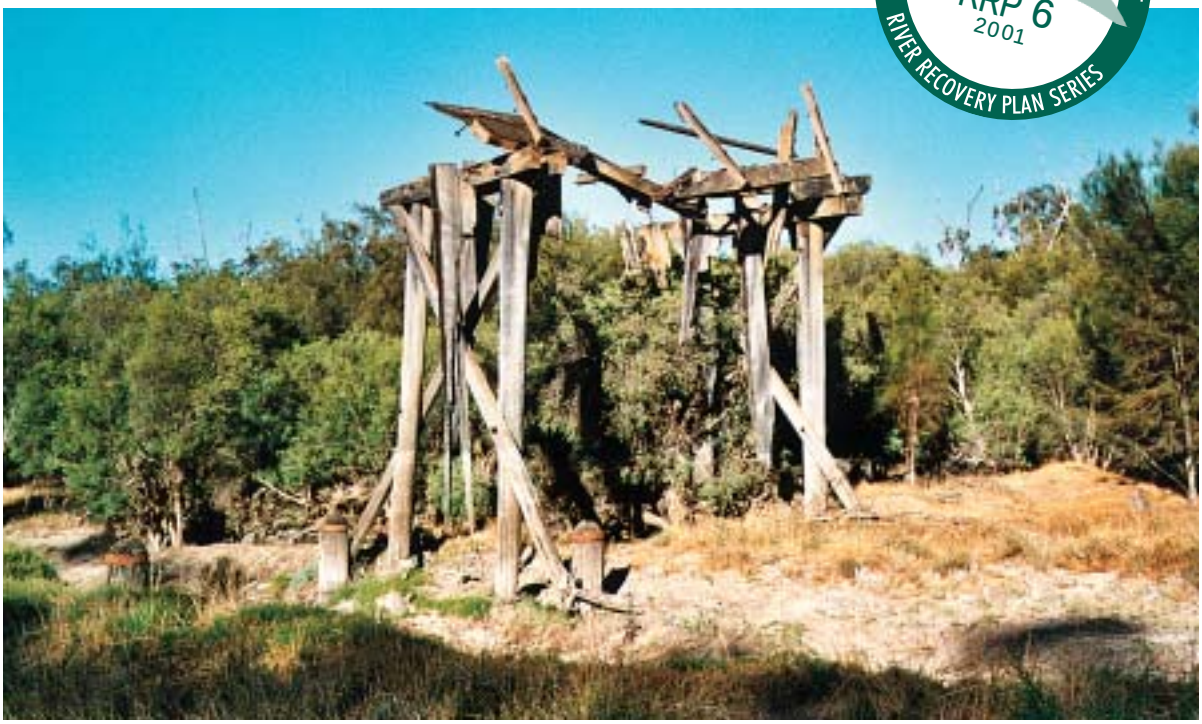
AVON RIVER MANAGEMENT AUTHORITY

# RIVER RECOVERY PLAN
## Section 11/12 – Gwambygine to Edwards Crossing



WATER AND RIVERS COMMISSION REPORT
RRP 6
2001
RIVER RECOVERY PLAN SERIES

Water and Rivers Commission

# AVON RIVER MANAGEMENT AUTHORITY
# RIVER RECOVERY PLAN
# Section 11/12 – Gwambygine to Edwards Crossing

prepared by

Viv Read & Associates
for
Water and Rivers Commission
and
Avon River Management Authority

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Avon River Management Authority,

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*Cover Photograph:*
*Remaining bridge poles at Oakover Crossing, May 2001*
*Photograph by Viv Read*

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# Preface

The Avon River has suffered a few set-backs over the past 50 years. The effects of sediment filling river pools following the River Training Scheme which was intended to reduce flooding is well known. However there are other threats to this once majestic river. Algae often blooms in the remaining river pools during summer due to there being too many nutrients, and ever-increasing salinity is also a problem for the river.

The Avon River Management Authority (ARMA) was formed in 1993 following community concern about the river. With government agency support, it has developed a strategic approach to river management outlined in the 'Avon River Management Programme'. The Mission of ARMA is "*…to restore and manage the natural functions of the Avon Rivers system for the long-term benefit of the community.*" ARMA members are now optimistic about making a difference.

