GOVERNMENT OF WESTERN AUSTRALIA

FORESHORE AND CHANNEL ASSESSMENT OF TALBOT BROOK

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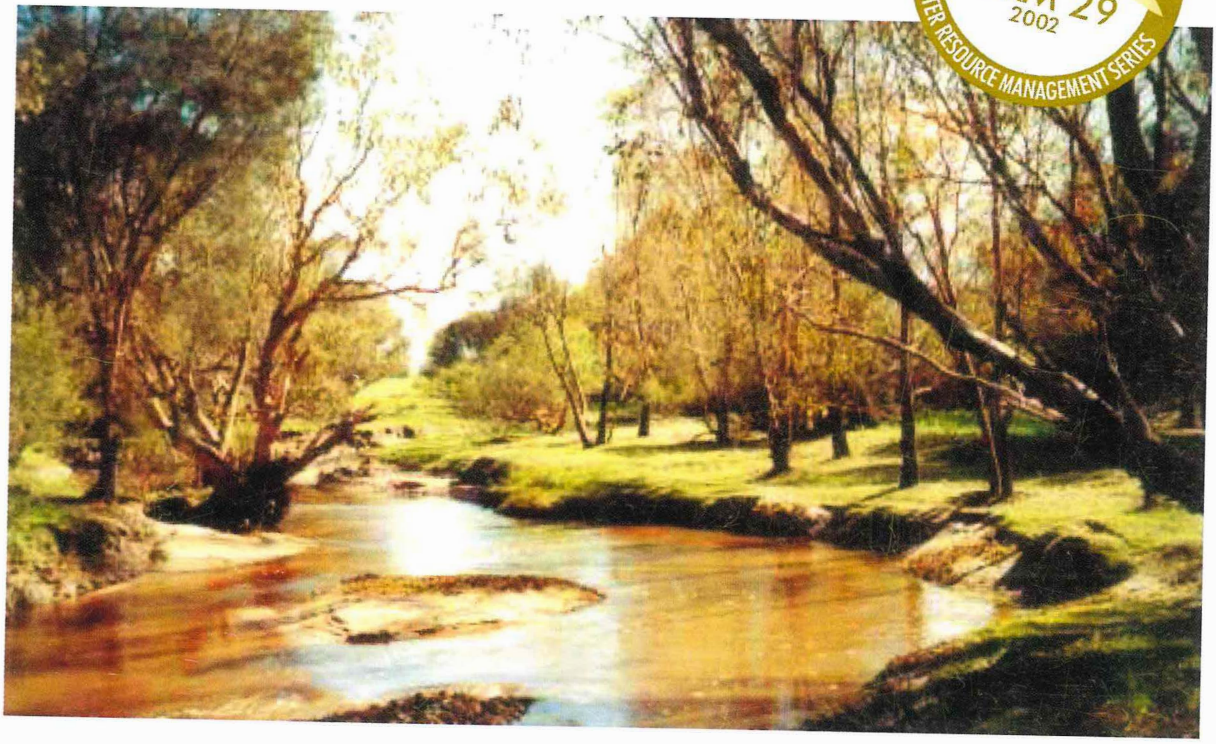

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Cover Photograph: Channel and foreshore condition along Talbot Brook (Patricia Janssen, 2001).

FORESHORE AND CHANNEL ASSESSMENT OF TALBOT BROOK

Jointly funded by

Natural Heritage Trust

Water and Rivers Commission

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Foreword

Jointly funded by the Natural Heritage Trust and the Water and Rivers Commission, this project is part of the Avon Waterways Committee's,(formerly the Avon River Management Authority) Avon Rivercare Program, a project undertaking management surveys of major tributaries feeding into the Avon River.

The objective of this project is to document the current condition and future management needs of Talbot Brook through consistent field surveys, in consultation with adjacent landholders and surrounding community. The purpose emphasises community consultation, with attempts made to involve landholders along the waterway in as many aspects of the survey as possible.

The Talbot Brook catchment drains portions of the Shires of York and Beverley into the Dale River which feeds the Avon River. Foreshore and channel assessments along Talbot Brook were undertaken between June and August 2001.

The purpose is to provide information to people within the Talbot Brook Catchment who manage or have an interest in waterways. It is hoped that this information will encourage and assist the planning of management actions that can be undertaken by landholders and community groups from the areas surrounding the waterway.

As a result of development pressures and inappropriate landuse, many sections of the study area under threat from degradation. A wide range of management issues, such as stock and vehicle access, erosion, feral animals and salinisation of the land and water, have been identified through field surveys and consultation with landholders along the waterway.

Management recommendations have been included to suggest ways in which the foreshore and channel conditions along the length of the brook can be improved to provide environmental, economic and social benefit to landholders and community members throughout the area.

Although this tributary has been surveyed in isolation to other major waterways, the long-term management of the riverine environment is dependent upon an integrated catchment approach, whereby landholders within the whole catchment are responsible for working together to improve the condition of the waterways. It is hoped that the results of this report will help to create a sense of ownership of the brook for the community as a whole and encourage integrated catchment management (ICM), conservation of the riverine environment and sustainable development.

"The future is not some place we are going to,
... it is a place we are creating.
The path to the future is not found,
... it is made."

Paul Ellyard
Author/Philosopher

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Disclaimer:

These maps are the product of Water and Rivers Commission, Regional Services Division, and were printed on 26 September 2001. The maps were produced with the intent that they be used for information dissemination at the scale of 1:160 000. While the Water and Rivers Commission has made all reasonable efforts to ensure the accuracy of this data, the Commission accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Introduction

Purpose of the survey

The purpose of this survey is to highlight areas of degradation along Talbot Brook and encourage landholders to undertake management strategies to increase the health of the waterway. Along with landholders, it is hoped that the community will see the need for an integrated approach to management of the brook and surrounding lands. Results will hopefully promote an awareness of the interrelated nature of landuse practices and the current state of the waterway.

The purpose of this survey is to assess and document the current uses, disturbances and health conditions of Talbot Brook and provide some guiding management recommendations. It is hoped that the information contained within this document will encourage landholders, Local Government Authorities and community members to use this data to undertake management along Talbot Brook channel, foreshore and within the surrounding catchment.

Objectives of this project can be summarised as follows:

- To provide a compilation of data regarding the condition of the brook which can be used to prioritise future management;
- To highlight areas needing future rehabilitation, conservation and/or management;
- To provide a benchmark against which landholders and surrounding communities can monitor future river health and management activities;
- To educate landholders and the community about the causes of waterways degradation; and
- To provide a sound technical basis for future funding or project submissions.

One of the main goals associated with this assessment is to identify the key issues related to the future use and management of Talbot Brook and its tributaries. Whilst achieving this goal the objective was to involve the adjoining landholders and community members in the foreshore and channel assessment and to encourage awareness of the importance of waterways management and conservation.

It is hoped that this data will eventually lead to a management or action plan for the channel, foreshore and catchment surrounding Talbot Brook to provide guidance and direction for future management of the waterway.

Study area

The Talbot Brook lies within the Avon Catchment, Western Australia, and feeds into the Dale River which is one of the larger tributaries feeding into the Avon River. The area assessed was located within the Shires of York and Beverley. The Talbot Brook begins south-west of the York township and flows south-east where it meets the Dale River approximately 29km south-south-east of the York townsite and 12km south-west of the Beverley townsite. Map 1 depicts the size of the Talbot Brook catchment and also shows the location of the brook in relation to main roads. This map also shows the boundaries of each of the 33 sections that the waterway was broken into for the purpose of this assessment.

The primary focus of this assessment was the foreshore and channel areas of the brook. The area studied includes the riverbed, channel embankments, floodway, verge, foreshore and land use adjacent to this waterway. It should be noted that when planning to manage Talbot Brook, there is a need to adopt a whole catchment approach rather than dealing with the waterway as an entity on its own.

Historical description of Talbot Brook

Aboriginal heritage

Data from the Department of Land Administration and the Aboriginal Affairs Department shows that there are no registered sites or communities of Aboriginal significance along Talbot Brook. Anecdotal evidence suggests that there were once Aboriginal clans living in the area surrounding Talbot Brook, with territories bordering the waterway. Past occupation of the land by Aboriginal people suggests that the land may have important spiritual and cultural meaning to the current generations of these tribes.

European heritage

The Avon region was explored by European settlers in 1830, when an expedition party led by Ensign Dale travelled overland from Guildford. Both Beverley and York were established to service the surrounding agricultural hinterland, York being established in 1831 and Beverley in 1838 (Western Australian Planning Commission, 1999). Land around the York area was subdivided into farming properties around 1842 (Underwood, 1995).

Development of the land centred on the agricultural industry with the introduction of wheat and sheep farming to the catchment. Landuse along the waterway has changed little since European settlement, however in recent years there has been a tendency for land to be subdivided into smaller lots that have a focus on hobby farming and rural lifestyle.

Catchment description

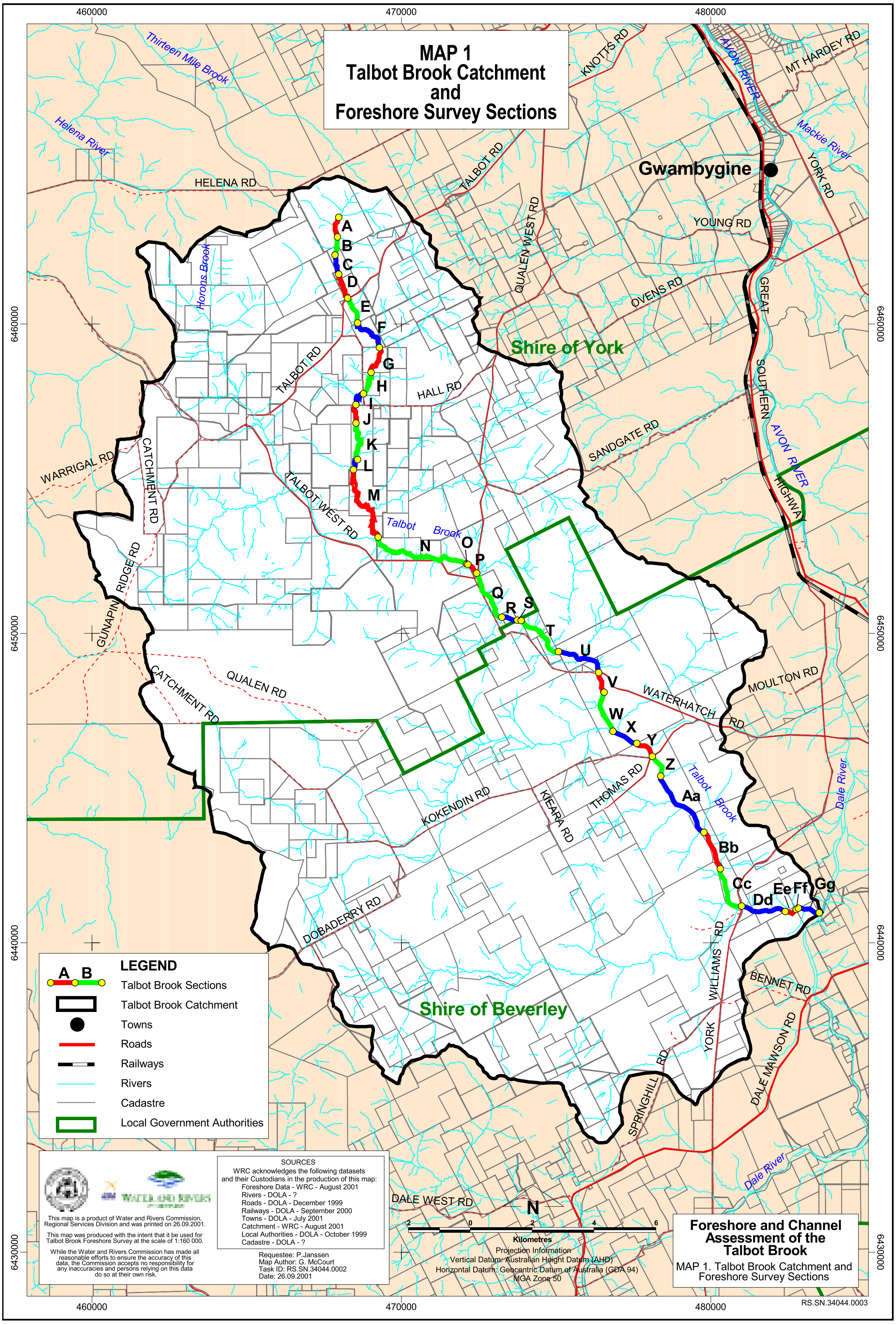
Population

The 1996 census of population determined that there were an estimated 2904 people living within the Shire of York, and 1453 people residing within the Shire of Beverley (Western Australian Planning Commission, 1999). There are 24 landholders along the length of Talbot Brook.

Location

The Talbot Brook lies within both the Shire of Beverley and the Shire of York. Map 1 shows the location of the brook in relation to the locality of Gwambygine.

The Talbot Brook, approximately 35km in length, feeds into the Dale River, one of the major tributaries feeding into the Avon River. The waterway runs from the south-west of York in a general south-easterly direction into the Dale River, approximately 11km south-west of the Beverley townsite. The brooks drain water from the surrounding catchment (356.94km^2 in size) into the Dale River in Beverley.



Map 1. Talbot Brook Catchment and Foreshore Survey Sections

Climate

Both the Shires of York and Beverley experience a Mediterranean type climate, with hot dry summers and mild wet winters. Climatic data was available for the Shire of York, whereas only data for the Beverley townsite was obtainable.

The Shire of York experiences an annual rainfall ranging from 1100mm in the west, to less than 451mm in the east of the Shire, while Beverley townsite receives an average annual rainfall of 420mm. Average maximum temperatures in York range from 34.3ºC in January down to 15.6ºC in July, while Beverley experiences an average maximum of 34.1ºC to 16.7ºC. Average minimum temperatures in Beverley range from 16.7ºC in February to 4.9ºC in August. York experiences an average minimum temperature of 16.8ºC in January through to 5.3ºC in July. Frosts are common during winter and are most frequent during July and August (Weaving, 1994 and Safstrom, 1997).

Geomorphology and soils

Talbot Brook lies within the Zone of Rejuvenated Drainage, characterised by a dissected landscape with steeper, narrow valleys where waterways commonly flow during winter (Lantzke and Fulton, 1992).

Map 2 shows the soil landscape systems of the Talbot Brook catchment, and depicts the dominant systems along Talbot Brook as being the Avon Flats, Clackline, Jelcobine, Wundowie and West Kokeby systems. The valley floors along the waterway are dominated by Avon Flats, Clackline and Jelcobine soil units. Appendix 1 provides definitions and associated characteristics of these soil landscape units.

The Avon Flats system is characterised by brown loamy earths, grey non-cracking clays, and deep brown sands. The Clackline soil system is located along the lower, mid and upper slopes of the surrounding catchment area and is characterised by grey shallow sandy duplexes, duplex sandy gravels, loamy gravels, shallow pale sands and red loamy duplexes. It is often limited to moderately dissected areas with gravelly slopes and ridges (Lantzke and Fulton, 1992 and Agriculture Western Australia, 1999).

The Jelcobine system is located on the hill slopes but is defined by deep red and shallow sandy and loamy duplexes, deep grey sandy duplexes, bare rock and cracking and non-cracking clays (Lantzke and Fulton, 1992 and Agriculture Western Australia, 1999).

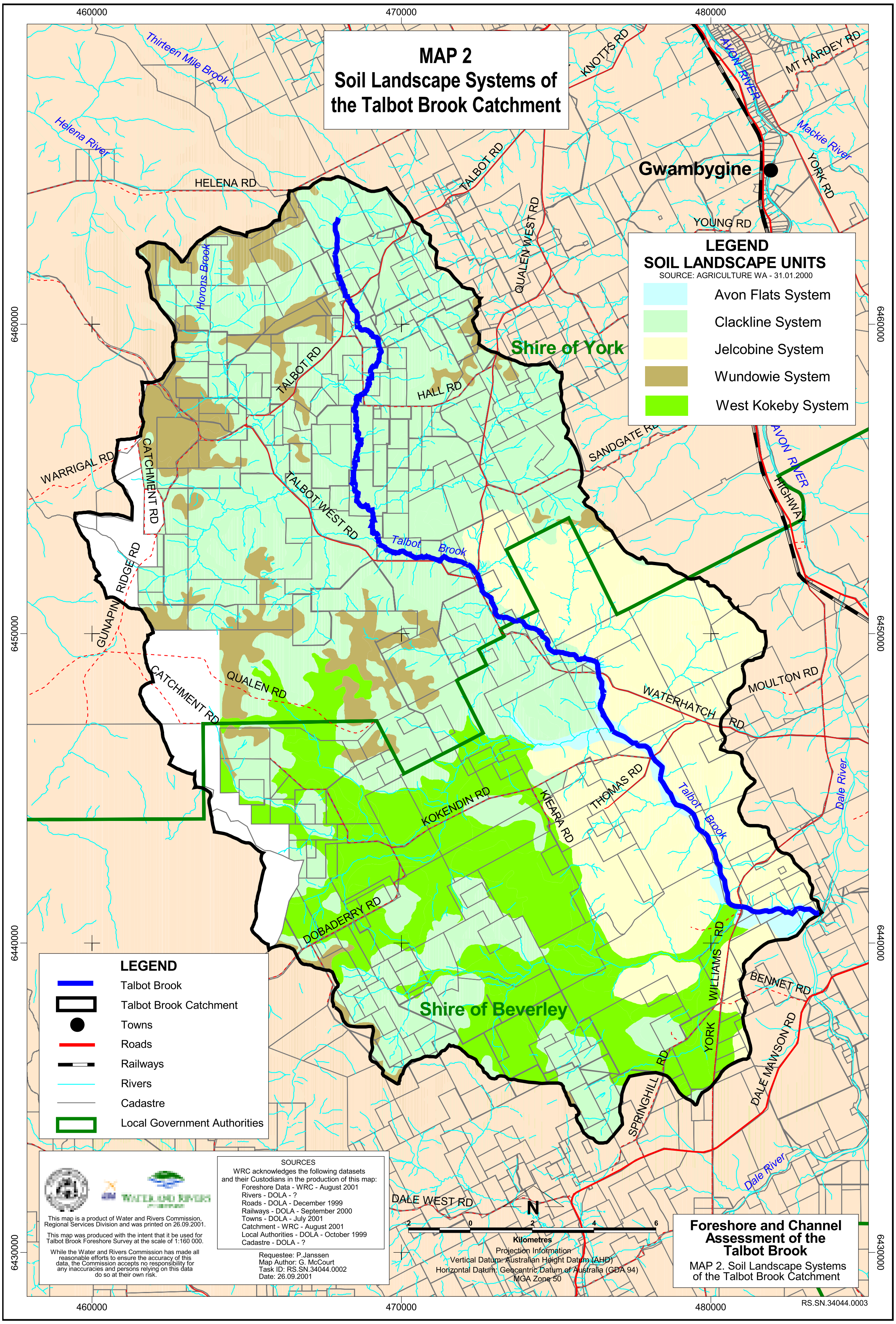
The Wundowie unit is defined by deep sandy gravels, duplex sandy gravels and shallow gravels. It is found in the higher areas of the catchment where lateritic plateaus with rocky outcrops are common (Agriculture Western Australia, 1999).

The West Kokeby system is described as having deep pale sands, pale gravelly sands, sandy duplexes, wet soil and minor rock outcrops.

Hydrology

Dale River is one of the many tributaries responsible for feeding saline water into the Avon River (Weaving, 1994). It enters the Avon River approximately 10km north-west of the Beverley townsite in the locality of Addington. Together with the Talbot Brook this waterway drains the south-western portion of the Shire of York and the western portion of the Shire of Beverley and a small portion of the Shire of Brookton.

There are several minor tributaries feeding into Talbot Brook from around its catchment. The larger of these are Christopher Brook, Norning Gully and Horons Brook. There are also many smaller waterways draining the surrounding catchment.



This map is a product of Water and Rivers Commission, Regional Services Division and was printed on 26.09.2001.

This map was produced with the intent that it be used for Talbot Brook Foreshore Survey at the scale of 1:160 000.

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

SOURCES

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

Foreshore Data - WRC - August 2001
Rivers - DOLA - ?
Roads - DOLA - December 1999
Railways - DOLA - September 2000
Towns - DOLA - July 2001
Catchment - WRC - August 2001
Local Authorities - DOLA - October 1999
Cadastre - DOLA - ?

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MGA Zone 50

Foreshore and Channel Assessment of the Talbot Brook
MAP 2. Soil Landscape Systems of the Talbot Brook Catchment

Map 2. Soil landscape systems of the Talbot Brook catchment

Talbot Brook flows actively after rainfall events, which usually means during winter, spring and early summer (Mulcahy and Hingston, 1961). There are now limited numbers of pools along the length of the brook, however anecdotal evidence suggests that in the past there were deep pools that would hold water throughout the dry summer months and act as a refuge and habitat for terrestrial and aquatic fauna. These pools have now become shallow as a result of sediment deposition and no longer provide these important refuges for organisms during the dry summer months.

The variability of flow and the periodical flooding and drying of the waterway system are important historical features of the waterway which many ecosystems are dependent upon for their long-term survival (Hansen, 1986). However, there has been a change in the frequency of flooding and drying as a result of settlement and development within the catchment, and this has meant that many ecosystems have had to adapt to these variations or perish.

