Fires Act to eliminate potential sources of fire.

    Open fires will not be permitted in camp grounds or other recreational areas controlled by the Department of Water along the river during restricted or prohibited burning periods, generally between the months of September and May.

12. AWC will seek endorsement of this Recovery Statement, and all fire management plans developed for the river system from local authorities, neighbours and relevant government agencies (especially the Bush Fire Service).

13. AWC will ensure that all fire management plans and regimes that are developed are consistent with the ACC Natural Resource Management Strategy

Review

The Recovery Statement will be reviewed annually.

Alan Cole

Chairman

Avon Waterways Committee

August 2007

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