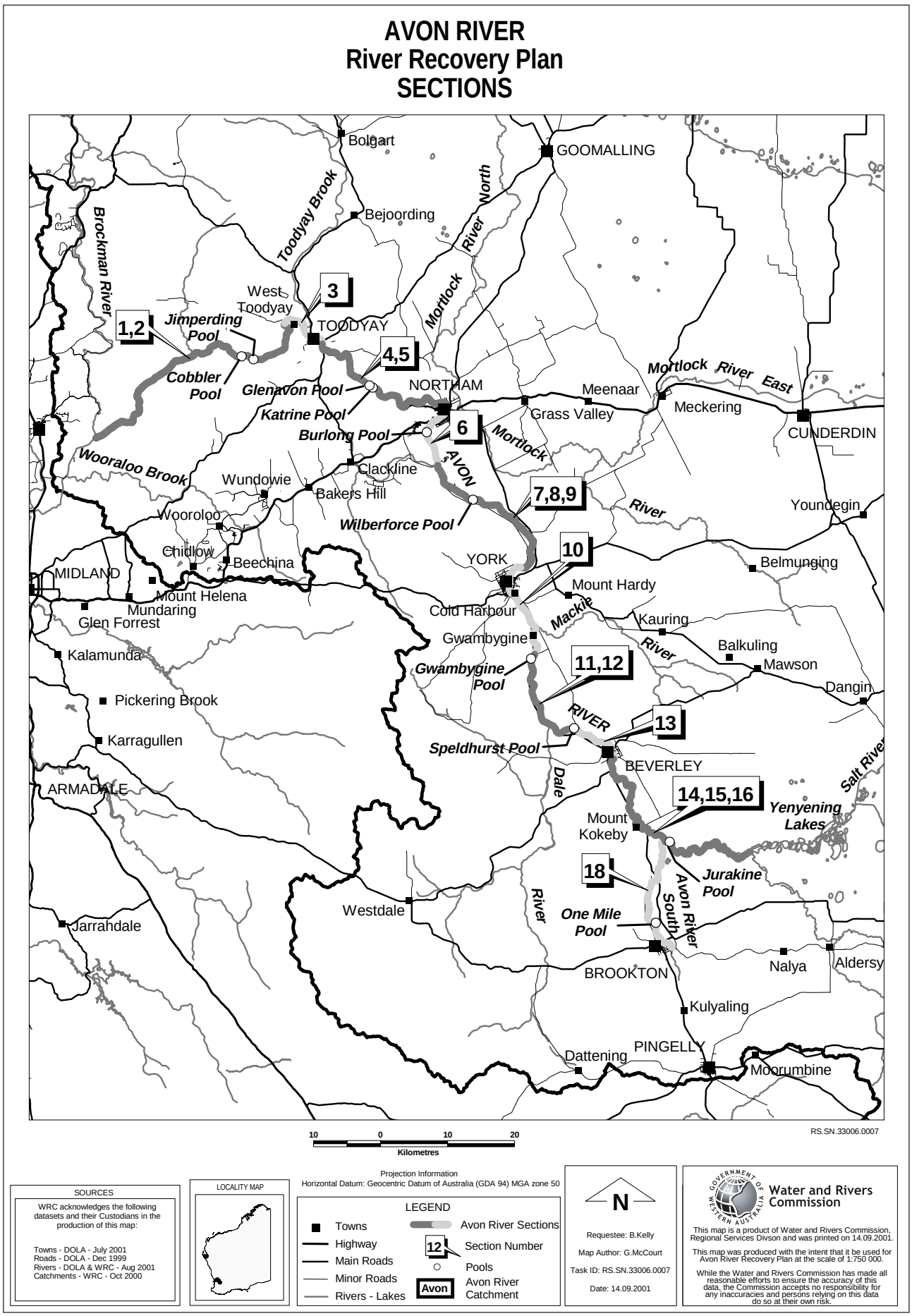
An important step in Avon River Management was to identify 18 sections of the main channel for management. Recovery Plans are now being prepared for each of these sections. Management of the major tributaries will also be considered. River sections for the towns of Toodyay, Northam and York are complete.

The Recovery Plan for Sections 11 and 12 covers an important part of the river between York and Beverley including 3 pools and the confluence of the Dale River. A Management Plan has been prepared for Gwambygine Pool (located within Section 11) because of it's significance as a large remaining river pool and because of the strong interest by the York River Conservation Society. The proposed actions for the pool should be considered with this Recovery Plan.

The purpose of the Recovery Plan for Sections 11 and 12 is to carefully consider the options for management of those key issues that threaten the health of the river. A Recovery Team including landholders along the river, interested community members, ARMA members and Water and Rivers Commission representatives have met to prepare the plan. Viv Read was the planning consultant and facilitator for the project. ARMA is keen to encourage this partnership approach to continue beyond the plan in order to ensure good local river ownership and management.

The river has suffered enough. Now is the time for us to do what we can to return it to the magical place that some of us can remember. I look forward to the continuing interest in implementation of this plan.

Doug Morgan
Chairman, ARMA




**Map 1: River Recovery Plan Sections**

# 1 Introduction

## 1.1 Recovering the Avon River

The Avon River Management Programme prepared by Avon River Management Authority (ARMA) outlines a strategic approach for recovery of the river from its current poor health. One key strategy was to segment the main channel of the Avon River into 18 sections for management (sections described in Appendix one). This Recovery Plan is for Sections 11 and 12 which occur between the towns of York and Beverley in the south-west of Western Australia. Sections 11 and 12 have been dealt with in this one plan because of the similarities of stream condition and the relatively few landholders in these sections.

ARMA also arranged a comprehensive management survey of the Avon River during 1996. Detailed site information was recorded at 500 m intervals for the entire 191 km of main channel length. An additional survey was undertaken of the river pools. This information helps to identify the relative importance of management issues for the complete river system. Relevant information from the survey for Sections 11 and 12 is given in this plan.

The recovery planning process is based on a partnership approach that links landholders along the river, government agencies and the broader community to achieve common goals. It is important to first understand the river as part of the Avon River Basin.

## The distinctive character of the Avon

## 1.2 Natural drainage for the Avon River Basin

The Avon River Basin is a major Australian river system that is dominant in the Central Wheatbelt of the Southern Land Division in Western Australia. It has an area of 120 000 km$^2$, which is larger than the area of Tasmania. It extends north of Wongan Hills, south of Lake Grace and east of Southern Cross (Map 2).