Vegetation

The banks of the brook are dominated by Flooded gum (Eucalyptus rudis), Swamp paperbark (Melaleuca rhaphiophylla) and Jam tree (*Acacia acuminata*), vegetation that is typical of marginally saline (fresh-brackish) environments. Agricultural weeds such as Wild oats (*Avena fatua*) and Barley grass (*Hordeum leporinum*) are also common throughout the riverine environment. The weed species Couch, Cape tulip and Soursob are widespread.

Field observations and anecdotal evidence have determined that some areas along the Talbot Brook support small communities of the gazetted rare species of Spider Orchid (*Caladenia triangularis*).

The catchment lies within the York Vegetation System, a system within the Avon Botanical District. Species common to this vegetation system are Flooded gum, Swamp sheoak (*Casuarina obesa*), York gum (*Eucalyptus loxophleba*), Jam tree and Needlebush (*Hakea preissii*) (Weaving, 1999).

Catchment landuse and tenure

Landuse within the catchment is a combination of agricultural (with a focus on sheep/cattle and wheat) and smaller semi-rural properties. In recent years there has been an increase in hobby farming with the subdivision of many rural farms into smaller lots.

The whole of Talbot Brook lies within private land ownership. There is increasing pressure to subdivide larger agricultural landholdings into smaller lots for uses such as rural residential, hobby farming and to cater for activities such as agroforestry and horticulture (Reid, undated).

Many of the historical land titles along Talbot Brook award ownership to the centre of the brook (Hansen, 1986). In some cases ownership includes the waterway where land ownership stretches across the river.

Survey methods

Community awareness and involvement

A letter of introduction was sent to landholders along Talbot Brook explaining the purpose of this survey. Arrangements were then made by phone for access onto properties to survey the brook. Letters were also sent out to local landcare, rivercare, catchment and Friends groups to allow them the opportunity to become involved in the assessment of Talbot Brook. Notices were placed in local newspapers advising of the project and inviting submissions from any member of the community.

Articles in local newspapers, the Avon Valley Advocate, York Community Matters and the York Chronicle, provided publicity about this project. Media releases were used to advise community members of the project and gave individuals and group members the opportunity to take part in field assessments.

A draft report was prepared and released for public comment, giving landholders and community members the opportunity to respond to report findings and the broad management recommendations that have been made.

Assessment technique

A *Foreshore and Channel Condition Assessment Form* was developed to standardise the field surveys and keep the collection of data consistent. The assessment template was based on the assessment techniques developed by Pen and Scott in their 1995 publication; *Stream and Foreshore Assessment in Farming Areas*, with some variations included to meet the specific needs of this assessment. The survey form was divided into the following categories:

- general details;
- bank stability;
- waterways features;
- foreshore condition assessment;
- vegetation health (and coverage);
- fencing status;
- overall stream environmental rating (stream health);
- habitats;
- habitat diversity;
- landform types;
- evidence of management;
- management issues;
- vegetation; and
- water quality data (pH and electrical conductivity).

Surveys were conducted along the whole length of Talbot Brook with survey sections being determined by paddock boundaries within each property. The length of Talbot Brook was divided into 33 survey sections (see Map 1 for a depiction of foreshore survey sections).

Foreshore and channel assessments were conducted by walking the length of each brook section and filling out the survey form (an example is provided in Appendix 2). In some instances, factors such as foreshore condition were averaged for the whole of a section with best and poorest conditions also recorded.

In all cases both sides of the brook were surveyed on one form and an average was determined for each assessment category. However, if each side of the waterway had differed greatly in either condition or surrounding landuse a separate survey sheet would have been completed for each side. Where assessment categories referred to each side of the waterway (ie fencing status on the left or right bank), surveys were conducted facing upstream.

The majority of assessment along Talbot Brook was observational. Foreshore and channel condition was assessed whilst walking along the waterway and recorded on the assessment template. Photos have been taken at points of interest and will be used for future monitoring of the brook and its foreshore. Landholders were also asked about changes in waterway condition and health, fauna, past landuse and management of the waterway.

Where vegetation was not identified during field assessments, samples were taken for later identification. Books such as *Western Weeds* (Hussey et al, 1997) and *Trees and Shrubs for the Midlands and Northern Wheatbelt* (Wilcox et al, 1996), as well as the expertise of Commission personnel was used to identify these specimens. *A Licence for Scientific or other Prescribed Purposes* was obtained from the Department of Conservation and Land Management giving permission to collect flora for scientific and identification purposes subject to certain conditions.

The use of a GPS unit (model Magellan GPS 315) allowed for points of interest to be recorded. Locations such as section start and end points were recorded to allow for accurate display of collated data on maps. Readings will also allow for accurate location of sections for future monitoring and management.

The assessment format used is comprehensive in recording foreshore and channel condition but does not require specialised knowledge or extensive technical assistance to complete. Hence, community groups, landholders and individuals without the aid of a qualified person can undertake assessments. The survey forms are sectionalised so that assessors can make use of sections relevant to their needs, whilst ignoring the other information. A blank assessment form is provided in Appendix 3 that can be copied and used by the community to assess waterways.

Method of analysis

A database has been set up to record information collected during foreshore and channel assessments. The database contains both numerical and written data taken directly from the survey forms. It does not include any anecdotal evidence supplied by landholders and other community sources. Only information that does not breach confidentiality has been included in this database.

Having information recorded in a database structure (as well as using a standardised assessment form) has allowed analysis to be performed between survey sections as well as along the whole watercourse. Queries within the database structure provided efficient collation of data that was then converted into spreadsheets for inclusion and interpretation in this report.

Five categories have been used throughout the field assessments to determine an overall stream environmental rating. Appendix 4 contains a table explaining the categories used to classify the stream condition and the overall health of the brook.

The overall stream environmental health rating is used to assess the ecological value of the individual brook sections and allows us to classify the health of the waterway. This rating system determines the current environmental condition of the waterway based on the six individual components listed below:

- floodway and bank vegetation;
- verge vegetation;
- stream cover;
- bank stability and sedimentation;
- habitat diversity; and
- surrounding landuse.

Depending on the rating (very poor up to excellent), points are allocated to each of these components and an overall stream environmental health rating is determined for each survey section. Appendix 4 provides a table that shows the points allocated to each individual component based on which rating the section received.

Results of the foreshore and channel assessment have been stored in a database that has been used to correlate figures for factors such as general foreshore condition and fencing along the brook. Data has been collated and is the source information from which maps have been produced. Key findings of this Talbot Brook assessment have been summarised within this report.

Survey results

Anecdotal evidence as well as survey results indicate that Talbot Brook and its surrounding catchment has historically been subjected to a wide range of disturbances that have led to a decline in the health. Field observations indicate that the main forms of river degradation present are bank erosion, sedimentation, and a decline in vegetation cover and health.

Bank and channel stability

Erosion, slumping and sedimentation all affect channel stability. The following factors influencing both bank and channel stability were used in this assessment:

- undercutting;
- firebreak/track washouts;
- subsidence;
- erosion;
- slumping; and
- sedimentation.

Field assessments of each river section evaluated the above factors that were used to determine channel stability. Channel stability is an average for the whole section and can be rated as shown in Table 1.

Channel stability	**% of Brook section affected**
Minimal	0-5
Localised	5-20
Significant	20-50
Severe	>50

Table 1. Rating system used to determine channel stability

Bank stability and sedimentation was determined as part of the overall stream environmental health rating, which indicated the average stream health of each survey section. It can also be used to give an idea of bed and bank stability within this river system. Table 2 shows the rating system used to determine the bank stability and sedimentation ratings of each section, and Figure 1 provides a collation of results for Talbot Brook which have been based on the information provided in Table 2.

Condition rating	**Bank stability and sedimentation**
Excellent	No erosion, subsidence or sediment deposits. Dense vegetation cover on banks and verge. No disturbance.
Good	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.
Moderate	Good vegetation cover. Localised erosion, bank collapse and sediment heaps only. Verge may have sparse vegetation cover.
Poor	Extensive active erosion and sediment heaps. Bare banks and verges common. Banks may be collapsing.
Very Poor	Almost continuous erosion. Over 50% of banks collapsing. Sediment heaps line or fill much of the floodway. Little or no vegetation cover.

Table 2. Ratings used to determine bank stability and sedimentation (Pen and Scott, 1995)

Results indicate that the majority of sections were recorded as having sedimentation and poor bank stability when rated in terms of the overall stream environmental health.

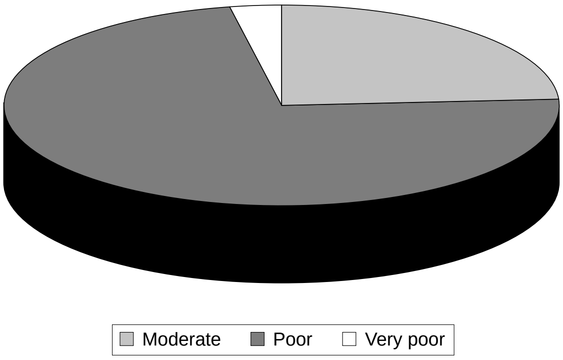


Figure 1. Bank stability and sedimentation ratings for Talbot Brook

Figure 1 shows that 24% of surveyed sections were rated as having moderate bank stability and erosion. The majority of sections (73%) were classified as poor and 3% as very poor. 9% of the surveyed sections were utilising artificial stabilisation techniques along the banks, meaning that techniques, such as log and rock walling, have been employed along the banks to protect degraded areas from further erosion and undercutting. There were also some locations (ie. road bridges) where channel stabilisation had been undertaken as part of engineering structures for safety reasons and to support the construction of such features.

Along Talbot Brook undercutting was recorded as being minimal in 15% of sections, localised in 67% and significant in 18% and of the survey sections.

Firebreak and track washouts were determined to be minimal along 6% of the sites, while the rest had no tracks and firebreaks running in close proximity to the channel.

Subsidence (the sinking of ground that is not slope related) was recorded as being minimal in 76% of surveyed sites, whereas the remaining sections showed no signs of subsidence.

Erosion was recorded as being localised in 6% of sections, significant in 91% of sites and severe in 3% of the sections.

Slumping also affected the banks with ratings recorded as minimal in 53% and localised in 38% of sections. 9% of the sections were not affected by slumping at the time the assessments were carried out.

Sedimentation was another prominent component of degradation recorded along the brook with 12% of the sites recorded as localised, 76% as significant and 12% as severe. Sand slugs were evident in 91% of sites.

The most significant components were erosion and sedimentation. The overall stability of the channel might be defined as poor (see Table 2) with nearly 75% of survey sections being highly eroded and unstable with large deposits of coarse sand sediment. Sediment deposits were identifiable along many areas of the channel, while there were also some areas along the riverbed that have been eroded down to the underlying clays.

Bank erosion along Talbot Brook

Anecdotal evidence suggests that sediment within Talbot Brook system is mobile. Field observations determined that the floods of January 2000 caused a lot of damage by eroding the bed, banks and foreshore. A lot of fresh sediment was deposited along the banks and foreshore during this period. This was supported by anecdotal reports of changes in foreshore and channel condition.

Waterways features

The features of a waterway often indicate the level of health associated with the riverine system. The presence of features such as pools, rapids, anabranches, riffles, bridges, sand slugs and vegetated islands allow us to assess, to some degree, the health of the waterway and determine options for future management.

Survey results show that 56% of the sections were comprised of a single channel, while 44% were braided. Of these sections, 47% had anabranches running in close proximity to the brook. Sand slugs within the channel were recorded at 91% of sections.

68% of the sections had natural riffles and 41% had shallow pools at the time of assessment (June – August 2001). Some of these pools and riffles are likely to be non-existent during the hotter summer months when the flow of water within the system stops.

24% of sites had dams situated in close proximity to the waterway, 24% had smaller tributaries feeding into Talbot Brook from the surrounding catchment, while a small number of properties had drains channelling water in from the surrounding landscape.

A man-made riffle provides a crossing point for stock and vehicles, acts as a sediment trap and aerates the water

Foreshore condition

General foreshore condition

91% of sections were rated as having a general (or average) foreshore condition of C-grade, meaning that there was minimal vegetation diversity. Essentially, a C-grade foreshore supports a limited diversity of trees over weeds or pasture. There may also be localised areas of bank erosion and subsidence (Pen and Scott, 1995). Appendix 5 provides an overview of all possible grades, from A1 through to D3. 3% of surveyed sections were rated as B-grade and 6% were rated as having a D-grade general foreshore condition rating. B-grade ratings were awarded to those sections that were in slightly better condition than the rest of the brook, with a more diverse cover of native vegetation being invaded by grassy weeds. Sections rated as D-grade were in great need of management, with the stream simply characterised as an eroding ditch or weed infested drain (Pen and Scott, 1995).

Best foreshore condition

The best foreshore condition recorded along each section varied greatly with 12% of the sites rated as B2, 44% as B3, 26% as C1, 15% as C2 and 3% as C3-grade. Appendix 5 provides definitions of foreshore condition ratings that have been used throughout this assessment.

Map 3 shows the best foreshore condition recorded within each section along the brook. Results indicate that there was no distinct pattern and foreshore condition was largely related to past and current landuses throughout the catchment.

Poorest foreshore condition

Map 4 depicts the poorest foreshore conditions recorded in each section surveyed along Talbot Brook. The map indicates that there was also a variation recorded in the poorest foreshore condition classifications with 3% of surveyed sections rated as C1, 15% as C2, 44% asC3, 35% as D1 and 3% as D2-grade.

A D-grade section of Talbot Brook

Foreshore vegetation

Presence of common species

The most common overstorey species recorded along Talbot Brook were Flooded gum (*Eucalyptus rudis*), Swamp paperbark (*Melaleuca rhaphiophylla*) and Jam tree (*Acacia acuminata*).

The most common understorey species recorded were weed species including Wild oats (*Avena fatua*), Cape tulip (Homeria sp.), Barley grass (*Hordeum leporinum*), Couch (*Cynodon dactylon*) and Soursob (*Oxalis pes-caprae*).

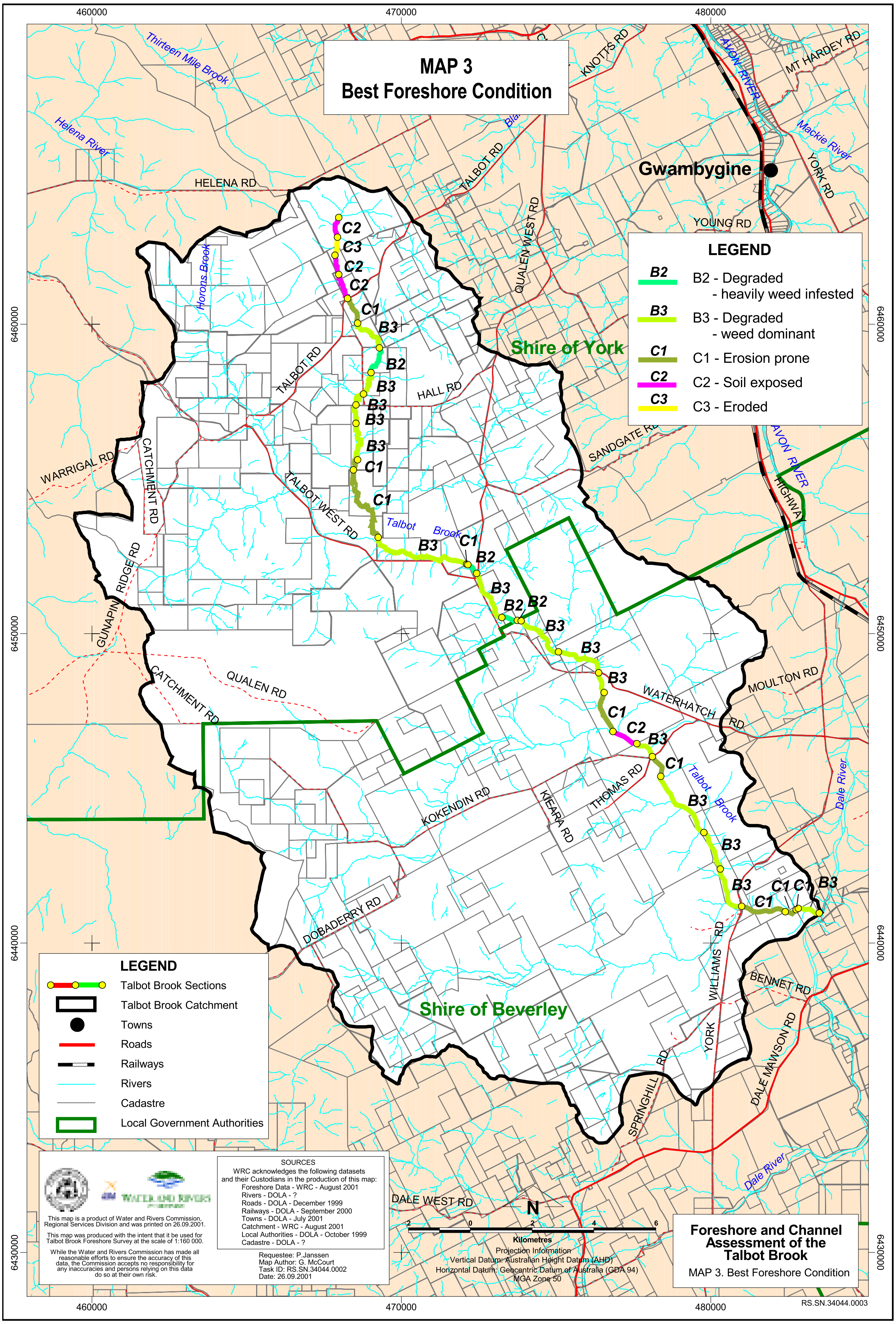
Field observations indicated that weed species were far more common than native species, with results showing that 68% of surveyed sections had an abundant occurrence of exotic vegetation (weeds), while 32% were recorded as frequent. Native vegetation, on the other hand, was recorded as frequent in 73%, occasional in 18% and rare in 9% of surveyed sections.

Proportion of native species

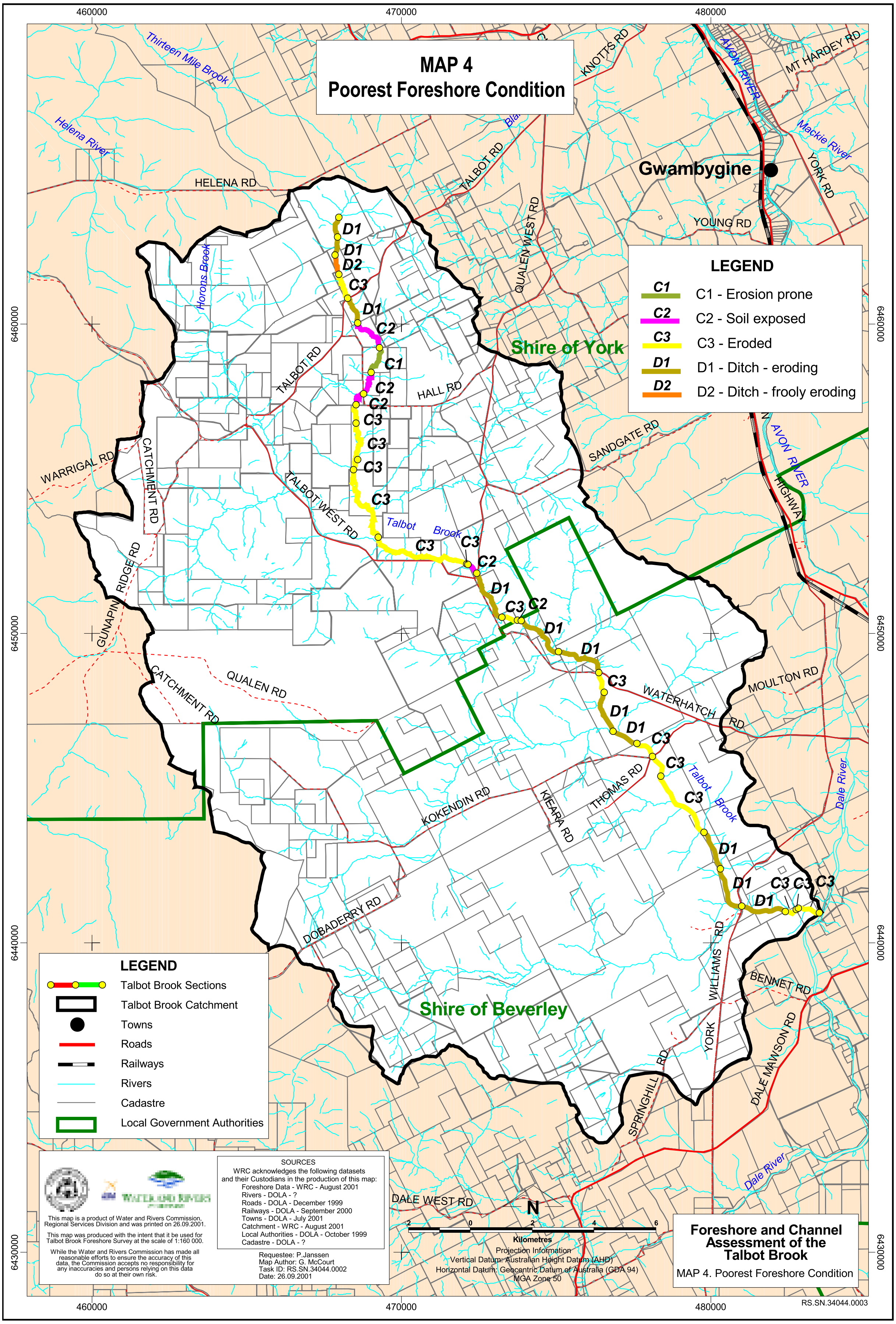
Table 3 shows the occurrence of native plant species recorded during foreshore assessments along Talbot Brook.