The Avon River Basin is also significant because it drains into the Swan-Canning Estuary that is central to the character of the State's capital city, Perth.

The Avon River basin differs to those in other countries. The outer areas of the Avon basin have low rainfall and low landscape gradient, with both rainfall and gradient increasing downstream. In contrast, most rivers start in mountains or hills with high rainfall, and discharge to a drier coastal area with low gradient floodplain or delta.

The Avon River and the Swan River are in fact the same river. There is no "confluence". The two names simply represent an historical anomaly. The Avon is taken as that section of the river inland of the entry of the Wooroloo Brook at Walyunga. The main waterway of the river is discernible upstream to Wickepin. The South Branch of the Avon arises near Pingelly and flows through Brookton and joins the main river channel downstream of the Yenyenning Lakes (Map 1).

The major tributaries of the Avon River downstream from the Yenyenning Lakes are:

- South Branch, which rises above Brookton
- Dale River (including Talbot Brook)
- Mackie River
- Bland's Brook
- Spencer's Brook
- The Mortlock Rivers (North, South and East branches)
- Wongamine Brook
- Harper's Brook
- Boyagerring Brook
- Toodyay/Yulgan Brook
- Jimperding Brook
- Julimar Brook
- Red Swamp Brook
- Brockman River
- Wooroloo Brook

### River flow

The winter Avon usually commences to flow in April after the onset of winter rains and with falling temperatures and evaporation. In most years flow diminishes or ceases before Christmas. At 'Broun's Farm' gauging station (between Beverley and York downstream from the Dale River confluence) the river has significant flow on average for 286 days or 78% of the year. At Walyunga, where the Avon becomes the Swan River, the average flow is 310 days or 85% of the year. In a dry year, the river above 'Broun's Farm' contributes only 12% of total river flow; in a wet year this can rise to over 40%.

The rate of flow of the Avon River is estimated to have increased by a factor of 3 to 4 since the River Training Scheme and the clearing of the catchment.

## Floods and flood management

The major flood years have been: 1910, 1917, 1926, 1930, 1945, 1946, 1955, 1958, 1963, 1964, 1983 and 2000.

Flooding of riverside towns (Beverley, York, Northam and Toodyay) and of agricultural land along the river was the principal concern that lead to the River Training Scheme. This scheme involved:

- removal of channel vegetation and debris to a width of 60 metres;
- removal of dead trees, logs and debris which impaired the river flow;
- ripping of the river bed to induce erosion of a deeper watercourse;
- removal of minor kinks and bends in the river.

The success of the scheme in ameliorating townsite flooding is unresolved. No floods of more than 50-year magnitude have occurred since the works were completed, perhaps because rainfall has generally been lower than average over this period.

## The inland catchments

There are three catchments that make up the Avon River Basin

- The Avon
- The Yilgarn
- The Lockhart

The Yilgarn and Lockhart catchments, which drain to the Avon via Salt River through the Yenyenning Lakes, have low or intermittent flow through drainage lines which usually comprise chains of shallow salt lakes. The contribution to water flow in the Avon River is generally less than 10% although the contribution of salt is high.

## The river pools

There were originally 26 major pools in the Avon River between Walyunga National Park and the confluence with the Yenyenning Lakes that were about 70 metres wide and varied in length from 370 metres to 2 kilometres. Some were over 10 metres deep.

Many of the pools are now filling with sediment as well as being subject to eutrophication as a result of nutrient enrichment.

The following pools are now totally filled:

*Two Mile Pool, Egoline Pool, Muresk Pool, Deepdale Pool, Cold Harbour Pool, Mt Hardy Pool and Burlong Pool*

The following pools are almost filled:

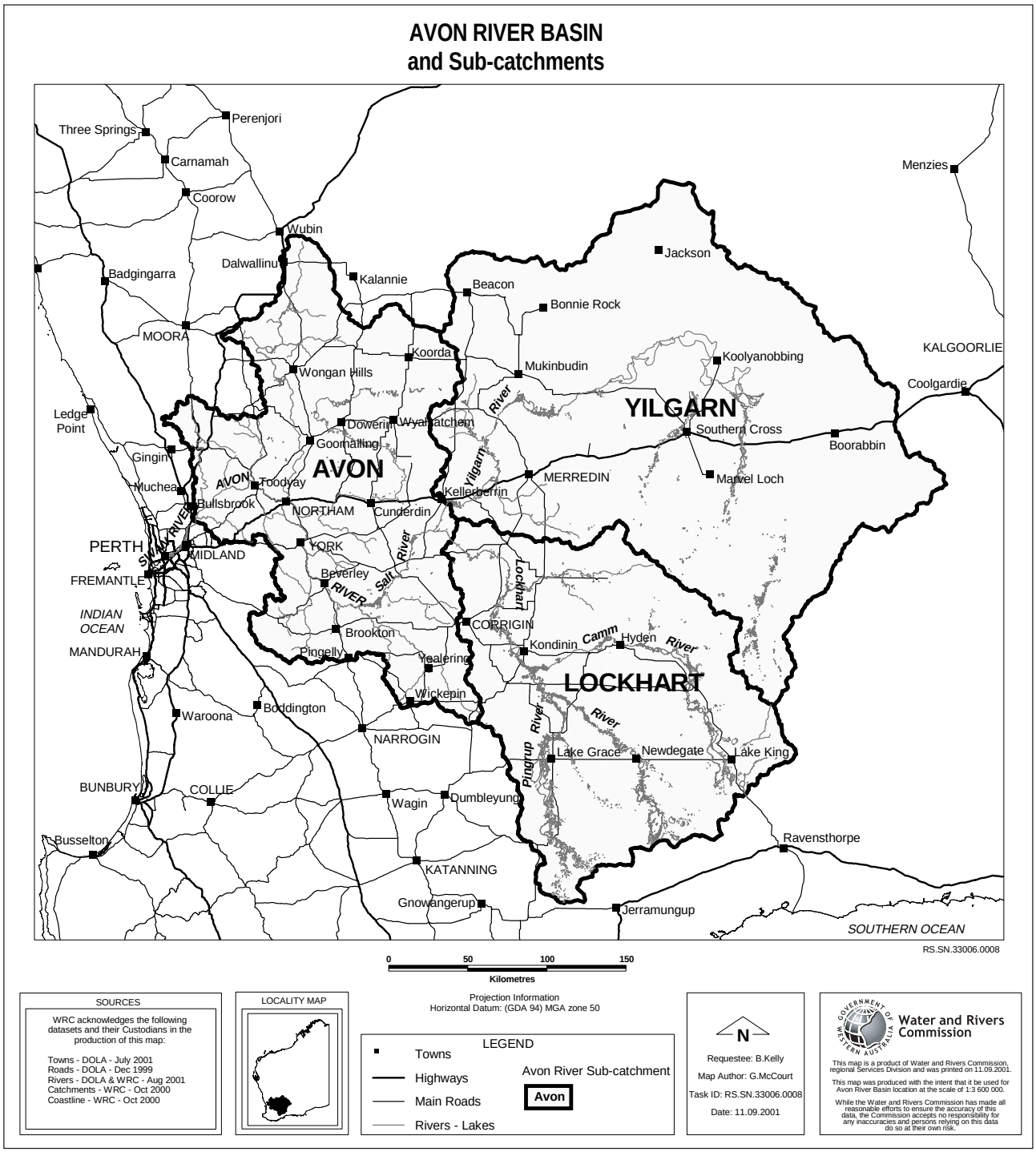
*Speldhurst Pool, Tipperary Pool, Yangedine Pool, Katrine Pool, Oakover Pool and Diving Pool*

## Biological diversity

A very high proportion of the Avon River Basin has been cleared of natural vegetation for agriculture. The original ecosystems are now represented by patches of bush in reserves or on farms in agricultural areas. Fringing vegetation of the Avon River, its tributaries and lakes provides one thin corridor for connection of these remnants.

The river is also significant in this altered landscape as summer and drought refuge for wildlife.

The river, and in particular the pools, have ecosystems that have adapted to fluctuating environmental conditions. However increasing salinity, sediments and nutrient enrichment and a changing flow regime still threaten these ecosystems.




**Map 2: Catchment**

# 2 Description of river sections 11 and 12

## 2.1 Physical description

### 2.1.1 Adjacent landscape

Sections 11 and 12 of the Avon River drain through a valley ranging 6–16 km in width in a well dissected landscape described as the Zone of Rejuvenated Drainage (Lantzke and Fulton, 1992). The elevation of the valley is from 155–175 m up to approximately 300 m Australian Height Datum (AHD).

The regional geology and general landscape physiology are well described by Lantzke and Fulton (1992). They describe four landscape units relevant to the area:

**Avon**: alluvial terraces and floodplains

**York**: hilly landscape with exposed bedrock typified by red duplex soils

**Steep Rocky Hills**: extensive rock outcrop

**Hamersley**: narrow minor drainage lines within the York landscape unit (e.g. Solomons Creek)

The alluvial terraces and floodplains of the Avon unit are derived primarily by river processes and vary from 0.2 to 2 km in width. The soils are from former river channels or were deposited by floods. Flooding still occurs but over a more confined area—the active floodplain is generally defined by the terraces adjacent to the modern channel. Some landholders observe that no significant floods have occurred since 1955 due to the River Training Scheme although there has not been major rainfall during this period.

### 2.1.2 River channel

The river flows westward for 5 km from Seaton Ross Bridge at Edwards Crossing to the confluence with the Dale River from where it adopts a north-south orientation. The total channel length from the Seaton Ross bridge to the Gwambygine Road East crossing is 17.92 km.

The river bed gradient is approximately 1.1 m/km (0.11%) for Sections 11 and 12 which is slightly higher than the general gradient from Beverley to Toodyay (0.8 m/km).

**Photo 1: Clay bed showing rip lines from the River Training Scheme.** *Photo courtesy Ecoscape/JDA.*

**Photo 2: Stumps of river vegetation remaining from the River Training Scheme.** *Photo courtesy Viv Read.*

**Photo 3: Spoil levees formed during the River Training Scheme.** *Photo courtesy Viv Read.*

Prior to the River Training Scheme (RTS), this section of the river channel was braided (many intertwining channels). Training works during the 1960s converted this to a single channel approximately 60 m wide. Current fluvial processes are re-establishing a braided channel form. The river bed is now 1–1.5 m deeper than its original level although this varies considerably. Channel bed erosion is limited in depth by cohesive clays.

Bulldozer action to clear the channel during the RTS has resulted in heaped spoil deposition parallel to stream flow. In places, this performs as a levee restricting access of floodwaters to the adjacent floodplain. It also truncates some floodways.