Plant name		**% of sites where the species occurred**	**Occurrence of each species (as a % of site where it occurred)**		
Common name	**Scientific name**		**High**	**Medium**	**Low**
Acacia sp.	*Acacia* sp.	15	0	40	60
Creeping salt bush	*Atriplex semibaccata*	6	0	0	100
Flooded gum	*Eucalyptus rudis*	97	6	76	18
Foxtail mulga grass	*Neurrachne alopeciroides*	6	0	50	50
Golden wreath wattle	*Acacia saligna*	3	0	0	100
Grass tree	*Xanthorrhoea drummondii*	6	0	0	100
Jam tree	*Acacia acuminata*	47	0	25	75
Manna gum	*Acacia microbotria*	3	0	0	100
Samphire sp.	*Halosarcia* spp.	6	0	0	100
Shore rush	*Juncus kraussii*	15	0	60	40
Smooth heliotrope	*Heliotropium curassavicum*	3	0	0	100
Spider orchid	*Caladenia triangularis*	3	0	0	100
Swamp paperbark	*Melaleuca rhaphiophylla*	59	15	75	10
Swamp sheoak	*Casuarina obesa*	38	8	23	69
Wandoo	*Eucalyptus wandoo*	18	0	17	83
York gum	*Eucalyptus loxophleba. var. loxophleba*	3	0	100	0

Table 3. Native species occurrence



Map 3. Best foreshore condition



This map is a product of Water and Rivers Commission, Regional Services Division and was printed on 26.09.2001.

This map was produced with the intent that it be used for Talbot Brook Foreshore Survey at the scale of 1:160 000.

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

SOURCES
WRC acknowledges the following datasets and their Custodians in the production of this map:
Foreshore Data - WRC - August 2001
Rivers - DOLA - ?
Roads - DOLA - December 1999
Railways - DOLA - September 2000
Towns - DOLA - July 2001
Catchment - WRC - August 2001
Local Authorities - DOLA - October 1999
Cadastre - DOLA - ?

Requestee: P.Janssen
Map Author: G. McCourt
Task ID: RS.SN.34044.0002
Date: 26.09.2001

Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia (GDA 94)
MGA Zone 50

Map 4. Poorest foreshore condition

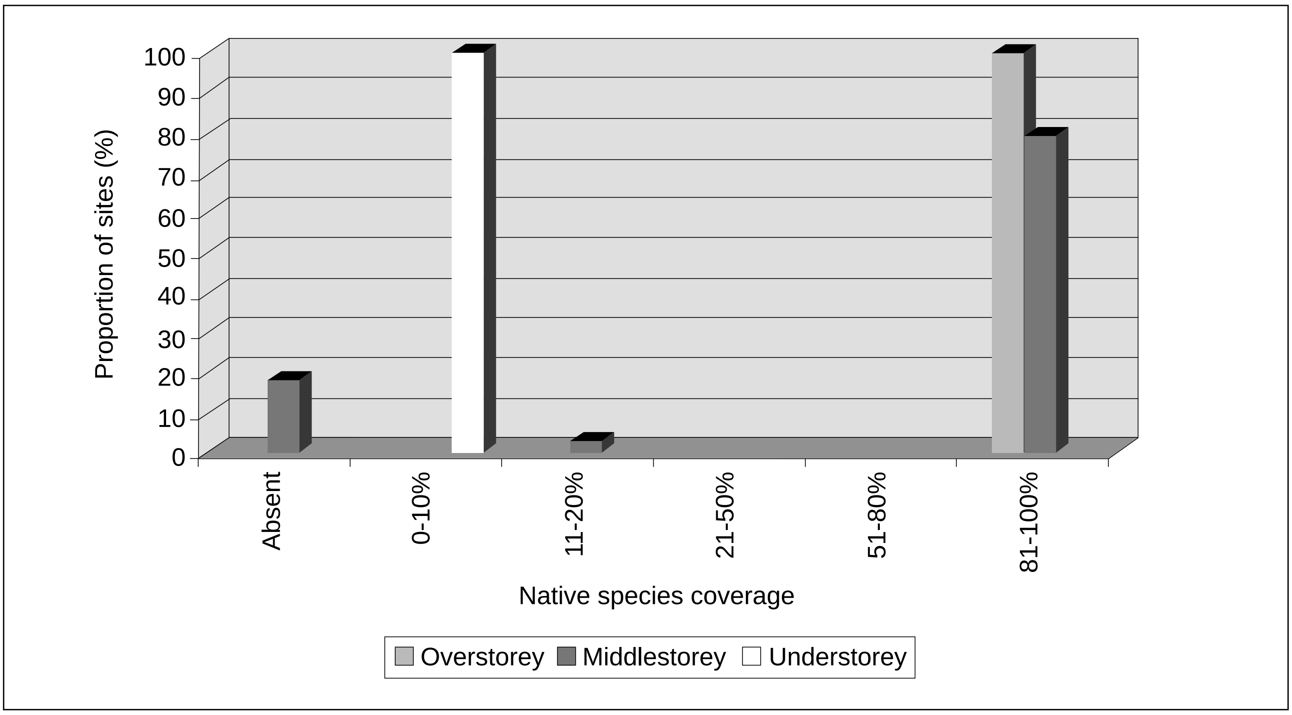


Figure 2. Proportion of native species in each vegetation layer

Figure 2 shows that the majority of native species occurred in the overstorey with 100% of surveyed sections recorded as being comprised of between 81-100% native vegetation in their tree layer.

Of middle storey species present (shrubs and small trees), 79% of sites were recorded as having between 81-100% native vegetation. Ground cover (ie. grasses) was predominantly weed species with 100% of sites recording a cover of between 0-10% native species. Native middlestorey species were found to be absent in 18% of sections.

Regeneration of native species

Natural regeneration of tree species was observed at 68% of the survey sections. The following species were showing signs of natural regeneration amongst foreshore vegetation along Talbot Brook:

- Flooded gum seedlings were recorded at 29% of survey sections;
- Swamp paperbark seedlings were recorded at 26% of survey sections;
- Jam tree seedlings were recorded at 15% of survey sections;
- Acacia seedlings were recorded at 12% of survey sections;
- Swamp sheoak seedlings were recorded at 6% of survey sections; and
- Wandoo seedlings were recorded at 6% of survey sections.

24% of sections showed evidence of plantings being undertaken as a part of the landholders' land management plan. Plantings consisted mainly of tree species. A number of landholders also indicated that they were also planning to plant native tree species within the riparian zone in the close future.

Death of common native species

Vegetation health was determined to be moderate along most of Talbot Brook and tree death was obvious in many areas. As described above, there was a lack of middle- storey plants in most areas and the ground cover was dominated in most instances by weed species.

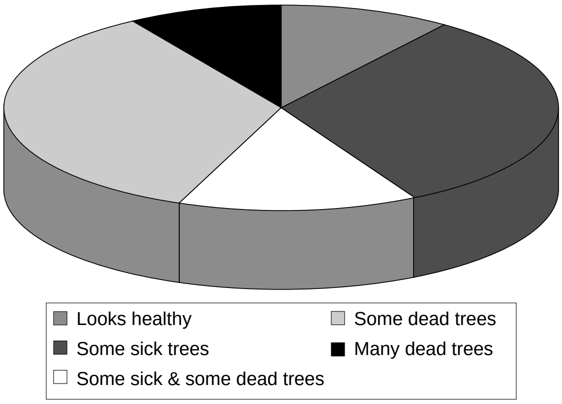


Figure 3. Vegetation health

Figure 3 shows that 32% of surveyed sections recorded some sick trees among the foreshore vegetation, while 35% of sites had some dead trees. Only 10% of sites were recorded as having healthy looking vegetation (ie. lots of leaves, natural regeneration of native species, lack of weeds, diversity of native species and a low level of disease and insects).

Many factors such as increasing salinity levels, waterlogging, disease and heat stress are responsible for causing the death of foreshore vegetation

Vegetation cover

Field investigations determined that the majority of sites were lacking a dense middlestorey (shrub layer) and were supporting a patchy upperstorey of tree species. Table 4 shows the number of surveyed sections that were classified as either absent, sparse, patchy or continuous (depending on the level of cover) in each vegetation layer.

	Proportion of vegetation cover			
	Absent (0%)	**Sparse (<20%)**	**Patchy (20-80%)**	**Continuous (>80%)**
Upperstorey (%)	0	9	91	0
Middlestorey (%)	12	47	41	0
Ground cover (%)	0	0	32	65

Table 4. Vegetation cover

The data in Table 4 shows that ground cover was the most dominant vegetation layer with 65% of sites recorded as being continuous and 35% as patchy. Middlestorey vegetation was absent in 12% of sites, sparse in 47% of sites and patchy in 41% of sites. The upperstorey was dominantly recorded as being patchy (between 20% and 80% coverage), with 91% of the sections rated in this category.

All of the surveyed sections had a percentage of bare ground. Results indicated that 18% of sections had less than 10% bare ground, 62% of sections between 11% and 20% bare ground, and 20% of sections between 21% and 50% bare ground. No sites were recorded as having over 50% bare ground.

Results collated for stream cover as part of an evaluation to determine the overall stream environmental health rating indicate instream vegetation cover along the brook. Stream cover was moderate in 65% of sections, meaning that there was some permanent shade and overhanging vegetation with some instream cover recorded (Pen and Scott, 1995). Poor stream cover was recorded in 29% of sections and very poor in 6% of surveyed sections.

Weeds

The most common weed species recorded along Talbot Brook were Wild oats (*Avena fatua*), Cape tulip (one and two leaf) (*Homeria* sp.), Barley grass (*Hordeum leporinum*), Couch (*Cynodon dactylon*) and Soursob (*Oxalis pes-caprae*). Wild oats was recorded as having a high occurrence in 85% of sections, while Barley grass, Couch and Soursob were all recorded in the majority of instances as having a moderate occurrence at the sites in which they were recorded. Table 5 shows the occurrence of the more common weeds found along Talbot Brook as a percentage of sections they occurred in.

Plant name		**% of sites where the species occurred**	**Occurrence (% of sites)** (as a % of site where it occurred)		
Common name	**Scientific name**		**High**	**Medium**	**Low**
Barley grass	*Hordeum leporinum*	82	36	46	18
Bindii	*Soliva pterosperma*	3	0	0	100
Blowfly grass	*Briza maxima*	3	0	0	100
Cape tulip sp.	*Homeria* sp.	91	87	13	0
Capeweed	*Arctotheca calendula*	6	0	100	0
Clover sp.	*Trifolium* sp.	15	40	60	0
Common barbgrass	*Hainardia cylindrica*	9	0	100	0
Dock (Sheep's sorrel)	*Rumex acetosella*	32	0	0	100
Doublegee	*Emex australis*	3	0	0	100
Fat hen	*Chenopodium album*	15	20	80	0
Four o'clock	*Oxalis purpurea*	26	55	45	0
Guildford grass	*Romulea rosea*	47	44	50	6
Paperwhite	*Narcissus papyraceus*	18	0	0	100
Perennial veldt grass	*Ehrharta calycina*	12	25	50	25
Pie melon	*Citrullus lanatus*	3	0	0	100
Prickly sowthistle	*Sonchus asper*	6	0	0	100
Saltwater couch	*Paspalum vaginatum*	53	44	44	12
Soursob	*Oxalis pes-caprae*	50	35	65	0
Spike rush	*Juncus acutus*	9	0	33	66
Typha sp.	*Typha* sp.	3	0	0	100
Wild oats	*Avena fatua*	94	44	47	9
Wild radish	*Raphanus raphanistrum*	3	0	0	100

Table 5. Common weed occurrence

Wild oats was by far the most dominant weed species, recorded in all survey sections, with a high occurrence in 44% of sites. Cape tulip was recorded in 91% of sections, Barley grass in 82%, Soursob in 50% and Guildford grass in 47% of survey sections. A high occurrence of unidentified broad-leaf weeds was also recorded in 24% of sections.

Pest plants

Pest plants are weed species that are seen as being a nuisance to the existing landuse. Local Government Authorities have the responsibility of administering the *Agriculture and Related Resources Protection Act 1976* and have the authority to enforce the control of such a species within its boundaries (Hussey et al, 1997). Three pest plant species were recorded amongst the foreshore vegetation along Talbot Brook; Bindii (*Soliva pterosperma*) was recorded in 3% of survey sections, Dock (*Rumex acetosella*) in 32%, and Pie melon (*Citrullus lanatus*) in 3% of survey sections. All were recorded in 100% of instances as having a low occurrence in these areas.

Declared plants

Declared plants are those plants that are classified as having a high management priority and that have the potential to become a major problem to the environment or to agricultural activities. They are formally declared under the *Agriculture and Related Resources Protection Act 1976* administered by Agriculture Western Australia. Under this Act, landholders are obliged to control any declared plants that occur within their properties (Hussey et al, 1997). Four declared plants were sighted along Talbot Brook, these being one leaf Cape tulip (*Homeria flaccida*), two leaf Cape tulip (*Homeria miniata*), Doublegee (*Emex australis*) and Soursob (*Oxalis pes-caprae*). Cape tulip (one and two leaf species combined) was recorded in 91% of sites with a high and medium occurrence in 87% and 13% of sites respectively. Soursob was recorded in 50% of survey sections and was classified as having a high occurrence in 35% of sites and medium occurrence in 65% of sections in which it was recorded. Doublegee was also recorded in 3% of sections with a low occurrence in all.

Habitat diversity

Field investigations determined the presence of potential habitat for both aquatic and terrestrial fauna. Results indicate that the most common habitat sources are trees, with this habitat type recorded in 100% of surveyed sections. Other habitat types were also recorded, although not as frequently as the above.

Providing habitat for aquatic organisms such as invertebrates, reptiles and fish:

- protected basking sites (ie. debris and branches) were recorded at 97% of sections;
- instream logs were recorded along 82% of sections;
- cascades, rapids and riffles were recorded along 68% of sections;
- meanders and pools were recorded along 68% of sections;
- a variety of instream and bank vegetation was recorded along 65% of sections;
- rushes (mostly non-native species) were recorded along 59% of sections;
- instream cobbles and rocks were recorded along 53% of sections; and
- emergent plants/soft substrate for eggs were recorded along 29% of sections.

Providing habitat for terrestrial animals such as invertebrates, birds, frogs, reptiles and mammals:

- trees were recorded along 100% of sections;
- shrubs were recorded along 62% of sections; and
- dense streamside vegetation along 6% of sections.

Instream cover was moderate in 65% of sections when determined as part of the overall stream environmental health rating. There was often a mixture of leaf litter, rocks, branches and vegetation. Figure 4 shows the proportion of sites that had instream cover.

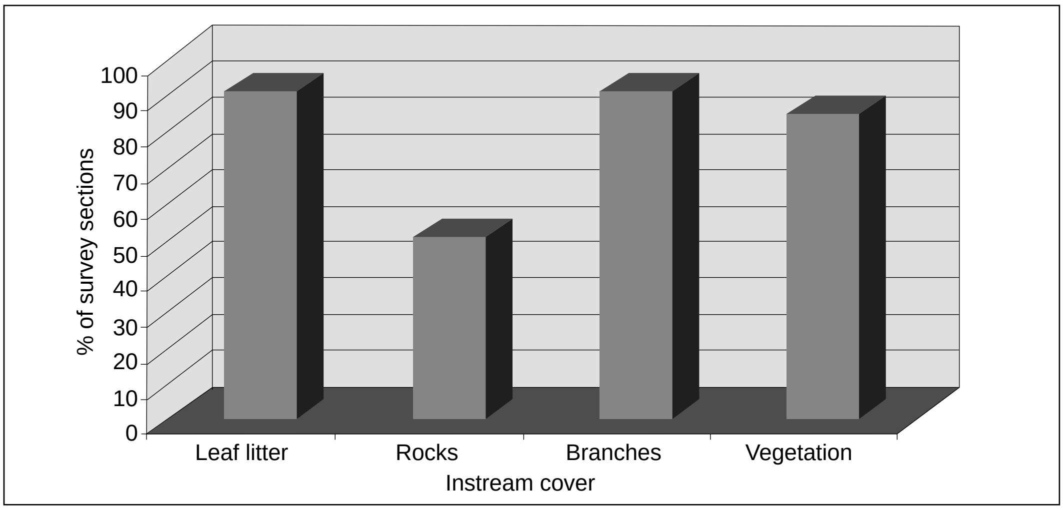


Figure 4. Proportion of instream cover

Figure 4 shows that leaf litter and branches were the most common form of instream cover and habitat type, occurring in 91% of sites, followed by vegetation which was recorded at 85% of sections.

Foreshore habitat differs slightly to that within the stream channel. Leaf litter along the foreshore was classified as minimal in 73% of sections, good in 24% and absent in 3% of survey sections. Ratings used during assessment of the overall stream environmental health rating determined that the majority (88%) of Talbot Brook was rated as having moderate habitat diversity. This is defined as a stream section with a range of habitat types, but without permanent water (Water and Rivers Commission, 1999).

A variety of wildlife was observed while conducting field assessments along the waterway. The following is a list of fauna recorded in and around Talbot Brook:

- Ants
- Australian Shelduck
- Bees
- Birds
- Bobtails
- Bullants
- Butterflies
- Cranes
- Crickets
- Corvids
- Dragonflies
- Ducks
- Fantails
- Feral cats
- Foxes
- Frogs
- Gambusia
- Gilgies
- Kangaroos
- Kingfishers
- Kites
- Kookaburras
- Lizards
- Magpies
- Mosquitoes
- Pink and grey galahs
- Rabbits
- Racehorse goannas
- Scarlet Robin
- Snakes
- Spiders
- Wedgetail eagles
- White-faced heron
- Willie wagtails
- Wrens

Anecdotal evidence suggests that the variety of fauna in the past was more plentiful. Many landholders commented that foxes, and rabbits have become more common in recent years, and may account for the declining number of native fauna, such as possums, recorded during field assessments. Anecdotal evidence also suggests that long neck tortoises are found in some areas of the waterway and that tiger snakes are common along the riparian zone along Talbot Brook.

A seasonal change in water depth in Talbot Brook suggests that habitat would change significantly from one season to the next (eg. alterations in the level of exposure of logs, branches, rocks and sand slugs). During field assessments the depth of water within the channel was low, but there was evidence of a significant fluctuation in water depth, such as exposed tree roots, dampness along banks, debris in trees, sediment and salt deposits, and bank erosion. As a result of a change in water levels and therefore habitat availability, the diversity and richness of fauna would also fluctuate. For instance, many birds would visit the waterway seasonally when water is available to fulfil food, shelter and nesting requirements.

Fencing status

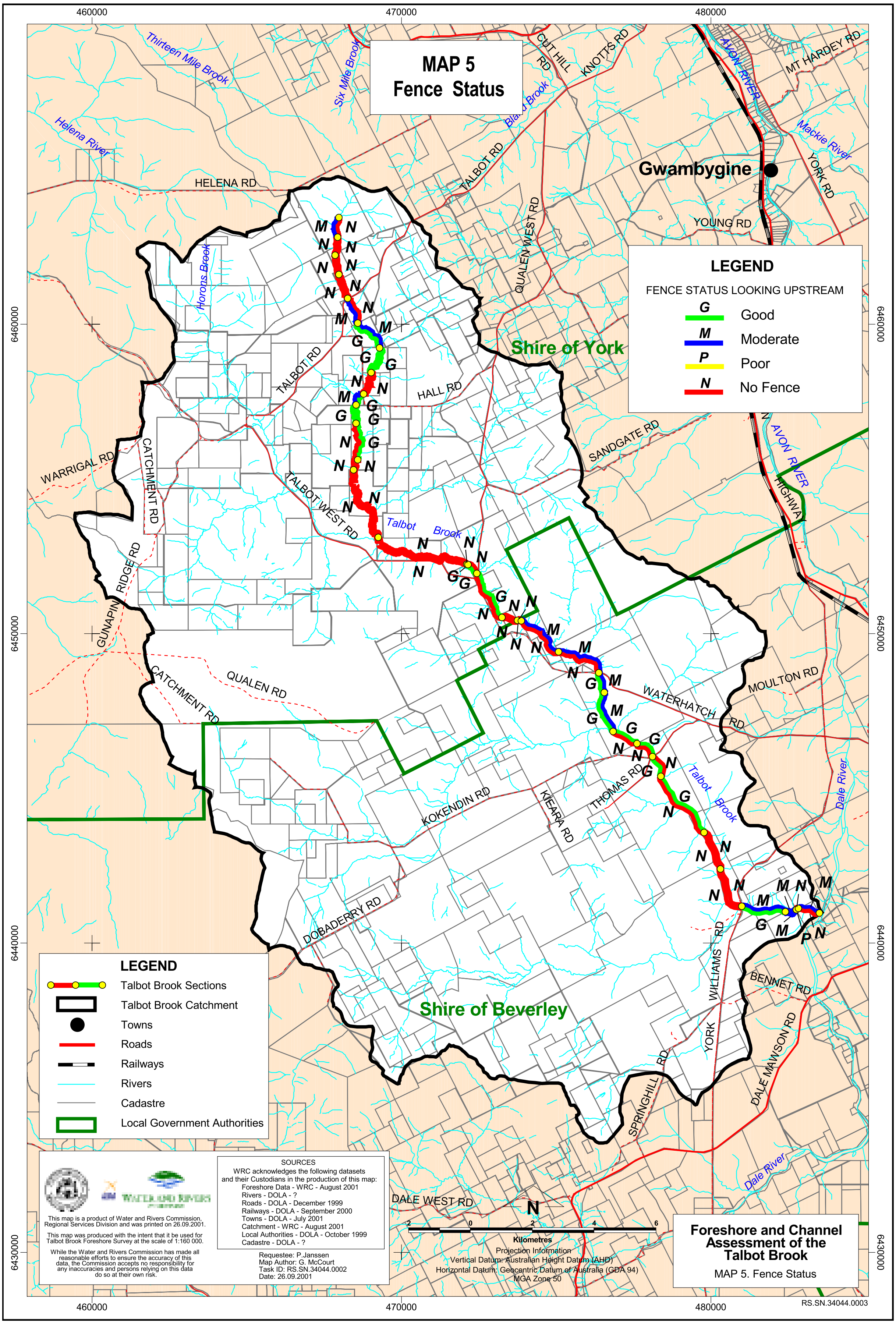
Foreshore assessments determined that 68% of river sections were fenced on one or both sides. When facing upstream 24% of sections were fenced on both sides, a further 20% of sites were fenced only along the left bank and 24% along the right bank, while 32% were not fenced at all. Map 5 provides a visual of fencing status along Talbot Brook. Results indicated that stock had access to the channel and riparian zone along 80% of the survey sections, and vehicles had access along 91%.