### 2.1.3 Streamflow

A stream gauging station ('Brouns Farm' Ref. 615014) with records dating back to 1975 is located on the Avon River 2.16 km downstream from the Dale River confluence. The station and records are maintained by the Water and Rivers Commission.

Recorded total annual stream flow ranges from 14 million $m^3$ in 1979 to 414 million $m^3$ in 1983. The average annual flow volume is 61million $m^3$. The mean monthly flow of 126 million $m^3$ for January 2000 was one of the highest recorded for this station (higher flows recorded in July of 1983 and 1996).

Other periods of high flow and potential flood conditions by records of mean monthly flow rates and maximum flow rates respectively. Appendix 4). The flood in January 2000 had a maximum flow rate of 210 $m^3/s$. This was estimated to be a 1:20 year summer event (Muirden, 2000).

### 2.1.4 Riparian vegetation

Natural river vegetation in Sections 11 and 12 consists of different plant communities to that of the adjacent landscape. It is dominated by Flooded Gums (*Eucalyptus rudis*), Swamp Sheoak (*Casuarina obesa*) and Swamp paperbarks (*Melaleuca raphiophylla*). Understorey species are recorded by the River Conservation Society (RCS, 1999).

The riparian community structure is altering. The Avon River Survey (Ecoscape, 1996) shows low regeneration for *E. rudis* and *M. rhaphiophylla* but high regeneration for *C. obesa*. Change is probably due to altered perched groundwater aquifer characteristics. This type of aquifer is recharged less frequently with reduced flooding, and it probably has increasing salinity. *C. obesa* is known to be salt-tolerant.

**Photo 4: Large remnant *Melaleuca rhaphiophylla*.** *Photo courtesy Viv Read.*

### 2.1.5 Pools

There are 4 significant pools within Sections 11 and 12 of the Avon River. (Map 3) They are **Seaton Ross** (otherwise known as Robins pool), **Yangedine** (otherwise called Avondale or Brouns pool), **Oakover** (otherwise called Fleays pool) and **Gwambygine Pools**. The physical dimensions of these pools are shown in Table 2.1.

**Seaton Ross**: this pool is not significantly filled by coarse sediments although it does have high fine sediment deposition. Phosphorus attached to the fine sediment is the main cause of the high phosphorus concentration measured in the sediments and water. The phosphorus concentration in water indicates the potential for eutrophication (i.e. it is more than 0.120 mg/L). The pool is not fenced. Riparian vegetation is not regenerating.

**Yangedine**: this pool is significantly filled with coarse sediment and the pool depth is generally less than 25 cm (JDA, 1996). Phosphorus concentration in water is lower than for Seaton Ross pool due to the high proportion of coarse sediments (less surface area for nutrient attachment). The relatively low salinity is probably due to fresh inflow from the Dale River.

**Photo 5: Regenerating Eucalyptus rudis following soil disturbance.** *Photo courtesy Viv Read.*

**Table 2.1: Physical and chemical characteristics of River Pools within Section 11/12**

| | Seaton Ross | Yangedine | Oakover | Gwambygine |
|---|---|---|---|---|
| 1960 length (m) | 1255 | 610 | 372 | 1109 |
| 1996 length (m) | 1000 | 500 | 740 | 800 |
| 1960 depth (m) | NA | NA | 2.53 | NA |
| 1996 depth (m) | 2.65 | 0.7 | 0.65 | 3.75 |
| Filled volume ($m^3$) | 55 000 | 60 000 | 36 000 | 50 000 |
| Unfilled volume ($m^3$) | 62 000 | 8 000 | 5 000 | 136 000 |
| 1996 salinity (mg/L) | 20 510 | 2 800 | 4 048 | 9 482 |
| 1996 phosphorus—sediments (mg/g) | 0.216 | 0.05 | 0.106 | 0.264 |
| 1996 phosphorus—water (mg/g) | 0.203 | 0.044 | 0.056 | 0.237 |

Information source: JDA (1996)

**Notes:**

(1) Sediments were removed from Gwambygine Pool after these measures were taken.

(2) Oakover Pool is effectively full of coarse sediment. The apparent increase in length is due to the measure being taken of very shallow surface water that varies in area annually. Earlier measures may also have underestimated the length.

**Photo 6: Replacement of Eucalyptus rudis adjacent to the river.** *Photo courtesy Viv Read.*

**Photo 7: Isolated tree with roots exposed by channel erosion.** *Photo courtesy Ecoscape/JDA.*

**Photo 8: Seaton Ross pool.** *Photo courtesy Ecoscape/JDA.*

**Oakover**: this pool is reported to have filled with coarse sediments within two years of the River Training Scheme. Small shallow pools of water occur between bars of sediment. Water quality is quite good with relatively low phosphorus levels and salinity.

**Gwambygine**: this is one of the few Avon River pools remaining in good condition. While some coarse sediment has been removed, there is further potential for increased sedimentation from unconsolidated sand slugs upstream of the pool. This pool has been a focal interest of the River Conservation Society. A management plan for Gwambygine Pool has been prepared concurrent with this Recovery Plan.

### 2.1.6 Tributaries

The major tributary to this section of the Avon River is the Dale River. This has a catchment area of 27 500 Ha and has significant flow for all but about one month each year (compared with about 3 months for the Avon). The annual average flow volume is 8 million $m^3$. This tributary is very significant because of fresh stream flow and as a potential source of sediment. Flow from Talbot Brook contributes to the Dale River. There are 6 smaller tributaries on the west side and 5 east of the Avon River.

### 2.1.7 Land use and infrastructure

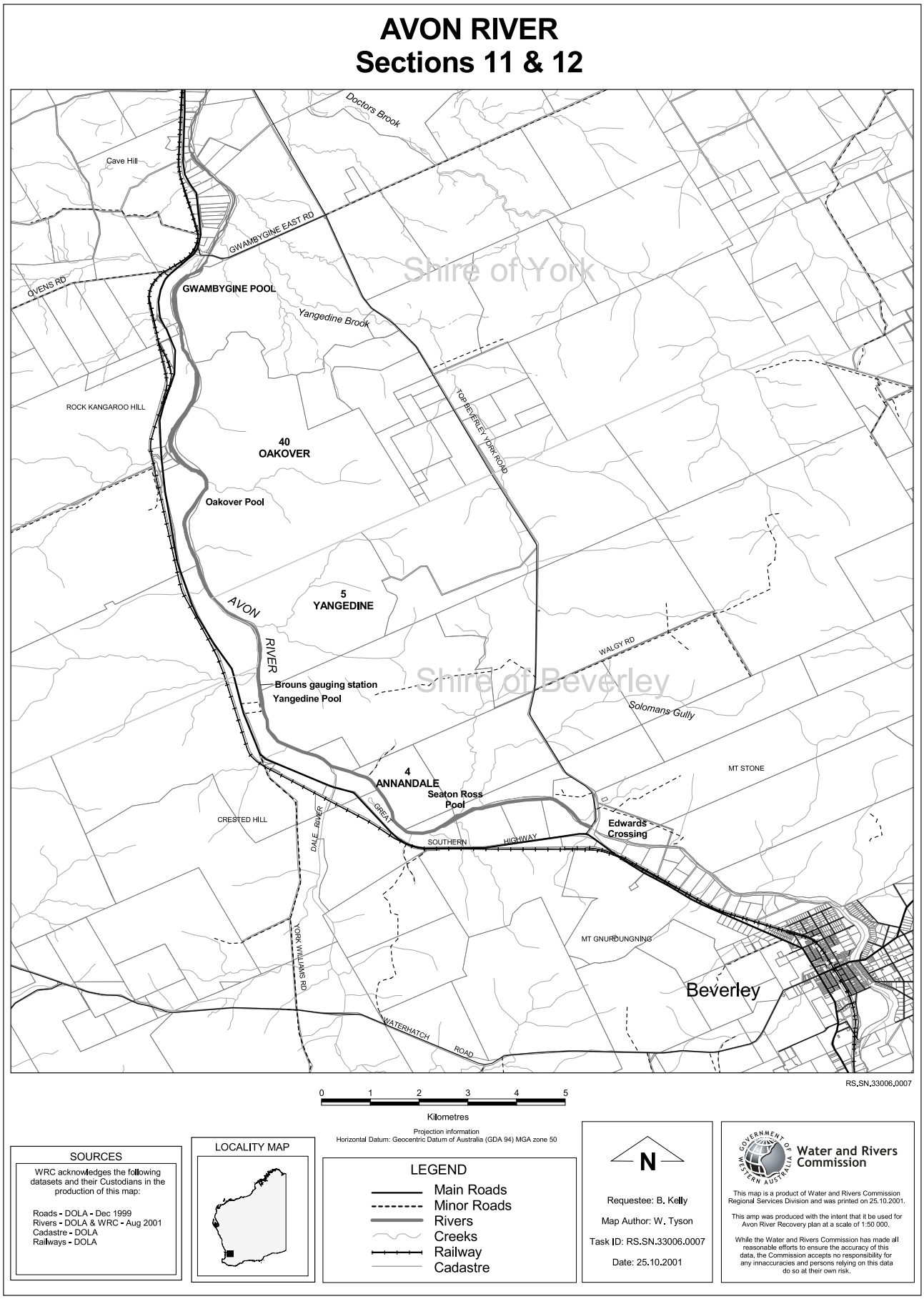
Land use adjacent to Sections 11 and 12 of the Avon River is mostly low input dryland farming. Eight farming families have land adjacent to the river. There are currently no intensive animal or processing industries close to the riparian zone. Apart from the eight, a further 5 properties are small-scale agriculture or recreational use. There is one small Reserve and a church (see Table 2.2).

There are no towns or proposed settlements along this section of the river. There are 6 occupied houses, 1 unoccupied house and a church within 500 metres of the river. Some of these buildings have historic significance. None are known to have been flooded. The town of York is located 11 km downstream and Beverley is 5 km upstream. The townsite originally planned for Beverley was at Edwards Crossing so there are some small-area blocks directly upstream of Seaton Ross bridge.

The Great Southern Highway, a railway and a water supply pipeline are west of the river. These do not cross the river in this section. There are sealed road crossings at either end of Sections 11 and 12. Gwambygine East Road is downstream and the Top Beverley Road crosses upstream at Edwards Crossing. There are established farm crossings at 'Oakover' (where there was a bridge built in 1899 that lasted until1968) and on 'Annandale'.