Of those areas that were fenced, 55% was in good condition, 42% was in moderate condition and 3% was in poor condition. Of the fencing style used along the fenced sections 22% were plain wire, 48% fabricated wire, 20% a combination of fabricated and barbed, and 10% a combination of plain and barbed wire. Appendix 6 provides a definition of each fencing style and examples of fence condition.

The position of the fence was also determined, with an approximation given for the distance of the fence line (left and right bank) from the bank of the waterway. Table 6 shows that the majority of fenced sections were fenced within 30 metres of the riverbank along the left and right banks.

Distance of fence from riverbank (metres)	**Proportion of sections in each category (%)**	
	Left bank	**Right bank**
< 10	0	0
11 – 20	11	3
21 – 30	11	15
>30	23	29
Not fenced	55	53

Table 6. Fence position along Talbot Brook



Map 5. Fence status

Water quality

An assessment of the water quality along Talbot Brook was not obtainable during field assessments due to the intermittent nature of the waterway. Water had only just started flowing along the channel for the majority of the surveys and it was thought unfeasible to obtain samples that would show extreme readings for pH and salinity and not give a true indication of water quality along the brook.

A report by Cobb, 2000, documenting water quality data during the period 1997-1999 (as part of the Avon Community Water Quality Monitoring Program supported by the Water and Rivers Commission) has been included in Appendix 7. This report looks at rainfall and flow response, sediment-flow relationship, phosphorus-sediment relationship, and dilution of salt, as well as major flow events affecting the catchment surrounding Talbot Brook.

Overall stream environmental health rating

The overall stream environmental health rating is a system used to determine the health of the waterway by rating health factors such as habitat diversity and verge vegetation.

The results in Figure 5 show that only 20% of the surveyed sections were classified as having a moderate stream health, 74% as poor and 6% as having very poor stream health. The dominantly poor health rating of the brook was mainly due to poor ratings in all categories with the exception of stream cover and habitat diversity of which 65% and 88% of sites respectively were rated as moderate, as shown in Table 7. Appendix 4 provides a description of each factor at each level of health.

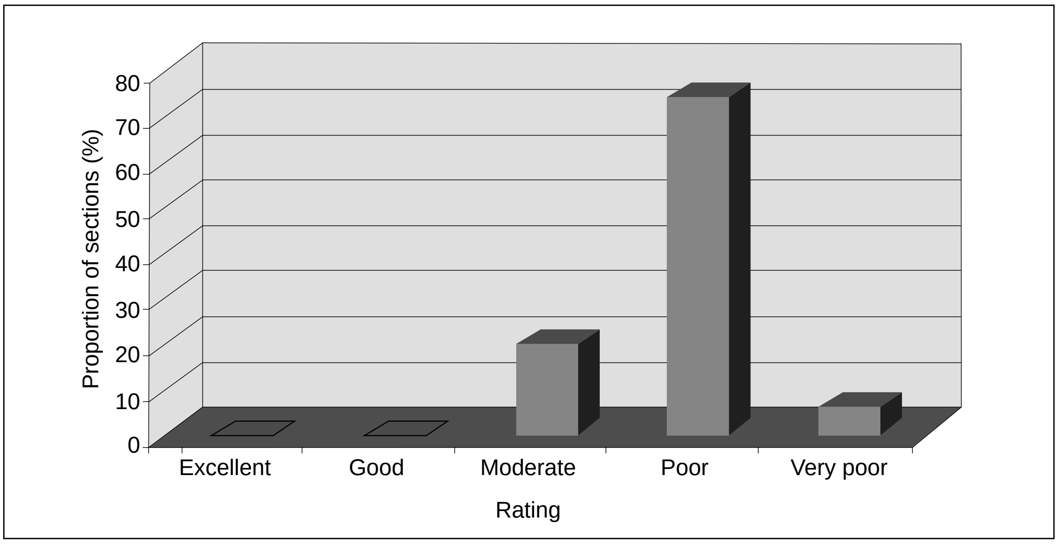


Figure 5. Overall stream environmental health ratings

Health Factors	Proportion of sites rated in each category (%)				
	Excellent	**Good**	**Moderate**	**Poor**	**Very Poor**
Floodway and bank vegetation	0	0	15	79	6
Verge vegetation	0	0	53	47	0
Stream cover	0	0	65	29	6
Bank stability and erosion	0	0	24	73	3
Habitat diversity	0	3	88	9	0

Table 7. Proportion of sites in each environmental health category

As indicated in Table 7, no sections were classified as excellent in any of the categories, while only 3% of sections were rated as having good habitat diversity. Habitat diversity rated the best with 88% of sections being classified as having a moderate condition. Floodway and bank vegetation was classified as poor in 79% of sites, while bank stability and sedimentation was rated as poor in 73% of sections. Only a small number of sections were classified as very poor as an indication of environmental stream health (with the exception of verge vegetation and habitat diversity which had no recordings of very poor).

Fringing vegetation provides shade and habitat, and also filters water entering the waterway

Disturbance

The riparian zone along Talbot Brook is subject to many disturbance factors that are contributing to the continual degradation of the channel and foreshore. The following gives a summary of the major disturbances observed during field surveys:

- 100% of sections contained weed species;
- 88% of the surveyed sections were disturbed by feral animals;
- 91% of sections were accessible by vehicles;
- 83% of surveyed sections were affected by pollution (mainly due to animal manures and crop sprays);
- 80% of the surveyed sections were accessible to stock;
- 44% of surveyed sections had crossing points allowing stock and vehicle access across the brook; and
- 33% of surveyed sections contained dumped rubbish.

Map 7 represents all sites along the waterway where stock and vehicles have access to the foreshore and channel of the waterway. It should be noted that not all sites are grazed by stock all year round. Some sites are used only for a few months of the year while others are continually under pressure from stock grazing and trampling.

Evidence of management

Of the sections surveyed along Talbot Brook 85% showed some evidence of attempts at river management, although not always on a large scale. The most common management control was fencing with 68% of sites having fences along one or both sides of the waterway. There were also other attempts at river management, with:

- 29% of properties along the brook employing surface water management (contour banks) and dams;
- 24% of survey sections showing evidence of tree planting;
- 20% of survey sections using firebreak control;
- 15% of survey sections showing evidence of weed control;
- 7% of survey sections using man-made riffles to control sediment movement and water flow;
- 6% of survey sections undertaking feral animal control (baiting); and
- 6% of survey sections showed evidence of prescribed burning.

Although survey data determined that only a low number of sections were employing feral animal control and weed control, anecdotal evidence suggested that these figures should be higher. Funding obtained by the Talbot Brook Land Management Association (Inc.) through the Natural Heritage Trust has provided an opportunity for subsidised fencing and revegetation of the riparian zone within the Talbot Brook catchment as part of a plan to improve the existing wildlife corridor.

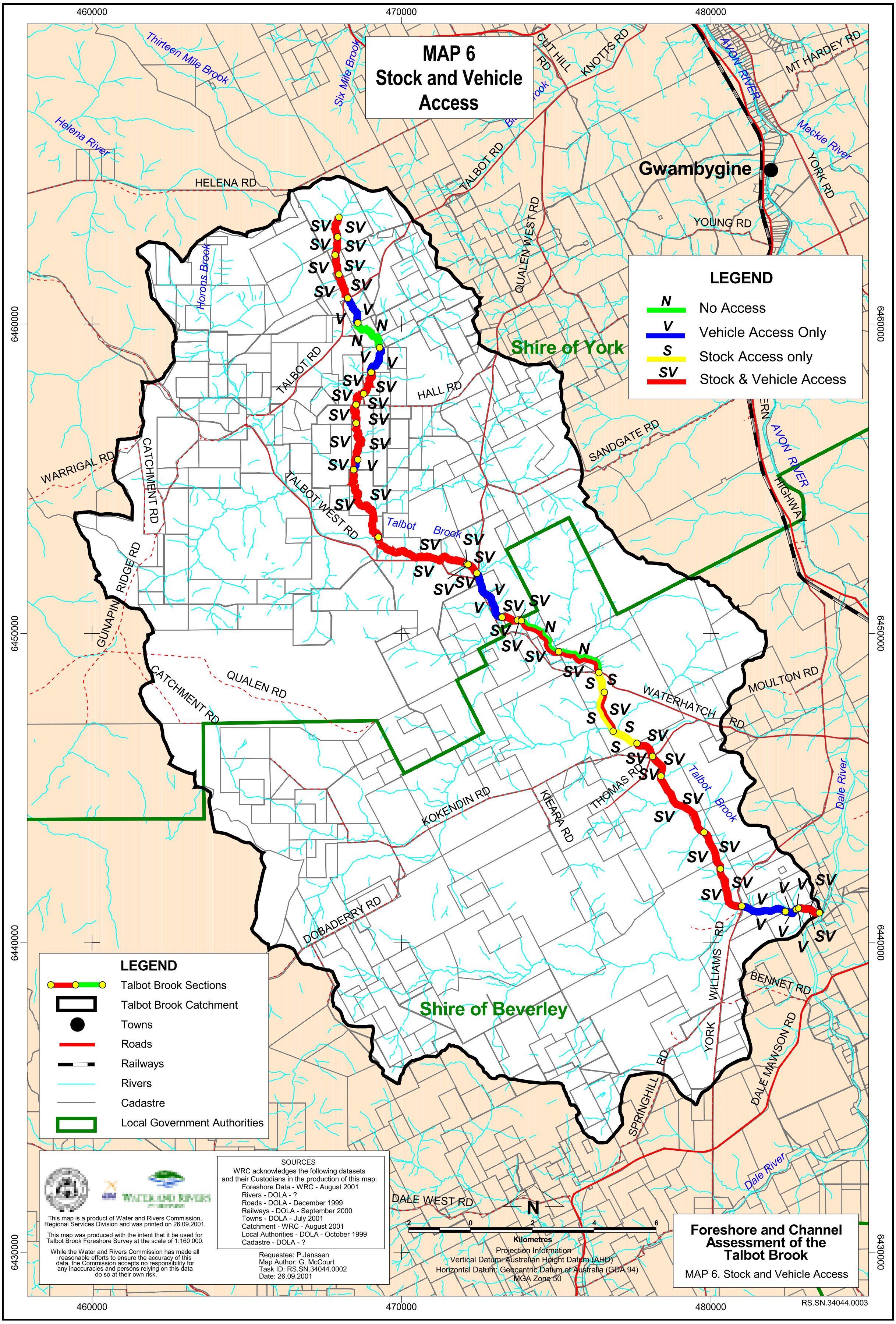
Priorities for management

Management along Talbot Brook has been prioritised with those issues needing urgent attention classified as having a high priority. Table 8 illustrates the issues that were determined to have a management priority and how each was rated as a matter of urgency.

Management issue	**% of survey sections requiring management**		
	High	**Medium**	**Low**
Fire	15	76	9
Weeds	97	3	0
Erosion	79	21	0
Salinity	6	88	6
Stock access	20	38	29
Vehicle access	0	38	44
Rubbish	3	18	12
Pollution	3	18	62
Crossing point	6	12	26
Feral animals	0	41	47
Dams	0	0	20

Table 8. Priorities for management

Results in Table 8 indicate that the main issues for future management of Talbot Brook are weed invasion and erosion of the riparian zone, with 97% and 79% of sections, respectively, being recorded as requiring a high priority for management. Salinity and fire were seen to be of medium management priority in 88% and 76% of sections surveyed recorded (respectively), while pollution and feral animal control were the largest low priority issues with 62% and 47% of sections (respectively) being classified in this category.



Map 6. Stock and vehicle access

Interpretation of survey results

Channel stability

Erosion and sedimentation have been determined to be the most serious concerns to channel stability along Talbot Brook. The severity of each is directly related to past and present landuse along the waterway. Grazing of the riparian zone and trampling of riverine vegetation by stock is often responsible for causing bank and instream erosion. Cropping activities also lead to sedimentation by increased runoff from cleared paddocks carrying soil particles into the waterway. The removal of large woody debris from within the channel has led to reduced protection of the banks and foreshore areas, allowing water to erode the banks and transport sediment within the channel.

A high level of disturbance will result in erosion and bank scouring which can lead to incision and widening of river channels. The manual straightening of the channel will lead to disturbance and lowering of the channel bed, resulting in an increased flow velocity. This will increase the probability of erosion and incision of the streambed and banks. Increased bank erosion means that there is potentially more sediment available to be moved along the watercourse. Hence, a higher amount of sediment can be deposited in downstream areas amongst woody debris, riffles, on the outside of meander bends, and in areas of slower flow, such as pools, which are important summer refuges providing habitat for aquatic and terrestrial organisms.

Cropping of the surrounding catchment means that land is left susceptible to erosion on a regular basis. Any wind or water moving across these paddocks will erode soil particles and deposit them at the lowest point in the landscape – the river channel.

In most cases the brook runs through the middle of property boundaries, but only 44% of survey sections were recorded as having man-made crossing points, with 24% being driveways or road bridges. This means that in many sites there was no defined crossing point for vehicles and stock. These disturbances will continue to contribute to erosion of banks, verges and the riverbed.

Talbot Brook is an unstable system, which has been exacerbated by the mixture of past and present landuse practices. Stock access to the riparian zone has led to foreshore areas becoming devoid of vegetation that plays a major role in channel stabilisation. Its intricate root network holds soil together to prevent erosion, subsidence and slumping of the banks and verges.

Riparian vegetation also performs a necessary function in flood control by reducing flow velocity and dissipating energy (Water and Rivers Commission, 1997). Diminishing species density and diversity has been a great disadvantage in terms of flood mitigation. The floods of January 2000 show the effects of high unseasonal rainfall and the inability of Talbot Brook to deal with such a high influx of water. Runoff from the surrounding catchment was high due to the large areas of cleared land and a lack of surface water management. Surface water management was absent in 70% of sections, resulting in a large amount of overland flow carrying sediment into the channel where it was (and will continue to be) deposited at points of slower flow.

The loss of riparian vegetation as a result of bank erosion, stock and clearing may have contributed to the shallowing of the channel in some areas. This is likely to be the cause of deeper pools filling with sediment and the consequent loss of habitat for fauna.

Waterways features and habitat diversity

The waterways features recorded during field observations along Talbot Brook are indicative of the health of the waterway, including habitat diversity and aquatic fauna.

Results indicate a variety of waterway features. The moderate number of small pools along the brook during the field assessments can be attributed to the seasonal nature of the waterway, and the variability of flow throughout the year. Sedimentation of the waterway can be degradational as an increase in sediment can alter river habitats and may even remove them altogether.

The unstable nature of Talbot Brook, and consequent sedimentation, has largely contributed to the loss of pools within the system. The high number of sand slugs recorded along the length of the waterway combined with the shallowing of pools indicates a decline in habitat diversity. In some areas the sandy soils had been eroded within the riverbed, leaving exposed clay bed material which has also led to a loss of habitat.

Suspended sediment is deposited in areas of slower flow such as in pools, along rocks, cobbles and logs, covering features that provide habitat to aquatic fauna. When deposited on substrate surfaces, sediment will commonly hinder algal growth that is an important food source for many aquatic organisms living in the brook (Jackson, 1997).

Removal of large woody debris from within some sections of the brook has allowed flow velocity to increase, resulting in a higher incidence of erosion and sedimentation. In some areas this has led to the widening and shallowing of the channel as banks are eroded and sediment is deposited in areas of slower flow.

Overhanging vegetation provides shade and habitat for a range of aquatic and terrestrial fauna

Areas where erosion is localised and a variety of vegetation (such as the Shore rush) is growing along the banks and verges provide important habitat for terrestrial fauna. Species such as birds, frogs and lizards utilise the vegetation for nesting and breeding.

Instream cover is important for water quality and the dependent aquatic fauna. Results indicate that there is a reasonable level of instream cover from leaf litter, branches rocks and vegetation. However, this cover is patchy and often does not extend far into the waterway, leaving some areas of the channel devoid of any cover and shade. A lack of shade will allow the water temperatures to increase and may lead to a decline in aquatic fauna and an increase in algal growth.

All survey sections were recorded as having tree species present, although 32% of sites were found to have ‘some sick trees’ and 35% ‘some dead trees.’ This may be attributed to waterlogging and rising salinity levels throughout the catchment, but may also be an effect of the unusually dry summer of 2000/2001. The dead trees still provide an important range of habitat for terrestrial fauna. Woody debris found instream and along foreshore areas provides an important habitat for aquatic and terrestrial organisms. An example of habitats along a watercourse and the terrestrial and aquatic fauna that may be found in each is provided in Appendix 8.

Bridges and crossing points allow vehicles to pass in close proximity to the waterway, increasing the likelihood of pollution by fuel, oil and other contaminants. Structures such as bridges and crossing points are likely to change the flow of the waterway and may also lead to problems such as increased erosive capacity and a decline in fish migration. Results indicate that crossing points were recorded as having a high management priority in 6% of sections, moderate in 12% and low in 26% of sections.

Foreshore condition

The high proportion of Talbot Brook foreshore that has been rated as C-grade indicates the degraded state of the riverine environment. A number of factors have contributed to the decline in foreshore health and condition. These are:

- surrounding agricultural landuse;
- uncontrolled access of stock to riparian zones (overgrazing and trampling);
- a lack of surface water management systems; and
- a lack of integrated waterways management practices.

The above factors may be attributed to historical landuse practices and a lack of community understanding about waterways management on a long term basis. The volatile nature of farming may also mean that land managers do not have the economic means to change farming practices and improve land and water management practices on their property.

Foreshore vegetation

A lack of riparian vegetation will adversely affect the health of a waterway. Riparian vegetation protects water quality and channel form by decreasing the amount of nutrient and sediment entering the brook, as well as reducing erosion of banks. Clearing of vegetation, weed invasion, disturbance by stock and salinisation all impact negatively on the health of riparian vegetation (Jackson, 1997).

The vegetation recorded along the foreshore is indicative of how salty the water within the brook is. All dominant tree species observed during field assessments (Flooded gum, Swamp paperbark and Jam tree) all have a low tolerance to salty conditions (Water and Rivers Commission (WRC) and Avon Waterways Committee (AWC), 1999). Table 9 shows what level of salinity and waterlogging each species can tolerate.

Species name	**Salinity range**	**Waterlogging tolerance**
Flooded gum	Fresh - brackish	High
Swamp paperbark	Fresh - brackish	Very high
Wandoo	Fresh - brackish	Low
Jam tree	Fresh - brackish	Low
Swamp sheoak	Fresh - saline	High

Table 9. Salinity and waterlogging tolerance of dominant tree species

The high numbers of Flooded gum (in 97% of sites) indicates that the water is brackish (acceptable for most stock and some irrigation) (ANZECC, 1992). Flooded gum can only tolerate moderate salinity levels but has a high tolerance to waterlogged conditions. Swamp paperbark (recorded in 59% of sections) can only tolerate fresh-brackish conditions, but very high levels of waterlogging.

The shallow to moderately steep landscape of Talbot Brook catchment, in conjunction with soil types, may mean that the foreshore is likely to be prone to waterlogging during the wetter months and this would kill Jam tree and Wandoo before salinity. This may account for the lack of these species in some areas, as well as the poor health of trees within the riparian zone.

The composition of native plant communities has been altered significantly as a result of past and present landuse (the introduction of crops, annual pasture plants and grazing animals) that have led to changes to the landscape (Walker, 1986). A decline in species richness and diversity of native understorey species has encouraged the spread of grass and pasture weeds such as Wild oats and Barley grass.

The current lack of native understorey species means that the nutrient stripping ability of the riparian zone is greatly reduced, leading to a higher level of nutrients entering the aquatic system. Nutrient enrichment and consequential algal blooms have the ability (directly and indirectly) to kill aquatic fauna.

Understorey vegetation is dominated by weed species, most of which have been introduced and spread by birds, stock, wind, and water erosion of soil particles containing seeds. Species such as Wild oats and Barley grass are agricultural weeds (related to the historical use of surrounding land for cropping and grazing) and have a high occurrence along most of the brook.

The dominance of weed species compared to native species is due to the continual overgrazing and trampling of the riverine environment, hindering the regeneration of the native species. Weeds species are quicker to adapt to fluctuations in the environment and an increasing level of salinity has led to the death of many native species, leaving room for weed species to invade. Numerous areas of bare ground, combined with an increase in shallow rooted exotic species has left the riparian zone susceptible to bank erosion and nutrient enrichment.

The intensity of grazing in those sections where stock had access to the riparian zone directly relates to the regeneration and survival of native seedlings. Regeneration of native seedlings was observed at 68% of sections. In most cases the number of seedlings was moderate, but declined significantly in number within those sections where stock had access to the foreshore area.