**Photo 9: The confluence of the Dale and Avon rivers.** *Photo courtesy Viv Read.*

**Photo 10: Farm crossing.** *Photo courtesy Viv Read.*




**Map 3: Sections 11 and 12**

## 2.2 Riparian land ownership and community interest

Current ownership of land along the Gwambygine-Edwards Crossing section of the Avon River is shown on Map 3. Table 2.2 shows the relative proportion of river frontage for each property.

Management of the river also has local and broader community interest. The River Conservation Society based in York has been established for over 10 years with a keen interest in the river. There are also Land Conservation District Committees for the Shires of Beverley and York.

The Avon River Management Authority represents broader community interest.

**Table 2.2 Length of Avon River Frontage for properties within Section 11/12.**

| **Owners/managers** | **Property name** | **Shire** | **Avon location numbers** | **West-bank length** (km) | **East-bank length** (km) |
|---|---|---|---|---|---|
| John Barrett-Lennard | *Annandale* | B | 0, 4, 20, 21, 22 | 6.41 | 2.81 |
| Andy McGlew | *Seaton Ross* | B | 23 | 1.01 | |
| Bill and Michael Hill | | B | 24,1,0 | 4.85 | |
| Peter, Janet and Duncan Young | *Yangedine* | B | 5 | 2.43 | |
| Neil Gooch | | B | 0 | 2.88 | |
| David Fleay | *Oakover* | Y | 40 | 2.60 | 5.33 |
| Frank, Murray and Allan Fleay | | Y | 1 | 2.63 | |
| Church of England | *Gilgering* | Y | 344 | 0.16 | |
| Joy Pottage | | Y | 342 | 0.15 | |
| Frank and Lynne Mathews | | Y | 340, 341 | 0.15 | |
| Raymond Marr | | Y | 501 | 2.56 | |
| Water and Rivers Commission | *Reserve 8125* | Y | 0.26 | | |
| Tony and Sally Boyle | | Y | 41 | 2.37 | |
| Martin Clifton, estate (manager, Simon Broun) | *Gwambygine* | Y | 36 | 1.70 | |
| Walter Scott | | Y | 0 | 0.27 | |

**Note:**

(1) B = Beverley Shire, Y = York Shire

# 3 River channel survey results

ARMA arranged a comprehensive survey of the 18 sections of the main channel of the Avon River during 1996 (Ecoscape, 1996), a total distance of 191 km. Records and observations were made at 500m intervals. The complete river channel survey results have been summarised by Black (1998). Appendices 1 and 2 show the significant features of these sections. Appendix Three shows summary information for the two river sections. The key findings are considered here.

## 3.1 Sediments and channel stability

The river survey shows that the banks of the channel in Section 11 are the most stable for all sections of the river (Figure 1). It is unlikely that these are a significant source of sediments infilling Gwambygine Pool. The river in this section has two significant meanders but it is fenced, restricting stock access to the bed and banks. Section 12 has less stable channel banks.

Both sections have below average bed stability (46% and 35% respectively when the average was 50.7%). Significant sand slugs were observed at 18% of sites for Section 11 but only 4% of sites for Section 12.

## 3.2 Vegetation condition

The survey portrayed the very low level of regeneration for *Eucalyptus rudis* (Flooded Gum) and *Melaleuca raphiophylla* (Paperbark) but high level of regeneration of *Casuarina obesa* (Sheoak). This is a consistent trend of waterways in South-West WA subject to increasing salinity. The consequences will be a simplified riparian ecosystem with diminished opportunities for native animal habitat (tree hollows, perches and food supply).

The weeds in these river sections are listed in Appendix Three.

## 3.3 Disturbance

Section 11 is well fenced so there are very few sites where livestock disturbance was recorded. This contrasts with Section 12 where 48% of sites recorded livestock in the river. Section 11 had rubbish disposal recorded at 9% of sites compared with none for Section 12.

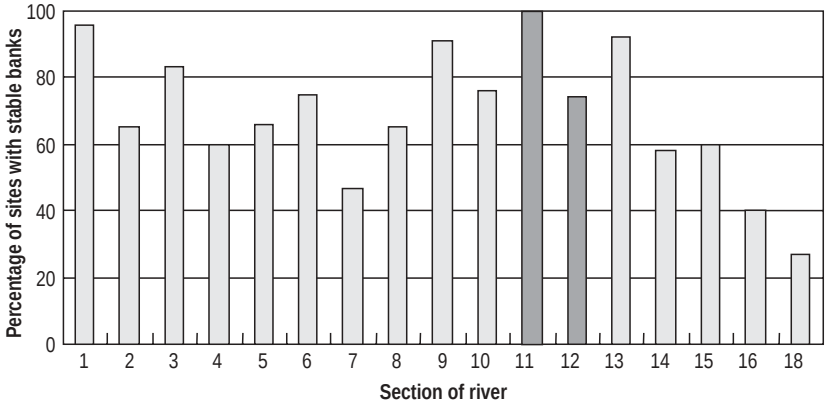



**Figure 1: Bank stability along the Avon River (from Black, 1997a).**

# 4 River recovery planning

The mission of the Avon River Management Authority (ARMA) is to restore and manage the natural functions of the Avon River system for the long-term benefit of the community. ARMA also recognises adjacent landholder issues and concerns with river management. The preferred approach to river recovery is by agreement between landowners along the river and those with direct community interest for management actions that are compatible with ARMA's Management Programme and also meet individual needs.