A lack of fringing vegetation along most of the banks and verges has contributed to the increase in sediment and nutrients entering the waterway. Fringing vegetation plays an important role in filtering water entering the channel and keeping the waterway healthy (Water and Rivers Commission, 1997).

Leaf litter and lichens are minimal along the majority of foreshore sections, however they still play an important role in stabilising the soil surface and assisting in the reduction of soil erosion and compaction. Both are helpful in retaining moisture within the soil and feeding nutrients back into the soils. Leaf litter and debris provide nesting, feeding and shelter sites for many terrestrial invertebrates (Abensperg-Traun, 1995).

It should be noted that the vegetation surveys conducted throughout foreshore and channel assessments are not conclusive. It is likely that there are other species present along the brook and it is recommended that future assessments include two separate vegetation surveys, at differing times of the year, to determine a more accurate list of species present.

Disturbance

The current condition of Talbot Brook is attributable to a number of past and present disturbances, the key ones being:

- current farming practices;
- stock access to waterways;
- vehicle access to waterways;
- feral animals;
- spread of weeds; and
- frequent fires associated with surrounding farming practices.

80% of survey sections were accessible to stock during the time assessments were conducted, however field observations and landholder comments suggest that the number of sites accessible to stock varies throughout the year. Approximately 68% of Talbot Brook is fenced on one or both sides. Many farmers graze stock along the waterway when there is a lack of feed and for other reasons such as reducing fire hazards. Over the years however, crop and livestock production has taken its toll on the landscape. Livestock access to the river channel and foreshore can lead to problems such as:

- foreshore and channel erosion;
- introduction and spread of weeds;
- trampling and eating of native vegetation (particularly regrowth);
- an increase in nutrients (animal faeces) being deposited into the waterway;
- a reduction in fringing vegetation;
- destabilisation and mobilisation of sediment; and
- loss of habitat for native fauna (through loss of vegetation as well as competition).

All of these factors combined contribute to the degraded state of the foreshore and channel of Talbot Brook. However, introducing stock to the landscape should not be seen as the only cause of land degradation within the catchment.

Weed distribution is closely linked to increased levels of disturbance in wetlands from activities that include clearing and grazing. Overgrazing of stock can also degrade the environment through soil compaction, increased nutrient levels, introduction of weed species, trampling of native wetland plants and the ringbarking of mature trees.

Feral animals may contribute to soil erosion; for example, rabbits burrow into the ground for nesting purposes and also eat vegetation. Birds nest in vegetation and also forage for food such as seeds and berries. Seeds are spread in bird droppings and easily carried throughout the riparian zone where the moist conditions are suitable for weed growth.

Stock trample and eat native vegetation and cause erosion of the bed and banks

Evidence of management

Results indicate that the level of management that has been undertaken to protect the brook was high. The small number of landholders who were not employing waterways management practices may be attributable to a lack of community education and awareness about river management. In many cases landholders indicated that cost was a major factor hindering further development and adoption of rivercare practices and actions.

Fencing was used in over half of the sections, and in some areas firebreaks were also used to lower the chance of fire spreading across the waterway into cropped areas or close to buildings such as houses and sheds.

Principles for waterways management

The need for management

The results of this channel and foreshore assessment indicated that there are many issues that need long term management if the health of the brook is to be improved. Results indicate a necessity for the implementation of appropriate integrated catchment management practices.

Water supplies in rural Western Australia are limited, and those in abundance are often affected by salinity and have limited use. Talbot Brook catchment has a low supply of water (surface and groundwater) to satisfy a wide range of competing needs, meaning that water resources need to be used and managed sustainably. A management or action plan can be used to guide sustainable land and water use, at the same time looking after the riverine environment in conjunction with the economic needs of the landholders. A management or action plan can be devised for individual properties or the catchment as a whole, and includes such things as:

- identification and prioritisation of potential future threats;
- indications of community and landholder needs and desires;
- actions to address management issues; and
- an implementation plan outlining recommendations for action, timeframes and responsibilities for undertaking actions.

Management of waterways and semi-rural land use should be closely related, as the interrelated nature of the two means that they have a wide range of effects on each other (Weaving, 1994). Management of Talbot Brook and its surrounding catchment will not lead to the waterway being returned to its pristine, pre-European settlement condition, but will prevent further degradation and encourage the system to become healthier and more resilient in the long-term.

Principles important for inland river management that are relevant to the management of Talbot Brook and other tributaries throughout the Avon River Catchment have been identified by Edgar (2001).

1. Natural flow regimes, (intermittent drying of the channel), and the maintenance of water quality are fundamental to the health of inland river ecosystems.
2. Flooding is essential to floodplain ecosystem processes and also makes a significant contribution to pastoral activities.
3. Structures such as dams, weirs and levees can have a significant impact on the connectivity along rivers and between the river and its floodplain.
4. The integrated management of surface and groundwater supplies is an important concept that needs to be undertaken on a catchment-wide scale.
5. Sufficient knowledge exists to ensure that water resource allocation decisions are made on a sustainable basis.
6. New developments should be undertaken only after appraisal indicates they are economically viable and ecologically sustainable. Promoting greater water efficiency is essential to achieving sustainable industries.
7. High conservation value rivers and floodplains need to be identified, and in some cases, protected in an un-regulated state.
8. Rivers at risk of further degradation need to be identified, and priorities established for their rehabilitation.
9. Improved institutional and legal frameworks are needed to meet community river management aspirations.
10. With all parties making a commitment to work together, management regimes can be developed that are ecologically, economically, socially and culturally sustainable.

Management responsibilities

The concept of this foreshore and channel survey is to encourage management activities as well as providing a condition report on the brook. The successful management of a waterway entails the successful management of the surrounding landscape. It is important to understand that the landscape components within the Talbot Brook catchment are interrelated and hence need to be managed as a whole.

The brook should not be managed as an entity on its own as there are many issues throughout the catchment that contribute to the current condition. Managing the waterway on its own can be likened to treating a problem but not the cause. A catchment wide approach should be employed with a range of objectives to improve the health of the riverine environment. There are many smaller tributaries feeding into Talbot Brook that impact on the quality of water, as well as sediment loads, and channel and foreshore condition.

Maintaining a catchment group or Friends group for the length of the brook is important to the long-term management of the waterway. Promoting the waterway as an asset to the community and encouraging community involvement on management may prove difficult as Talbot Brook runs through private landholdings. Small groups of landholders along the waterway and from within the surrounding catchment should be encouraged to band together to plan and implement river management actions.

The Talbot Brook Land Management Association Inc. is committed to the management of the waterway and surrounding catchment, while the Kokendin Catchment Group and the Waterhatch Catchment Group are both community groups working towards the management of catchments within the Talbot Brook catchment. The Avon Catchment Council (ACC), Beverley LCDC, York LCDC, York River Conservation Society, Beverley Naturalists' Club and the Avon Valley Environmental Society, are community groups aiming to promote and coordinate integrated catchment management within the Avon River Catchment for the surrounding community. These groups have committed themselves to improving the health of the waterways and surrounding catchments, and may possess many resources and knowledge that will be useful in the future management of this waterway. These groups will require strong support from government agencies, Local Government Authorities, other catchment groups, landholders and the surrounding community if they are to contribute to the management of the whole catchment.

Waterways management should be undertaken with the objective of resolving competition between incompatible land uses to ensure that those values that are high or irreplaceable can be maintained. Efforts should be made to maintain and enhance the quality of the water in Talbot Brook and adjoining tributaries, in order to conserve ecological systems and meet the needs of present and future generations. Flexibility in the management plan is a must if it is to have the long-term ability to combine waterways conservation with agricultural practices and semi-rural lifestyles which are highly dependent on climate and other environmental factors (Clement and Bennett, 1998).

A blank survey sheet is included in Appendix 3 for use by landholders, catchment groups, and community members who are interested in assessing the condition of their waterway to use for future monitoring and management purposes.

Anecdotal evidence suggests that landholders along Talbot Brook are aware of the benefits of long term management of the waterway. Economics is one of the main issues hindering development of on-ground management actions. The lack of financial resources available for landholders to direct into waterways management and the management of surrounding land may mean that there is a need for government and community groups to provide support and encouragement (Coates, 1987).

Management requirements

Weeds management

Weeds have many negative impacts on the riverine environment. They degrade the bushland along the waterway, and are a fire hazard. Introduced species replace native vegetation, or prevent the regeneration of native vegetation, and are often visually unattractive. They compete with native vegetation for space and water. The resulting loss of native species may lead to a change in the food and habitat source for native fauna, hence altering the food chain.

Weeds are also a fire hazard. Many weeds are winter active, meaning that they die off (or become dormant) during summer. In areas of high weed coverage the dry grasses provide an excellent source of fuel for fire and may increase the possibility of the spread of a wildfire along the waterway corridor.

An integrated catchment management approach should be encouraged as the best way to deal with weeds. Weed control needs to focus on the immediate area as well as upstream areas where seeds can be easily transported downstream to susceptible areas. Information should be sought from the Environmental Weeds Action Network to develop a catchment-wide weed control strategy.

Landholders should undertake weed control by targeting the best areas and working towards the worst weed-infested areas. Focusing on invasive species as well as declared and pest plants will give a more productive outcome to weed control. Working from the edge of the weed infestation towards the centre, and removing the seed source followed by new growth is the most effective way to manage weed infestations. Working from upstream areas means that the likelihood of seeds and cuttings being washed downstream and recolonising in weed free areas is reduced significantly.

Weeds growing along road verges that run in close proximity to the waterway and its tributaries should be controlled, so as to reduce the risk of spreading into surrounding riparian zones.

Some introduced species perform a useful role in rehabilitation and riverbank stabilisation. For example, Saltwater couch colonises bare areas along banks and verges and often is useful in stabilising the area that would otherwise be susceptible to erosion and undercutting. These species should be tolerated in the short term, but in the longer term they will need to be controlled before spreading too far. When undertaking weed management weeds should only be removed from areas susceptible to erosion when revegetation is about to begin. Areas left bare for long periods will be eroded and may contribute to sedimentation within the waterway.

Riparian revegetation

The health of the bank and foreshore vegetation along a waterway is indicative of the health of the waterway. Riparian vegetation is an important component of the river ecosystem, and when salinity levels increase, for example, many plant species will die off and be replaced by more salt tolerant species.

Vegetation along waterways should be managed with a view to improving catchment health. Riparian vegetation improves waterway health by:

- providing habitat for native fauna;
- stabilising the channel bed, banks and verge;
- providing wildlife corridors allowing fauna to move along the river;
- providing shade over the waterway, thus providing a more favourable habitat and decreasing the likelihood of algal blooms;
- providing woody debris for habitat and bank stabilisation;
- filtering runoff from surrounding land to decrease nutrient input into the waterway; and
- protecting soils from wind and water erosion (Olsen and Skitmore, 1991).

Management works should be prioritised to gain the greatest benefit from the available resources. Protecting areas of good (weed free) riparian vegetation and working towards more degraded areas will be more economically viable for landholders (Price and Lovett, 1996b). It is more costly to rehabilitate a degraded area than to protect it before it becomes weed infested.

Revegetation of the riparian zone is a common management practice

If revegetation of riparian areas takes place, it is important that stock do not have access to these areas of fringing vegetation. A fence around the revegetated area (or the riparian zone) is the most effective tool to prevent livestock grazing and trampling newly revegetated areas.

Where grazing of the riparian zone is necessary, the following rules should be followed to minimise disturbance and limit the environmental and economic losses associated with an unhealthy riverine system.

- Avoid grazing the riparian zone during the germination, growing and flowering times of the native plants;

- Do not overstock the riparian zone. This will minimise the negative impact that grazing and trampling have on the productivity of this area, as well as the water quality within the brook; and
- Adjust stocking rates and the frequency of grazing within this zone to suit the carrying capacity of the land (Price and Lovett, 1996b).

Riparian vegetation plays an important role in protecting the waterway from degradation. Vegetation along banks, verges and foreshore areas can help to regulate the hydrological processes, filter nutrients from recharge water as well as nutrient cycling, and prevents soil erosion by overland flows of water and wind (Coates, 1987).

Fire management

Annual weeds, such as grasses, dry out during the summer months and can pose a serious fire risk if not kept under control. Along Talbot Brook the vegetation exists as a corridor, and after frequent or uncontrolled fire, may be vulnerable due to the limited opportunity for recolonisation from surrounding areas (Underwood, 1995).

An abundance of weed species that die off during summer months means that the riparian zone along Talbot Brook is susceptible to fire, and hence a management plan to accommodate any risks needs to be decided upon and implemented. There are many disadvantages to fire, including risk to persons and property, livelihood, weed invasion, loss of habitat for fauna, loss of some seed, loss of peat soils and an increase in erosion. Under controlled circumstances, when risks are reduced, there are also benefits of fire to the natural system. For example, fire provides the opportunity for many native plant species to germinate by providing the right conditions.

To reduce any serious threat of fire, it may be necessary to implement controlled grazing along some sections of the river (WRC and ARMA, 1999). This can reduce the threat of fire to those people living and farming along the waterway. A controlled fire regime can be a useful tool in the regeneration of native species growing within the riverine environment as many species have adapted to occasional fire and benefit from it. When uncontrolled and on too frequent a basis, fire may lead to a loss of habitat, an increased susceptibility to weed invasion, and can hinder management works if rehabilitation plantings and fences are burnt (Underwood, 1995).

If areas are burnt too frequently, there is a risk of weed invasion. Fire creates bare open ground which is ideal for the germination of weed species, and if fires become too frequent it is easy for weeds to out-compete native plants.

Burning of vegetation and debris along the waterway foreshore and banks should be responsive to the condition of the vegetation, but it is important to remember that leaf litter and debris contribute important habitat for organisms, as well as protecting the soil from erosion. A set time regime should be put into place to monitor burning within the riparian zone. This will deter burning too frequently and minimise the damage caused by doing so (Price and Lovett, 1996a).

Firebreaks along foreshore verges are important to protect the fragile vegetation from unintentional fires that may result from crop and pasture burning in surrounding paddocks. To maintain effective fire control for the riparian zone, firebreaks and fencing should be upgraded and maintained along verge areas of the foreshore. When fencing for protection of riparian vegetation the firebreak should be located on the river side of the fence, as far away from the bank as possible. A firebreak on the river side of the fence will allow easy access to this zone, and prevent stock from pushing the fence over to graze on the other side.

The Avon Waterways Committee (AWC) has a fire policy that sets out the objectives for bushland management in and along the river. The main goals are to manage the fire problem along the waterway, while minimising the threat to the river environment and to neighbours. It is also a priority to educate river neighbours and encourage landholders to take responsibility for protecting their own assets. A copy of this policy is attached in Appendix 9.

Water quality

Poor water quality can significantly affect the health of the brook and its surrounding ecosystems. It is likely that the clearing of the land, associated with the agricultural development of the catchment, has had a negative impact on the health of this waterway. Combined with current land use practices, the clearing of vegetation has increased the sediment loads and possibly the salinity levels within the brook and its tributaries, adversely affecting the health of the riverine system (Schofield et al, 1988).

Restricting stock access from the brook will help to improve water quality. Stock, (sheep and cattle, along with goats and horses), are responsible for mobilising plant nutrients, that they distribute via their faeces (Swan River Trust, 1998). Controlled access will minimise the amount of manure within the waterway and limit nutrient enrichment.

Water resource management is best approached as a part of integrated catchment management. Managing each catchment area as a whole allows the diverse range of social, economic and ecological activities that affect a particular waterbody to be coordinated. Water and biological resources are firmly linked within the natural environment, and disruptions to either one can have significant implications on these resources and the environment as a whole (Australian Water Resources Council, 1992).

Development

Within the last decade there has been subdivision of land into smaller lots for rural lifestylers. Many of the older land titles give ownership across the brook. This makes it difficult to encourage management of the waterway.

As landholdings are subdivided for resale, titles are changing and so is the ability of the Department of Environment, Water and Catchment Protection (formerly the Water and Rivers Commission) to encourage management of waterways. Any future development of land within the region would be through the Shires of York and Beverley

Applications for subdivision are sent to the Western Australian Planning Commission for assessment and for referral to relevant organisations (including the Department of Environment, Water and Catchment Protection and the Avon Waterways Committee (AWC)) to provide advice. It is usual practice for a Foreshore Management Plan/Agreement to be requested where development and/or subdivision is planned for land surrounding a waterway. The agreement aims to protect the environmental, social and economic values associated with the channel and foreshore.

A small number of properties along Talbot Brook have houses, sheds and other buildings located close to the waterway, within the immediate floodplain. As small landholdings are becoming increasingly common within the catchment, it is important that landholders and planners are educated about the potential risks of flooding.

The flood regime within the Avon catchment tends to be approximately 10 years apart (Hansen, 1986). When planning development within the Talbot Brook catchment the flood regime needs to be taken into consideration so that damaged caused by floods is minimised. Development within flood-prone areas should be actively discouraged.

Any existing and future landuse should be guided by either the Shire of York Town Planning Scheme, the Shire of Beverley Town Planning Scheme, the Ministry of Planning and the Department of Environment, Water and Catchment Protection, while providing for the protection and enhancement of the environment and the catchment surrounding Talbot Brook.

Areas of cultural significance (both Aboriginal and non-Aboriginal) should be recorded and protected through the Town Planning Scheme to prevent any changes to landuse that may be detrimental to these sites. It should be noted that where Aboriginal sites may be affected by proposals for development and land use change, the requirements of the *Aboriginal Heritage Act, 1972* must be met (Western Australia Planning Commission, 1999). Any sites listed on the State Register of Heritage Places are protected by the *Heritage of Western Australia Act, 1990*, which determines certain requirements for individual sites, aiming to conserve the associated heritage values.

Large woody debris

Large woody debris (also known as snags) are branches, large limbs or whole trees which fall into the watercourse and either remain in place or move downstream where they come to rest. It is common for smaller debris and leaf litter washed downstream to become accumulated at these points, providing an important habitat for many aquatic organisms. Some areas along Talbot Brook have been cleared of this material due to perceived risks of flooding and bank erosion, highlighting the need to educate people to the benefits of keeping the debris within the river system, and the disadvantages of removal.

Contrary to common belief, the removal of large woody debris does not reduce flood risk and will actually lead to bank and channel erosion caused by an increased flow velocity. The increased movement of sediment through the system will be deposited in pools and along floodplains and may lead to a decline in habitat, raised channel beds and increased threat to infrastructure such as low bridges. Reintroducing large woody debris to the system will increase river stability and provide a greater diversity of habitat for native fauna.

In areas where large woody debris has been removed, attempts should be made to add sufficient debris material to the waterway to return it to its natural load. By considering the amount of debris found in healthier parts of the brook (or in waterways in close proximity under the same conditions) assumptions can be made as to how much woody debris to return to the system (Price and Lovett, 1996b).

Sediment deposition

The goal of management is to minimise sediments entering the brook, to reduce the movement of sediment along the waterway, to stabilise the riverbanks and channels, and to remove sediments from the brook at selected places.

Sediments comprise sand (the heavy, course fraction which is mostly carried in suspension), and silt (the finer fraction which is carried in solution). Both are moved down the river channels to be deposited when the river velocity is slowed, either by natural pools, a natural obstruction, or by the drying up of the river in summer.

A riffle is an engineer-designed low rock bar, or some other form of engineered structure, placed across the river at a strategic point with the aim of slowing river velocity. These structures can also become places where coarse sediments will be deposited and can later be removed.

Fencing

When revegetating an area along the riparian zone it is important to exclude stock so that they do not eat and trample revegetated areas. Fencing is the easiest and cheapest means of excluding stock. It is recommended that stock be excluded from the planted area for at least three years to allow plants to grow and recolonise the area (Piggott et al, 1995). After this period the plants should be established and stock access, if allowed, should be minimised and properly managed.

Controlled grazing requires fencing to confine stock to the approved grazing area and to control the intensity of grazing. Fenced areas will regenerate naturally over time, or can be replanted with native trees and shrubs. The vegetation helps to control soil erosion along the river, and provides habitat for wildlife. Riparian vegetation is an effective way of preventing sediment entering the waterway.

Fences should be erected outside the riparian zone, as far away from the bank as possible, to exclude stock from the riparian zone. This will encourage the regeneration of native tree species and the growth of ground covers that will aid in stabilising the waterway banks and verges. Fencing of the zone should follow certain parameters if it is to be of benefit to both the environment and economic pursuits of the landholder. A good management tool is to develop a firebreak inside the riparian zone to allow for easy access and to prevent stock pushing fences down to gain access to vegetation.

The type of fence used should be suited to the flood regime. For example, drop fences will drop to the ground during flood events where pressure from water and debris builds up (see Appendix 6 for a description of fencing systems). Using the right type of fence is more economically viable, as it decreases the need for repairs. Fencing along riparian zones should be located parallel to the waterway to minimise the impact of floodwaters on the fence. Most importantly the type of fence used should be suited to the surrounding landuse if it is to have the maximum benefit of protecting the water resources for future use (Price and Lovett, 1996b).

Feral animals

Field observations and conversations with landholders along Talbot Brook determined that there are a high number of feral animals resident within the riparian and channel vegetation. The most common are rabbits and foxes, but feral cats have also been sighted on occasion. Feral animals take over habitats and prey on native fauna, they destroy native vegetation, increase the spread of weeds, contribute to bank destabilisation and erosion through burrowing into the soil, and are often a threat to livestock being grazed along foreshore and surrounding areas.

Management of feral animals should be approached as a whole throughout the catchment. There is no use in working to rid one property of pest animals to have them migrate from surrounding properties. There is a need for cross boundary management of feral animals to stop this happening. Surveys show that feral animal control (baiting) is already in practice along some areas of the waterway and surrounding landholdings. Controlling weeds will also help to deter pest animals due to a lack of food, nesting and breeding sites.

Waste disposal

Field observations determined that along some sections of the brook it has been and still is commonplace to dispose of unwanted farm machinery, cars and chemical containers along the banks of the waterway. Refuse can cause pollution of the waterway and those into which it feeds (the Dale River) when oils, fuel and chemicals leach into the waterway and are moved downstream during periods of flow. Landholders should be encouraged not to dump unused items near the river by educating them on the risks involved in affecting the surrounding environment.

Education and awareness

For the long-term benefit of the riverine ecosystem, measures should be taken to educate landholders in an effort to promote understanding and awareness of the significance of waterways and their management for future use. Landholders along Talbot Brook were given the opportunity to take part in the foreshore and channel assessment, and it is important that involvement is on-going, especially in any future plans to improve the health of this waterway.

Catchment management and community action require awareness of the issues, education and information, technical advice and practical support. Local Government Authorities, as well as relevant government and non-government agencies need to provide support to these groups, while banding together to promote issues such as waterways management, integrated catchment management and land management to community members.

There is a wealth of information already learnt and gathered from other community, catchment and friends of groups which is valuable and can be passed on through establishing networks between groups in surrounding areas. The Avon Catchment Network provides a range of resources helpful to land and waterways management.

Concluding comments

This foreshore and channel assessment has been undertaken to provide landholders, interested community groups, Local Government Authorities and Government and non-Government agencies within the surrounding catchment an understanding of the current condition of Talbot Brook channel and foreshore.

The survey process has been developed to suit the needs of this region and can be used by interested individuals, groups and organisations to gain an understanding of the condition of other waterways within their community. It is hoped that this process will be useful for these people to monitor the health and condition of this waterway into the future.

By using a standard methodology to gather information it is possible to compare and contrast foreshore conditions of the same area over time, or between different sites in the same survey season. Results can then be used to prioritise management needs, determine the impact of new disturbances and assess changes in foreshore and channel condition.

This document provides the results of the foreshore assessments undertaken along Talbot Brook. The main conclusion to draw from findings is that in many ways the health of the brook is suffering, both directly and indirectly, as a result of past and present landuse activities.

Talbot Brook is generally degraded. Historically land has been overused, but land use activities employed within the catchment are becoming more compatible and ecologically sustainable. There is hope that with a greater understanding of the condition of Talbot Brook, community members will band together to try and recover some of the natural health and beauty of the waterway.

In general Talbot Brook is described as a C-grade system, meaning that the foreshore vegetation support only trees over weeds or pasture. Bank erosion and subsidence may also occur in localised areas. The high sediment loads within the channel mean that the system is very mobile and unstable and is in need of rehabilitation.

There is a lack of native plants and an abundance of weeds. The most common native vegetation are trees with Flooded gum and Swamp paperbark being the most prevalent. Of the weed species invading the groundcover Wild oats, Cape tulip (one and two leaf) and Barley grass were the most common during this assessment.

The major disturbances along the length of this watercourse are weeds, feral animals and pollution, as well as vehicle and stock access to the riparian zone. Observations determined that the issues in greatest need of management were weed invasion, stock access, fire, and salinisation of the waterway and surrounding land.

The need exists to assess competing land-uses and determine a compromise that allows for the rehabilitation and conservation of Talbot Brook along with sustainable and economically viable land use practices. This will lead to many economic, environmental and social advantages both now and into the future.

Future strategies to improve the ecological health of Talbot Brook need to be linked to the development of more sustainable farming systems within its catchment. If management of the riverine system is to be effective, degradation associated with Talbot Brook must be treated at the cause and not the symptom.

Management of this waterway requires knowledge and understanding of what factors are present and how they are effecting (either positively or negatively) the surrounding environment. This survey provides that information so that the community can work together to initiate an integrated approach to improving the health of Talbot Brook. The data collected throughout this foreshore and channel assessment is also an effective tool to monitor future changes in the stability and health of this waterway.

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Glossary

Anabranch	A secondary channel of a river which splits from the main channel and then later rejoins.
Bank	The steeper part of a waterway channel cross-section, which is usually considered to lie above the usual water level.
Barbed wire fence	Any fence that is in part barbed wire.
Bed stability	When the average elevation of the streambed does not change much through time.
Biodiversity	The number, relative abundance and genetic diversity of life forms within an ecosystem.
Carrying capacity	The maximum population of organisms or the maximum pressure than an environment can support on a sustainable basis over a given period of time.
Catchment	The area of land drained by a waterway and its tributaries.
Channelisation	The straightening of the river channel by erosional processes.
Contour farming	Plowing and planting across the changing slope of land, rather than in straight lines, to help retain water and reduce soil erosion.
Debris	Loose and unconsolidated material resulting from the disintegration of rocks, soil, vegetation or other material transported and deposited during erosion.
Declared plant	Plants that are classified as high priority and which may become a major problem to the environment or to agricultural activities.
Degradation	Specifically the general excavation of a streambed by erosional purposes over a number of years. Has a broader meaning of reduction in quality.
Electrical conductivity	A measure of salinity. The higher the electrical conductivity of a stream the greater the salinity.
Electric fence	Any fence design which is electrified, irrespective of whether they consist of electric tape, a single smooth electric wire or one barbed wire, four plain wires of which two are electric.
Environment	All the biological and non-biological factors that affect an organisms life.
Environmental degradation	Depletion or destruction of a potentially renewable resource such as soil, grassland, forest, or wildlife by using it at a faster rate than it is naturally replenished.
Erosion	The subsequent removal of soil or rock particles from one location and their deposition in another location.
Eutrophication	An excessive increase in the nutrient status of a waterbody.
Evaporation	A physical change in which liquid changes into a vapour or gas.
Exotic vegetation	Introduced species of vegetation from other countries or from other regions of Australia (ie. not indigenous to the region).
Fabricated fence	Includes rabbit netting, ringlock and hinge point fences.
Floodplain	A flat area adjacent to a waterway that is covered by floods every year or two.
Floodway & bank vegetation	Vegetation which covers the floodway and bank part of the riparian zone. The vegetation which actually grows in the floodway or on the banks above the stream.

Habitat	The specific region in which an organism or population of organisms live.
Large woody debris	A branch, tree or root system that has fallen into or is immersed (totally or partially) in a stream.
Leaf litter	The uppermost layer of organic material in a soil, consisting of freshly fallen or slightly decomposed organic materials which have accumulated at the ground surface.
Monitoring	The regular gathering and analysing of information to observe and document changes through time and space.
Native species	Species that normally live and thrive in a particular ecosystem.
Organism	Any form of life.
Overgrazing	Destruction of vegetation when too many animals feed too long and exceed the carrying capacity of a rangeland area.
Pest plant	Weed species that are seen as being a nuisance to the existing landuse. Local Government Authorities can enforce the control of such a species.
pH	Technically this is the hydrogen ion (H^+) concentration in the water. It is the simplest measure of acidity.
Pollution	Any physical, chemical or biological alteration of air, water or land that is harmful to living organisms.
Regeneration	Vegetation that has grown from natural sources of seed, from vegetative growth, or has been artificially planted.
Riffle	The high point in the bed of the stream (accumulation of coarse bed materials), where upstream of accumulations a shallow pool is formed. Downstream from the crest of the accumulation the water is often shallow and fast flowing.
Riparian zone	Refers to the zone directly adjoining a waterway. Any land that adjoins, directly influences, or is influenced by a body of water.
Salinisation	The accumulation of salts in soil and water which causes degradation of vegetation and land.
Sediment	Soil particles, sand and other mineral matter eroded from land and carried in surface waters.
Sedimentation	The accumulation of soil particles within a waterway, which leads to a decline in water quality.
Slumping	The mass failure of part of a stream bank.
Snags	Large woody debris such as logs and branches that fall into rivers.
Subsidence	The sinking of parts of the ground which are not slope related.
Terrestrial	Relating to land.
Turbidity	A measure of the suspended solids in the water.
Undercutting	The undermining or erosion of soil by water from underneath an existing landform (ie. riverbank), structure (ie, fence post) or vegetation (ie. tree).
Verge	The area extending from the top of the bank to the next major vegetation or land use change.
Verge vegetation	The strip of land up to 20m from the immediate river or creek valley.
Waterlogging	Saturation of soil with irrigation water or excessive rainfall, so that the water table rises close to the surface.
Weed	A plant growing where it is not wanted.

Appendix 1. Soil landscape systems

MU_Symbol	MU_Name	MU_Landform	MU_Soil
257Af	Avon Flats System	Alluvial terraces and flats.	Browns loamy earths, grey non-cracking clays and brown deep sands.
253Cc	Clackline System	Moderately dissected areas with gravelly slopes and ridges and minor rock outcrop.	Grey shallow sandy duplexes, duplex sandy gravels, loamy gravels, pale shallow sands and red shallow loamy duplexes.
257Jc	Jelcobine System	Major valleys with isolated lateritic remnants.	Red deep and shallow sandy and loamy duplexes, grey deep sandy duplexes, bare rock and cracking and non-cracking clays.
257Wk	West Kokeby System	Low, smoothly undulating interfluves with broad swampy flat valleys.	Deep pale sand, pale gravelly sand, sandy duplexes, wet soil and minor rock outcrops.
253Wn	Wundowie System	Lateritic plateau with some rock outcrops.	Deep sandy gravels, duplex sandy gravels and shallow gravels.

Appendix 2.
Completed tributary assessment form

Please note that the information contained in this completed assessment form is an example only.

Foreshore and channel condition assessment form

For property and paddock scale surveys

General details

Recorder's Name: P. Janssen

Survey Date: 10 July 2001

Tributary Name: Talbot Brook

Section Number: TaB001

Catchment Name: Dale River Catchment

Length of Section: 1.2Km

Sub-catchment Name: Talbot Brook Catchment

Shire: York

Nearest Road Intersection: Talbot Road and Qualen Road

GPS (start of survey section) E: 509320 N: 6459158

GPS (end of survey section) E: 508091 N: 6459597

Landholder contacted: Yes ✗ No ☐

Landholder consent obtained: Yes ✗ No ☐

Landholder present during survey: Yes ☐ No ✗

Bank(s) surveyed (facing upstream)

left ☐ right ☐ both ✗

Landholder: Jack and Jill Brown

Contact Number: 9555 5555

Property address: Lot 89 River Road, Riverville

Bank stability

Proportion of bank affected (% of survey area)	Undercutting	Firebreak/trackw washouts	Subsidence	Erosion	Slumping	Sedimentation
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
☐ Braided channel
☐ Pool
☐ Wetlands
☐ Other
………………………………..

✗ Dam
☐ Groundwater
☐ Rapids
☐ Annabranch

☐ Riffle
☐ Bridge
✗ Sand slugs
☐ Vegetated islands

Foreshore condition assessment

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 - rate between A1 and D3)

General: C Best: C2 Poorest: D1

Vegetation health

☐ Looks healthy ☐ Some sick trees ☐ Many sick or dying trees ✗ Some dead trees ☐ Many dead trees

Are there any tree seedlings or saplings present?: ✗ Yes ☐ No Species: Acacia sp., Flooded gum

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

Bare ground: % cover: 35%

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

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

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

Vegetation cover

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

Proportion of native species

	Proportion (%) of native species
Overstorey	> 80%
Middlestorey	> 80%
Understorey	< 10%

Fencing status

Fence present? ☒ Yes ☐ No Fence condition: ☐ Good ☒ Moderate ☐ Poor

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

Fence position (approximate distance [m] from river bank): LB: 10 – 15m RB: ~ 30m

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

Crossing Point: ☐ Yes ☒ No

Overall stream environmental 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 = 15 Environmental rating = Poor

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

Habitats

Aquatic organisms

Invertebrates, reptiles and fish

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

Terrestrial animals

Invertebrates

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

Birds (roosting/nesting sites)

✗ Trees
❐ Shrubs
✗ Rushes

Frogs

❐ Dense streamside vegetation
❐ Emergent plants/soft substrate for eggs

Reptiles

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

Mammals

❐ Dense protective vegetation

Habitat diversity

Any data or observations on variation in water depth?

Salt crystals along the bank.
Bank erosion.
Debris in trees and along fence lines.
Flood channels.

Any data or observations on water quality? (i.e. discoloured water, debris, algal blooms)

Algea.
High sediment load.
Limited overhanging vegetation.
Salt crystals.
Discolouration of water.

Any wildlife (or evidence of presence) observed?

Birds, ducks, flies, rabbits, dragonflies, ants, spiders, snakes, lizards

Landform types

Description (ie. major v-shaped river valley with granite outcrops, shallow valley with low relief).

Moderately steep valley with granite outcrops.

Evidence of management

Tick the appropriate boxes:

☐ Prescribed burning

☒ Firebreak control

☒ Fencing

☐ Nest boxes

☐ Recreational facilities (e.g. rubbish bins, BBQ's, benches)

☐ Signs

☐ Planting

☐ Weed control

☐ Erosion control

☐ Earthworks

☐ Dredging

☐ Other:………

Management issues

Tick the appropriate priority box for each management issue.

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

Issue	Priority		
	High	Medium	Low
Recreation			
Garden refuse			
Service corridors			
Crossing point			✗
Feral animals		✗	
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Cultural features			

Vegetation

Plant name	Abundance (H,M,L)	Plant name	Abundance (H,M,L)
Cape tulip	M	Golden wreath wattle	L
Soursob	M	Four o'clock	H
Wild oats	H	Samphire	L
Swamp sheoak	M	Grass tree	L
Barley grass	H		
Fat hen	L		
Thistle	L		
Sowthistle	L		
Swamp paperbark	L		
Flooded gum	M		
Couch	M		

Water quality data

Sample number	pH	Conductivity mS/cm	Temperature ºC	Location
1	8.33	18.4	22.1	482821 E 6465810 N
2	8.06	19.3	23.8	482834 E 6465873 N

GPS coordinates

Coordinate	Description
LMK01	Start point of survey section
LMK02	Start of large sand slug
LMK03	End of large sand slug
LMK04	Area of many sick and/or dead trees
LMK05	End of survey section

Photos

1. Channel condition
2. Sand slug
3. Dying foreshore vegetation
4. Foreshore condition
5. Fence condition
6. Stock in river
7. Bank erosion

Appendix 3.
Tributary assessment form

Foreshore and channel condition assessment form

For property and paddock scale surveys

General details

Recorder's Name:... Survey Date:..

Tributary Name:... Section Number:...

Catchment Name:.. Length of Section:...

Sub-catchment Name:... Shire:..

Nearest Road Intersection:..

GPS (start of survey section) E:................................ N:................................

GPS (end of survey section) E:................................ N:................................

Landholder contacted: Yes ☐ No ☐

Landholder consent obtained: Yes ☐ No ☐

Landholder present during survey: Yes ☐ No ☐

Bank(s) surveyed (facing upstream)

left ☐ right ☐ both ☐

Landholder:... Contact Number:..

Property address:..

Bank stability

Proportion of bank affected (% of survey area)	Undercutting	Firebreak/trackw washouts	Subsidence	Erosion	Slumping	Sedimentation
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
☐ Braided channel
☐ Pool
☐ Wetlands
☐ Other
………………………………..

☐ Dam
☐ Groundwater
☐ Rapids
☐ Annabranch

☐ Riffle
☐ Bridge
☐ Sand slugs
☐ Vegetated islands

Foreshore condition assessment

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 - rate between A1 and D3)

General: Best: Poorest:

Vegetation health

☐ Looks healthy ☐ Some sick trees ☐ 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

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	

Fencing status

Fence present? ☐ Yes ☐ No Fence condition: ☐ Good ☐ Moderate ☐ Poor

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

Fence position (approximate distance [m] from river bank): LB:.................. RB:.....................

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

Crossing Point: ☐ Yes ☐ No

Overall stream environmental 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 = ☐ Environmental rating = ...

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

Habitats

Aquatic organisms

Invertebrates, reptiles and fish

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

Terrestrial animals

Invertebrates

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

Birds (roosting/nesting sites)

☐ Trees
☐ Shrubs
☐ Rushes

Frogs

☐ Dense streamside vegetation
☐ Emergent plants/soft substrate for eggs

Reptiles

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

Mammals

☐ Dense protective vegetation

Habitat diversity

Any data or observations on variation in water depth?

Any data or observations on water quality? (i.e. discoloured water, debris, algal blooms)

Any wildlife (or evidence of presence) observed?

Landform types

Description (ie. major v-shaped river valley with granite outcrops, shallow valley with low relief).

Evidence of management

Tick the appropriate boxes:

- ☐ Prescribed burning
- ☐ Firebreak control
- ☐ Fencing
- ☐ Nest boxes
- ☐ Recreational facilities (e.g. rubbish bins, BBQ's, benches)
- ☐ Signs
- ☐ Planting
- ☐ Weed control
- ☐ Erosion control
- ☐ Earthworks
- ☐ Dredging
- ☐ Other:……

Management issues

Tick the appropriate priority box for each management issue.

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

Issue	**Priority**		
	High	**Medium**	**Low**
Recreation			
Garden refuse			
Service corridors			
Crossing point			
Feral animals			
Point source discharge			
Pumps or off-take pipes			
Dam/weir			
Cultural features			

Vegetation

Plant name	**Abundance (H,M,L)**	**Plant name**	**Abundance (H,M,L)**

Water quality data

Sample number	pH	Conductivity mS/cm	Temperature ºC	Location

GPS coordinates

Coordinate	Description

Photos

Appendix 4. Overall stream environmental health rating

Living streams survey: Information to determine environmental ratings of streamlines

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

Source: Pen and Scott, 1995

Overall stream environmental health rating: Points system

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 = ☐

Environmental rating = ...

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

Appendix 5.
Foreshore assessment grading system

A Grade

Foreshore has healthy native bush (ie. similar to that found in nature reserves, state forests and national parks).

A1. Pristine - 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 degraded - Native vegetation dominates. Some areas of human disturbance where soil may be exposed and weeds are relatively dense (ie. 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 (ie. 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 humans 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.

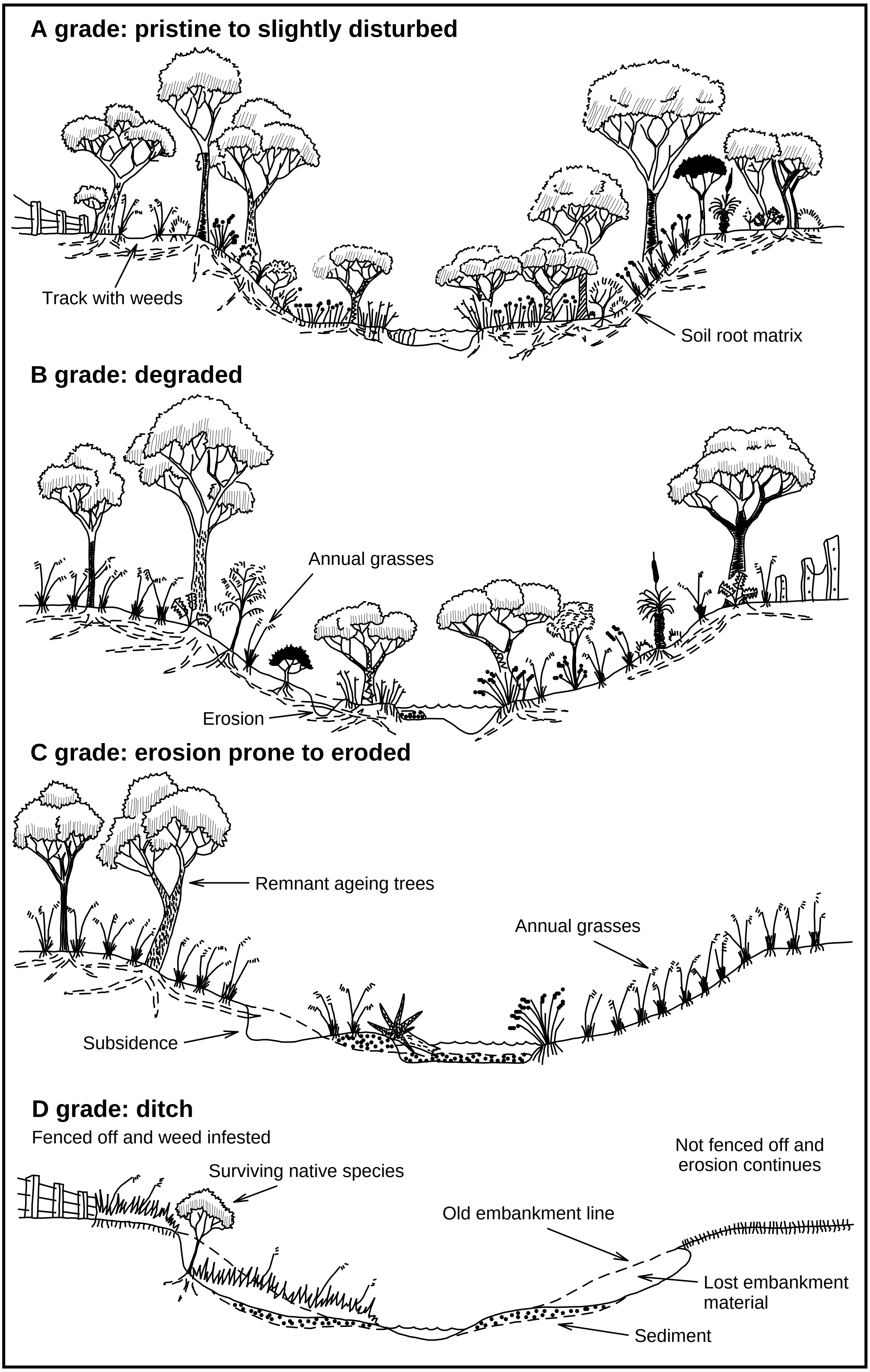
D Grade

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.



Source: Water and Rivers Commission, 1999

Appendix 6. Fencing styles

Barbed wire fence: Any fence that is part barded wire, usually in conjunction with plain wire and droppers and which is not electrified is classified a barded wire fence. Barded wire deters stock from rubbing, which is the main cause of fence damage.

Electric fence: Electric fencing uses a high voltage pulse to deter animals, for both feral animals and stock. Electric fencing has been most commonly used in conjunction with conventional fencing, enhancing its effectiveness and, in case of heavy stock, reducing fence damage.

Fabricated fence: includes rabbit netting, ringlock and hinge point fences

Plain wire fence: Plain wire fences consist of multiple strands of plain wire, which collect less flood debris and are less prone to flood damage. Provided corner and end strainer assemblies allow wires to be tensioned correctly, post and dropper numbers can be reduced, resulting in considerable savings.

Drop fences: Drop fences are designed to be either manually dropped before a flood, or dropped at anchor points under the pressure of floodwater and debris.

Hanging fence: Hanging fences are suspended fences made out of steel cable or multi-stranded high tensile wire. The purpose of these fences is to keep animals from walking along waterways to bypass fence lines.

Source: Australian Wire Industries, 1993.

Fencing status – examples of fence condition

Fence condition: POOR

Fence condition: MODERATE

Fence condition: GOOD

Appendix 7. Avon water quality project – Talbot Brook 1997 - 1999

March 2000
Stephanie Cobb
Avon Water Quality Project Coordinator
Swan Goldfields Agricultural Region

Introduction

The Avon Community Water Quality Monitoring Program is a Natural Heritage Trust funded project set up to develop and assist a monitoring program suitable for catchment groups in the Avon Catchment to implement and manage. Since the project inception in 1997, three years ago, a total of twelve sampling sites have been established on main watercourses of selected catchments in the Avon River basin. Sites were erected as close to the bottom of the catchments as practical for regular sampling and representative of the 'whole of catchment' flow.

Winter 1999 ends the third year of data collection at Talbot Brook. Following the lack of direct support resultant from the Project Coordinator position vacancy for the first 6 months of 1999, four of the twelve catchment groups lost sampling momentum this season. Credit should be extended to original sampler Keith Weaver and subsequently Liz Manning of the Talbot Brook Land Management Society who have ensured that the monitoring at Talbot Brook remains on-going.

Method

Talbot Brook surface water quality monitoring site is located on the northern side of the bridge at the intersection of Qualen West Road and Talbot Road West (Figure 1). The site consists of a staff gauge and an integrated height sampler (IHS), and Talbot Brook Land Management Society is equipped with a handheld WTW Electrical Conductivity meter that can measure conductivity *insitu* (in the field). The staff gauge provides an indication of the depth of the water in the brook. The IHS is designed to capture the flow in response to major rainfall events.

Samples were collected from the IHS sampler following a rainfall event (when the bottles were full) and a falling limb grab sample taken once the creek level had started to fall. Fixed grab samples were taken at weekly intervals to give us an indication of how the water quality in the creek is usually compared to higher flow situations.

Samplers recorded recent weather conditions, conductivity and the stage height (noted off the staff gauge) with each sampling visit to the site. In addition, the peak stage height of major flow events were recorded from a cork height indicator once the water flush had passed and the level of water fallen.

All samples were frozen and delivered to the Water and Rivers Commission, Northam. Samples were analysed by Natarsha Woods and Stephanie Cobb, successive Project Coordinators, at the Avon Catchment Network (ACN) Laboratory, Northam.

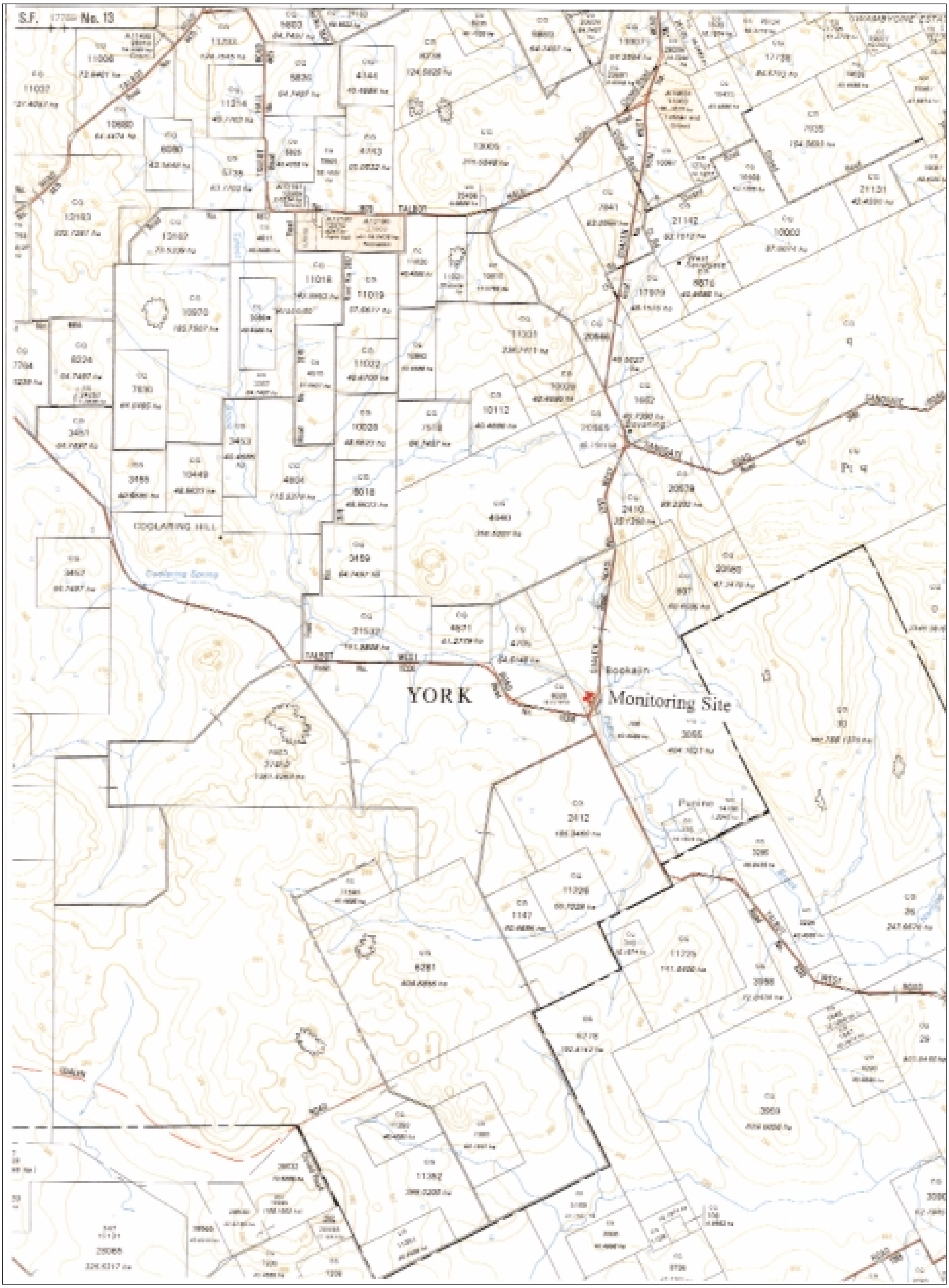


Figure 1: Location of Talbot Brook surface water quality monitoring site

Parameters measured are tabulated below.

Parameter	**Measurement**	**Acronym**	**Location**
Phosphorus	Total Phosphorus (mg/l)	TP	ACN lab
Sediments	Total Suspended Sediments (mg/l)	TSS	ACN lab
Salt	Conductivity (mS/m or mS/cm)	EC	insitu
Water level	Stage (m)		insitu
Rainfall	Rainfall per day (mm)		insitu

Table 1: Water quality parameters

Rainfall records for each season were collated from one or two regions within the catchment and averaged to provide a rainfall record representative of the entire catchment area.

Note: When reading stage heights, 'no flow' is at ten metres. This means that when the stage reading is 10.2, the water depth is really only 0.2m deep above the control point. The reason we use ten metres as the cease to flow point is to avoid recording negative level values, no matter the depth or height of the water.

Results

- **Rainfall and flow response**

The Avon catchment received relatively low rainfall over 1997 and 1998 comparative to 1999. Two of the twelve demonstration catchment sites had no flows and some sites received only two or three samples total for each year, 1997 - 1998. Talbot Brook is located in the highest rainfall area of all the demonstration catchments, and as a result Talbot Brook Land Management Society were able to sample a good amount of water quality data 1997 through 1999.

Figure 2 depicts the response of flow[1] readings (taken from the staff gauge at the monitoring site) to averaged rainfall figures[2] from the catchment, 1997 to 1999.

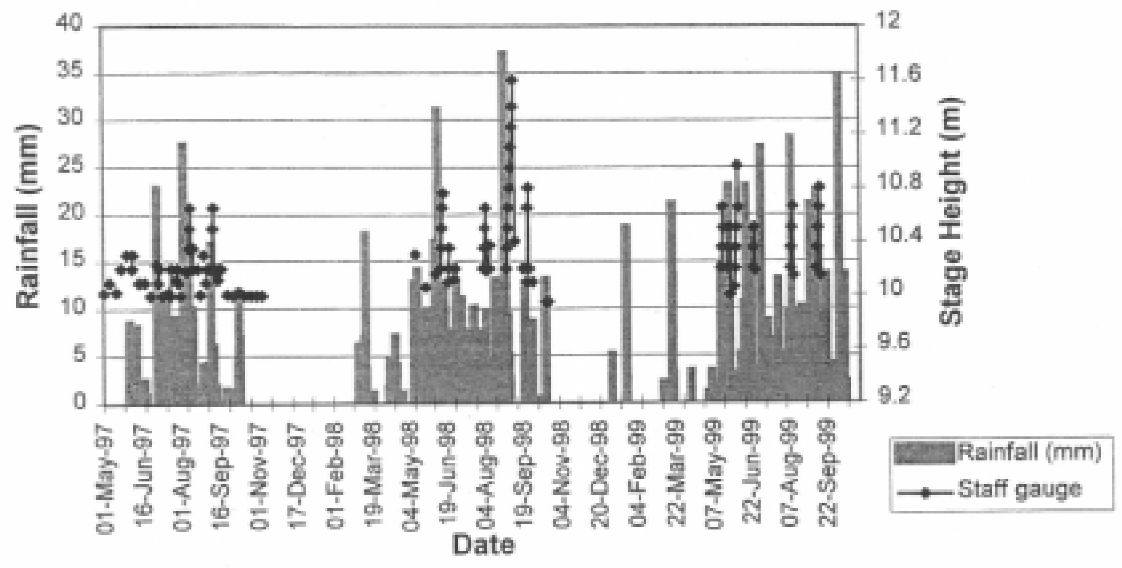


Figure 2: Flow response to rainfall

[1] We know that 'flow' (measured in cubic metres per second) is directly related to 'stage height' (metres) at a stable streambed cross-section.

[2] 1997 rainfall charts were from K. and V. Weaver and a nameless source; 1998 chart from E. Manning; and 1999 chart from V. and S. Green.

In both 1998 and 1999 we can see that Talbot Brook was influenced by higher rainfall years than the sampling year prior (Figure 2).

Also of significance, 1998 and 1999 received unseasonably high rainfall events *early* in the year. In 1999, Cyclone Elaine's influence mid-March delivered a lot of water across the northern half of the Avon catchment early in the season - Gabby Quoi Quoi catchment, which feeds the Mortlock River North, recorded a peak of over 100 mm on the 21st March (compared to Talbot Brook's 21 mm).

You will also note that despite the higher rainfall years, there were fewer samples collected in 1998 and 1999 than in 1997. This is due to the difficulty Liz Manning sometimes has getting to the monitoring site. In 1997 Keith Weaver was responsible for the weekly collection of fixed grab samples whilst Liz Manning collected samples from the IHS following storm events. Due to personal reasons, Keith discontinued his direct involvement at the end of 1997 and Liz has taken full responsibility for sample collection through 1998 and 1999. Sharing the sampling responsibility may be an issue the group needs to address.

No samples were collected January through to April both 1998 and 1999, therefore failing to give us any indication of the changes to flow with the "summer" rainfall that occurred each year. However, analysis of the samples collected on the 29th of January 2000 ("Deluge 2000") will provide us with our first data set of water quality conditions during a summer storm event!

Of data analysed to date, the single largest flow event that we have successfully sampled occurred on the 31st August 1998. As is evident from Figure 2, we have yet to sample an event of the same magnitude.

We can see that the response rates of flow to rainfall were quite rapid during the winters of 1998 and 1999. The unseasonably high rainfall events that occurred during March 1998 and over the December-January 1999 period meant that each winter the catchment profile was already 'wetted up'. Further rainfall brought the catchment profile to a saturation point, encouraging surface runoff and therefore a rapid response rate of flow levels 2-3 days following a downpour.

- Sediment – Flow relationship

Water flowing in a stream derives its *energy* from a combination of the amount of water entering it and the slope of the stream channel. Most of this energy is dissipated (or lost) in overcoming the resistance of the stream channel, and only a small amount is available for other work – such as moving sediment.

Intuitively, as flow increases in the brook, we would expect to see more sediment in the water. Figure 3 is a scatter plot of the relationship between flow and total suspended sediment (TSS) at Talbot Brook for each sampling year.

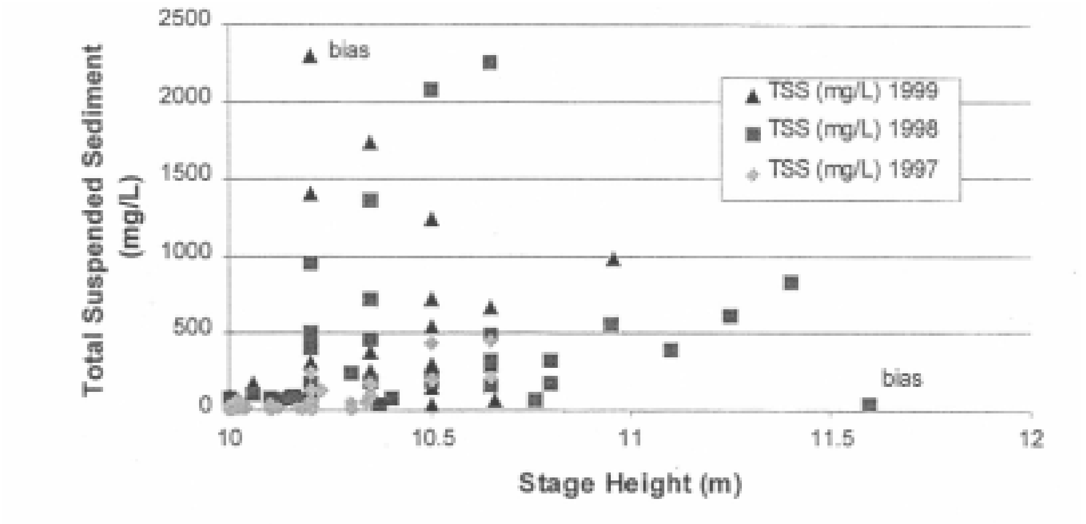


Figure 3: Total suspended sediment versus stage 1997 – 1999

Correlation coefficient is a mathematical tool used to describe how well two sets of data are related (or correlated) to one other. The coefficient will be a number anywhere between –1 and 1 where:

–1 indicates that the two data sets are directly negatively correlated

1 means that they are directly positively correlated, and

0 suggests that, for example, TSS and flow be not related at all.

Figure 3 clearly depicts that our measurements of TSS in 1997 were significantly correlated to stream flow - with a correlation coefficient value of 0.757. This means that there was a good trend for an increase in flow to be associated with an increase in TSS, as we might expect. The clear relationship that we can see is likely to be influenced by the comprehensive data set of both fixed grab and IHS samples taken over the year. This provides us with adequate variation in flows not only during storm events, but also during ‘normal’ flow conditions.

In 1998 and 1999, however, there was no obvious relationship between the amount of suspended sediment and the level of flow. The correlation coefficient for 1998 was 0.230 (insignificantly low) and in 1999 was 0.067 (no correlation).

Unlike the data collected in 1997, the samples from 1998 and 1999 were predominantly taken from the IHS – that is, from major flow events. So although we were sampling the range of flow heights we need to establish a relationship (from the integrated bottles), the sediment concentrations were more likely to be effected by factors other than stream flow – such as the rate of water level rise, or topsoil exposure to erosion.

Looking at Figure 3, there were two samples clearly acting as a bias to the trend. One sample was taken where a high flow of 11.6 m had very low suspended sediment levels (42 mg/L). This sample was a fixed grab taken at the peak flow of the major event sampled on the 31st August 1998, once the brook had exceeded its bankful capacity and flooded onto the surrounding floodplain. The low suspended sediment content reinforces the role of the floodplain in the dissipation of the stream energy, and therefore its ability to carry sediment. That is, once the brook exceeded bankful, the suspended sediment load was deposited onto the floodplain.

Alternately, the sample acting as a bias was taken at a low flow of 10.2 m and measured a high suspended sediment load (2300mg/L). This sample was taken from the base bottle of the IHS during a flow event measured on the 15th May 1999. Liz Manning recorded in her field notes that the creek showed evidence of a rapid flow during the week prior to the event, when 25 mm rainfall was recorded in one day. Bearing this in mind, the high energy first flushes of water following the rainfall were likely to have moved bed material and influenced the sediment readings in the base bottle on the IHS.

The dramatic difference in TSS levels from 1997 to 1999 clearly show that with a catchment in this type of climate, the major erosion problems are not necessarily a result of the cumulative effect of low flows, but rather the "one off" major storm events. We have yet to analyse data collected from a summer storm to compare sediment and phosphorus loads of a winter and summer storm event.

The TSS levels during the major flow events recorded will be discussed in greater detail later (Major Flow Events).

- Phosphorus – sediment relationship

Eutrophication is the term used to describe the excessive enrichment of water by nutrients. A water body which becomes eutrophic will normally experience a surge in the growth of aquatic plants and algae, leading to a severe depletion in dissolved oxygen, subsequently ensuing stress on fish and other aquatic organisms.

In recent years, eutrophication has become a problem in the Avon River. The increased level of nutrients entering the Avon River system over the last decade has resulted in the remaining river pools of the Avon River experiencing algal blooms and associated problems. More topically, the unseasonable flushing of around 60 million tonnes of water through the Avon and Lockhart catchments mid-February 2000 stimulated a breeding ground in the Swan River for the toxic blue-green algae, *Microcystis aeruginosa*.

The Australian and New Zealand Environment and Conservation Council (ANZECC) Water Quality Guidelines recommend that in fresh and marine waterbody, concentration values between the range of 0.01 - 0.1 mg/L phosphorus are not exceeded in order to prevent undesirable phytoplankton growth.

During the past three seasons, total phosphorus (TP) concentrations measured at Talbot Brook have at times well exceeded the recommended guidelines (Table 2). In 1997, 97% of the 55 samples were within the guidelines. In 1998 and 1999, however, 53% of 40 samples and 36% of the 30 samples collected had low or pristine conditions.

	Total Phosphorus (mg/L)	**# Samples**		
		1997	1998	1999
Pristine	0.0 – 0.05	38	8	7
Low	0.05 – 0.15	13	13	4
Moderate	0.15 – 0.25	4	4	6
High	0.25 – 0.40	0	4	4
Very High	> 0.40	0	11	9

Table 2: Total Phosphorus ranges and the number of samples in each range

The significantly higher TP levels in 1999 were likely to be related to the fact that the samples were taken primarily from storm events and associated land runoff and erosion. The relationship between phosphorus and suspended sediment loads at Talbot Brook is graphed below (Figure 4).

In 1998, there was one sample that recorded an extremely high TP result compared to remaining samples – marked on Figure 4 as an ‘outlier’ because of its extreme value. This sample was taken from the IHS B (second from the base at 10.35 m) during the storm event on the 31st August 1998. In Natarsha’s lab notes she had commented that this sample was "very, very muddy", indicative of the high suspended sediment load. This outlier has been removed to look only at the TSS and phosphorus relationship with the remaining samples (Figure 5).

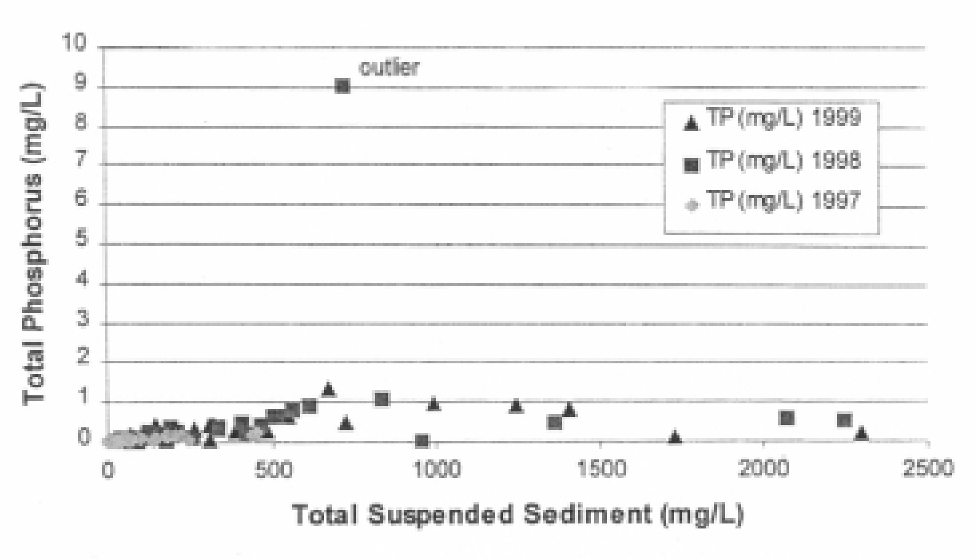


Figure 4: Total Phosphorus versus Total Suspended Sediment 1997 – 1999

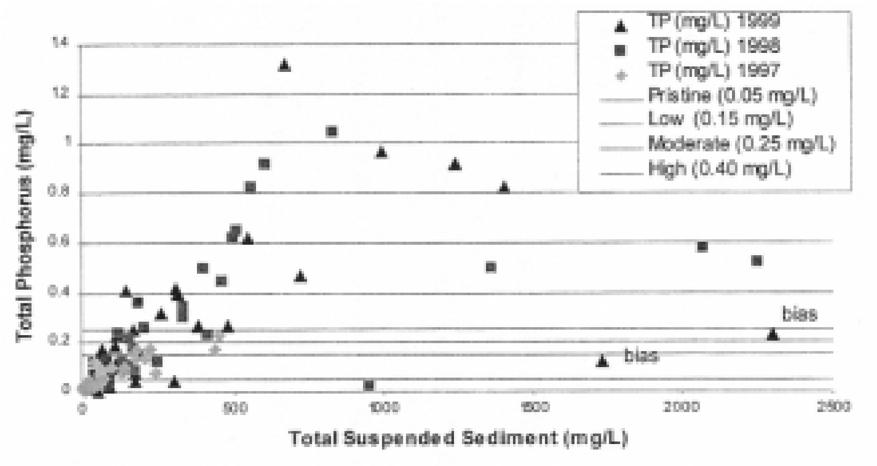


Figure 5: Total Phosphorus versus Total Suspended Sediment 1997 – 1999 (outlier removed)

Water is the medium by which phosphorus moves through the landscape. Phosphorus can be either dissolved in the water or attached to soil particles carried along by the water.

Figure 5 depicts samples taken in both 1997 and 1998 showing a positive correlation between TP and TSS. This is as we would expect – an increase in sediment was associated with an increase in TP (correlation coefficients of 0.886 in 1997 and 0.558 in 1998).

In 1999, however, the correlation coefficient was significantly lower at 0.418. Looking at Figure 5, there are two samples that are acting as a bias to the 1999 trend we would expect – where high sediment levels had comparatively low TP levels. These samples were taken during very different circumstances.

The sample with a sediment level of 1734 mg/L and TP of 0.12 mg/L was collected during the falling limb of the event on the 17th of May 1999. This sample, taken once the brook levels had dropped after the peak flow, may have collected sediment that had been scoured from the less nutrient-rich banks of the brook – rather than fertilised topsoil with the initial, possibly rapid, flush.

The other bias sample was collected from the base bottle of the IHS on the 15th May 1999 – a sample we previously considered unusual for its high sediment concentration under low flow conditions (see Sediment-Flow Relationship). The low TP concentration may have been a result of the suggested high-energy first flush sufficient to scour sediment from the banks of the possibly low-nutrient banks of the brook.

With both samples removed from the 1999 data set, the relationship is almost directly proportional with a positive coefficient of 0.812.

These relationships highlight that in our dryland catchments, with conditions such as those of Talbot Brook, nutrient management is sediment management.

- Dilution of salt

There are many different units that are used when referring to the salt content in water. In this report we use a measure of electrical conductivity . When in water, salts dissociate into positive and negatively charged ions that pass an electrical current. The current reading, we call electrical conductivity is directly related to the water salt content.

Increased flow and associated mobilisation of salts with rising water tables throughout the catchment has resulted in saline ground and surface waters reaching the river system. Salinity levels in the Avon have risen from their original levels of between 70 – 550 mS/m to the extremely saline condition of between 350 – 3000 mS/m measured in 1986.

For livestock supply purposes, a salinity content within the range of 545 mS/m to 2350 mS/m has been suggested as a general guideline. For freshwater aquatic biota protection, a salinity content of much less (one recommendation 180 mS/m) is required.

Conductivity readings measured at Talbot Brook for the past three years have been tabulated below (Table 3). The salinity concentrations have consistently fallen within the fresh to brackish margins defined in the table. In 1997, only 42% of samples were less than 200 mS/m, whereas in 1998 and 1999 65% and 76% were less than 200 mS/m.

	Salinity (mg/L)	Conductivity (mS/m)	# Samples		
			1997	**1998**	**1999**
Fresh	0 – 550	0 – 100	2	8	14
Marginal	550 - 1100	100 – 200	21	12	2
Brackish	1100 - 5000	200 – 900	32	11	5
Low Saline	5000 - 11000	900 – 2000	0	0	0
High Saline	11000 - 30000	2000 – 4500	0	0	0
Hyper-saline	30000 – 89000	4500 - 13000	0	0	0

Table 3: Salinity ranges and the number of samples in each range

The overall low salinity results can be attributed in part to the sampling period - samples collected from Talbot Brook over the three years were taken exclusively from winter (Figure 6).

We would expect a seasonal fluctuation in salt levels with the summer/winter variation in the amount of water in the brook. In winter, as water levels increase it would dilute the salt and our conductivity readings would decrease. The higher values recorded in 1997 comparative to 1998 and 1999 are therefore a result of the lower flows recorded in the low rainfall year.

Figure 7 depicts that in 1997 and 1998, EC was related the stage - with correlation coefficients of –0.581 and –0.674 respectively. That is, an increase in flow decreases the salt content.

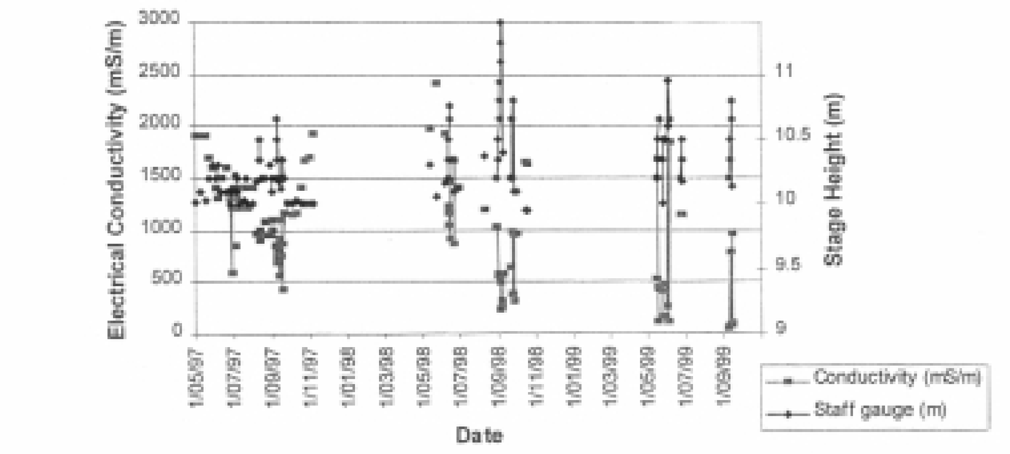


Figure 6: Electrical conductivity and stage trends over time, 1997 – 1999.

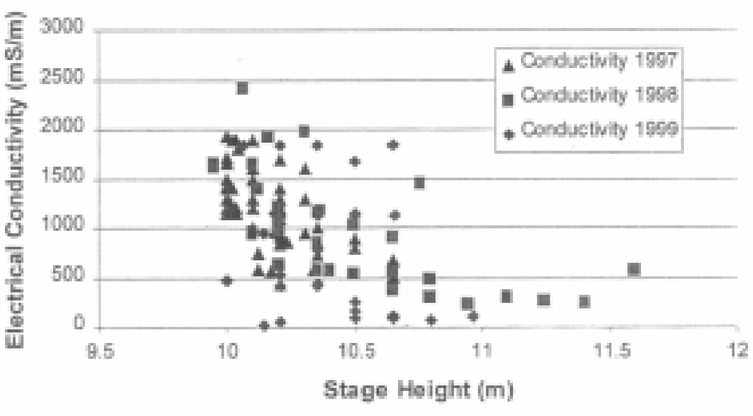


Figure 7: Electrical conductivity versus stage, 1997 – 1999

Figure 7 depicts no clear relationship between EC and stage height in 1999, with a coefficient value of –0.198. This lack of a direct relationship may indicate that there were insufficient fixed samples taken to establish a trend. In 1999, the samples were taken from different stage levels during the same three events – when EC may be effected by both dilution and incoming salt from surface runoff.

These results don't really give any indication whether there is any increase in the salt concentration at Talbot Brook. Further long-term monitoring will help establish whether salt levels are changing.

- Major flow events

Of data analysed to date, the single largest flow event that we have successfully sampled occurred on the 31st August 1998. The trends in TSS, TP, EC and flow for the event have been plotted below (Figure 8).

To consider when reading this graph:

- The x-axis represents the flow over the event. The rising stage height readings correspond to the bottle heights on the IHS. The heights after the peak were taken from a falling sample and then a fixed water sample.
- The event occurred over a 24-hour period.

Note that the outlier sample previously excluded from Figure 5 is included in Figure 8 to illustrate the initial influx of water (and energy) sufficient enough to move bedload sediment.

We can see the clear relationship between flow and conductivity. As the level of water in the brook increased, the conductivity levels decreased with the effect of dilution. This clear trend suggests that the overall salt load in the creek did not alter much over the event.

We have already established that there is a strong relationship between TP and TSS, and we would therefore expect the two parameters to follow one another closely. The initial peak in both TP and TSS is following high rainfall on saturated soils - massive overland runoff causing phosphorus-rich topsoil to be washed into the brook. After the initial peak, both TSS and TP values decline sharply - as rainfall soaks into the land its power to erode decrease. As the water in the brook rises, its gains energy to erode sediment from within the channel. We can see a gradual increase in both TSS and TP levels until the water level exceeds bankful capacity at 11.6 metres flooding the surrounding floodplain and depositing its bedload.

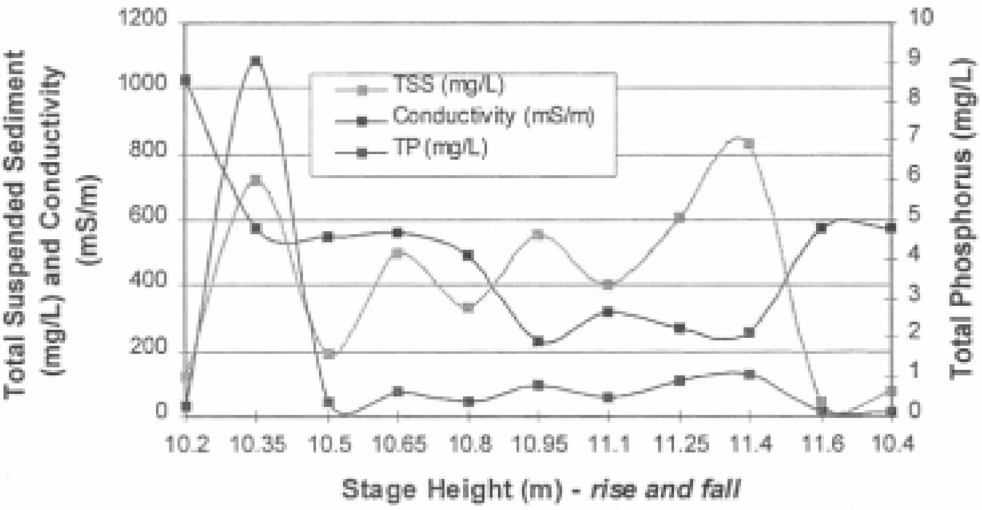


Figure 8: Major flow event at Talbot Brook 31st August 1998

Management implications

The water quality data collected over the past three years clearly show that the major erosion problems in the Talbot Brook catchment arise from independent storm events.

The storm events that occurred during winter 1998 and 1999 were responsible for the highest sediment and phosphorus loadings into the brook over the three-year sampling period. We can also conclude from this data that phosphorus management essentially equates to sediment management in the Talbot Brook catchment.

We do not have sufficient seasonal data to establish the impact of summer storm events on the catchment. It is also difficult to surmise the dominant sediment source to be from within channel erosion or overland runoff.

There is some obvious management implications arising from this.

- Reduce the amount of phosphorus available for transport with overland runoff.
  - What is particularly clear from this data is that the timing of fertiliser applications is very important. As much as possible, fertilisers should be applied when heavy rains are not expected. Although, following our recent summer floods this January 2000, predicting the weather is obviously not easy!
  - Soil testing and applying only the fertiliser that the crop or pasture needs, obviously makes good economic sense, but will also limit the opportunity for excess phosphorus to enter the brook.
- Limit opportunities for soil-bound phosphorus to enter waterways.

Management practices that minimise or intercept water erosion are also likely to minimise phosphorus transport. These are to be emphasised:

- Reducing the frequency and depth of soil tillage.
- Installing buffer strips.
- Establishing perennial pastures in appropriate areas to minimise surface soil exposure during autumn.
- Revegetation across the catchment.
- Prevent streambank erosion and provide a nutrient buffer by revegetating the streamline.

It was very difficult to draw conclusions from the conductivity data collected. Hopefully regular sampling in 2000-2001 will help to establish salt trends and subsequently direct future management options.

Management implications should be considered in relation to suggestions outlined in Guy Boggs honours thesis (UWA 1998) on the Talbot Brook catchment.

Comments

- **Sampler pointers for 2000:**
  - Where possible, please take your conductivity readings in situ (in the field). When taking bottles from the IHS, take a conductivity reading from each bottle. Conductivity readings taken by me back at the laboratory 2 months after collection are not very accurate!
  - This report is a good indication of the importance of flow readings in our interpretations. Take care when reading the stage heights – and try to include a height reading with every FIXED and FALLING sample.
  - Record any maintenance requirements you might need or that are concerning you.
  - Use the ‘COMMENT’ section on your sampling sheets. It helps me to make sense of "strange" readings, to understand more about what is happening in the brook and is by far a more interesting read!

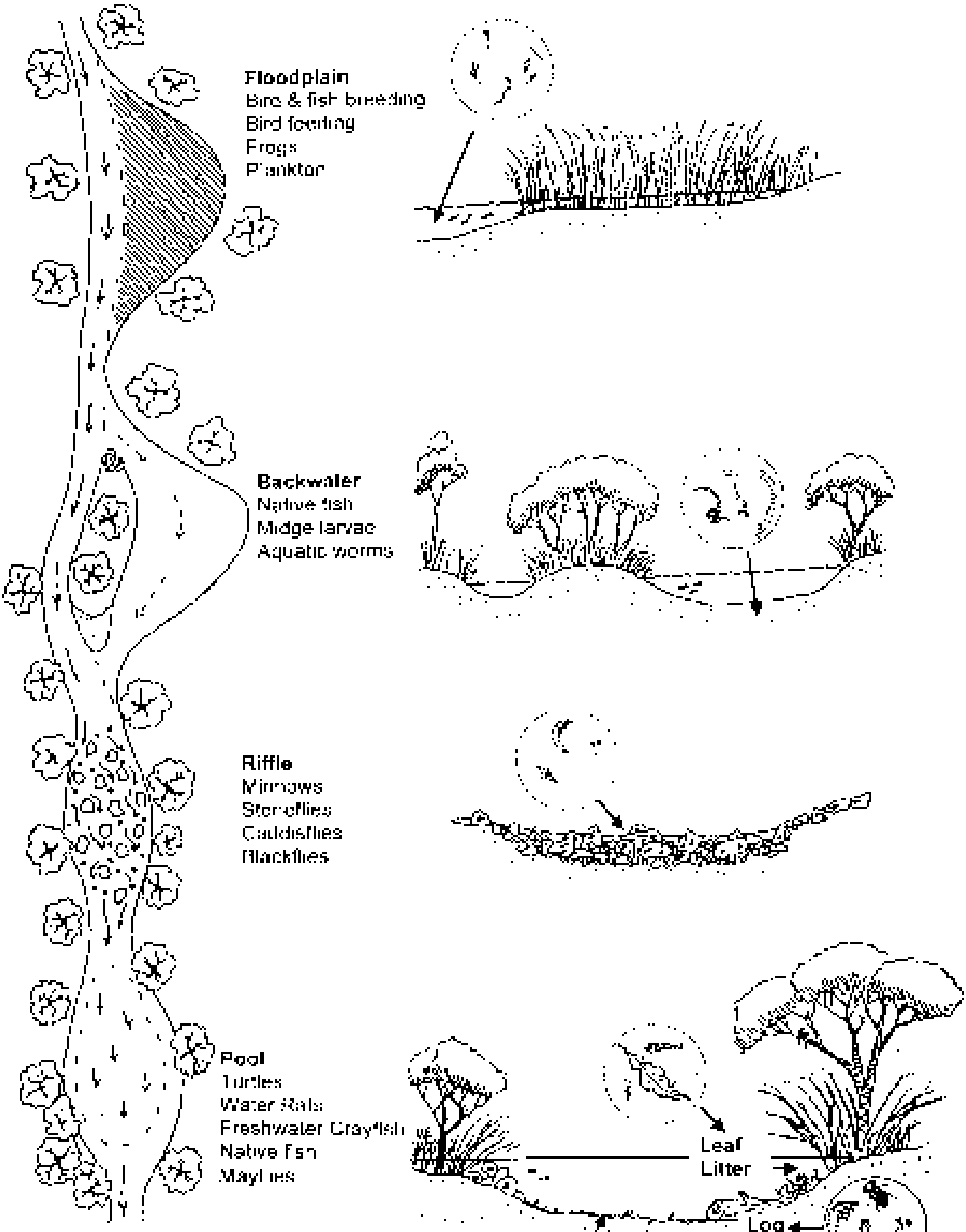
The water sampling has been carried out very successfully at Talbot over the past three years, although emphasis should now be placed on taking fixed grab samples of ‘normal’ flows, and sampling summer events. I look forward to what has already begun as an unseasonably wet year this year.

I hope to take velocity readings at Talbot brook over this season to help establish information on the volumes of water passing through the site.

Appendix A.
Salinity units and conversions

Salinity	**Conversion factor**		**Salinity**
Electrical conductivity (mS/cm)	X 550	=	Total soluble salts (mg/L)
Electrical conductivity (mS/cm)	X 38.5	=	Total soluble salts (gr/gal)
Electrical conductivity (mS/cm)	X 1000	=	Electrical conductivity (umhos/cm)
Electrical conductivity (mS/cm)	X1000	=	Electrical conductivity (us/cm)
Electrical conductivity (mS/cm)	X 100	=	Electrical conductivity (mS/m)
Total soluble salts (mg/L)	/ 1	=	Total soluble salts (ppm)
Total soluble salts (mg/L)	/ 100	=	Total soluble salts (ppt)
Total soluble salts (mg/L)	/ 14.25	=	Total soluble salts (gr/gal)

Appendix 8.
Habitats found along waterways



Source: Water and Rivers Commission, 2000.

Appendix 9. Avon Waterways Committee (AWC) Fire Policy

Avon Waterways Committee

Policy Number 1

FIRE

Objectives

The long-term objective of AWC is to restore the natural functioning and vegetation of the Avon River and its major tributaries. Arising out of this aim, the Authority 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, Bush Fire Brigades and neighbours with respect to fire management.

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 which 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 and pasture, 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 which 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 which 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 Location Authorities and experienced Bushfire personnel in each district. The purpose will be to identify all the important values which 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 will be approved by AWC.

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 protection old trees, hollow logs etc. In the case of herbicide spraying, a prescription must be prepared which specifies the chemical to be used, the rate an time of application and the measures to be taken to protect non-target species or guard against off-site effects.
5. All controlled burning must be in accordance with the Bush Fires Act and meet Local Government requirements, and all prescriptions must be approved by AWC.
6. Uncontrolled grazing by sheep, cattle, goats, pigs or horses will not be permitted in the river system in areas controlled by AWC. Some limited controlled grazing may be approved during an interim periods in which other hazard reduction measures are being developed. Proposals to graze AWC-controlled land must be approved by AWC.
7. Owners of riverine vegetation will be encouraged to phase out grazing on their lands in favour of less destructive measures of hazard reduction.
8. 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 an urban development, none of which may take place along the river without approval of AWC.
9. 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 AWC to approval.
10. Encourage neighbours to the river to make their own properties fire-safe, rather than relay 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.
11. AWC will also support measures promoted by Landcare groups to minimise stubble burning on farmlands adjacent to the waterways.
12. 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 which 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 which help to achieve this aim.
13. Monitor areas burnt. Where good regeneration of desirable species has occurred, areas will be set aside from fire for a sufficient period to enable the young plants to flower and seed.
14. AWC will strongly support volunteer Bush Fire Brigades located along the river, to ensure they are properly equipped and organised. This support will take the form of supportive submissions to Local Authorities and the Bush Fires Board, until we are in a position to provide direct financial support.
15. 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 to enforce the Bush Fires Act to eliminate potential sources of fire.
16. Open fires will not be permitted in camp grounds or other recreational areas controlled by AWC along the river between the months of September and May.
17. AWC will seek endorsement of this policy, and all fire management plans developed for the river system from local authorities, neighbours and relevant government agencies (especially the Bush Fires Board).

The policy will be reviewed annually.