Recovery planning has been through a series of 4 meetings, a river walk and individual property inspections during March and April, 2001. Individual and site specific information was integrated with river channel survey information and ARMA policies and management guidelines to develop a draft Recovery Plan. An interim Recovery Team including landowners, interested community members and WRC staff provided direction for this process.

The Gwambygine-to-Edwards Crossing Avon River Recovery Plan provides a blue-print partnership arrangement between the Water and Rivers Commission, the Avon River Management Authority and a Recovery Team specific to this section of the river. The plan is developed for a period of 5 years but is set in a 20-year time-frame.

The Recovery Plan consists of :

- A local Vision for this section of the river in 10-20 years time,
- A set of local management objectives,
- Identification of key management issues,
- Management actions that respond to the issues, and
- An Implementation Schedule.

## 4.1 A "Vision" for the river

ARMA has a broad vision for the complete Avon River system. With this in mind, the Gwambygine to Edwards Crossing Recovery Team has the following vision for management:

*The Avon River between Gwambygine Road East and Edwards Crossing (Sections 11 and 12) looks well managed as a natural river that has retained its characteristic meanders, remaining pools, vegetation and links with the past. Wildlife breeds and takes refuge there. The river engenders happy memories and inspires hope for the future.*

*Threats to the river ecosystem by sediments, nutrients, salinity, weeds and fire are well understood.*

*The river is fenced to manage stock access. Bed load sediments affecting river pools are controlled and revegetation to combat potential salinity is thriving. Actions for river management are according to voluntary Management Agreements between landholders and the Avon River Management Authority (ARMA).*

*The landscape adjacent to the river is managed in a sustainable way. Risks to the river by new development are minimised through appropriate planning.*

*Adjacent landowners are recognised and supported for their river management effort. The local and broader community also continue to enjoy the Avon River well into the future.*

## 4.2 Local management objectives

The five objectives identified for management through the recovery planning process are:

- To retain the natural attributes and river characteristics wherever possible
- To understand the processes that have caused the river to deteriorate
- To reduce the risk of further river degradation
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers
- To communicate good river management to others.

# 5 Key management issues and proposed actions

The key management issues to be considered in recovery planning were derived from meetings with the Section 11/12 Recovery Team and field survey as well as from the Avon River Channel Survey reports and ARMA's Management Programme.

The 18 issues that were identified are shown in Table 5.1. Recovery Team members ranked the issues according to perceived importance. The table shows the relative priority as well as the average score and the range of scores for each issue (based on the opinions of 7 members). The priority ranking is a relative guide only for management. While it is difficult to separate some of the issues, it is clear that managing the river pools and the riparian zone vegetation is a high priority.

Public access is ranked last which reflects the Recovery Teams concern about the potential impacts of the issue rather than the issue being not important. Water regulation is ranked low because it is not considered a major issue at present but is one that can not be ignored.

The Key Management Issues are described according to the current understanding of the Recovery Team, and the preferred management actions are outlined in the following sections.

**Table 5.1 Recovery Team priorities for Key Management Issues**

| Issue | Priority | Average Score | Highest Score | Lowest Score |
|---|---|---|---|---|
| 1. River Pools | 1 | 8.0 | 10 | 5 |
| 2. Sediments | 4 | 6.4 | 10 | 3 |
| 3. *Paspalum* causing increased flood risk | 7 | 6.1 | 10 | 4 |
| 4. Fire | 6 | 6.3 | 10 | 2 |
| 5. Nutrients | 4 | 5.3 | 8 | 2 |
| 6. Salinity | 12 | 5.3 | 8 | 2 |
| 7. Riparian zone vegetation management | 2 | 7.7 | 10 | 6 |
| 8. Public Access | 18 | 3.7 | 8 | 1 |
| 9. Pollutants | 14 | 5.0 | 7 | 3 |
| 10. River crossings | 8 | 6.1 | 10 | 2 |
| 11. Heritage values | 15 | 4.6 | 7 | 2 |
| 12. Aquatic ecosystem management | 3 | 6.6 | 10 | 3 |
| 13. Flood mitigation | 9 | 5.7 | 7 | 2 |
| 14. Water regulation | 17 | 3.9 | 6 | 1 |
| 15. Sub-divisions and development | 13 | 5.1 | 8 | 2 |
| 16. Integrated management and links to catchments | 5 | 6.4 | 10 | 2 |
| 17. Education and awareness | 10 | 5.7 | 7 | 2 |
| 18. Recovery Team structure | 16 | 4.5 | 7 | 2 |

**Importance score** (1 = low, 10 = high)

## 5.1 River pools

### Management issues/options

The condition of the four river pools in the Gwambygine to Edwards Crossing section is described in section 2.1.5. Consistent use of locally acceptable names for the pools is desirable.

The major concern is about sedimentation of the pools by coarse and fine sediments. Oakover Pool is considered to be filled with sediments. The greatest risk is for Gwambygine Pool to fill with unconsolidated sediments in the channel bed upstream to Oakover Pool. Actions for management of this sediment are included in the Gwambygine Pool Management Plan, which is being prepared in conjunction with this plan. The potential for coarse sediment now in Oakover Pool to transfer to Gwambygine Pool is low because the power of the river even during flood flows is inadequate to scour the pool. Some coarse sediments may be sourced upstream of Oakover Pool but these are considered minimal.

Dredging Oakover and Yangedine Pools was considered. Returning these pools to open water bodies is desirable but the excavated areas could function as sediment traps and this may not prevent further sedimentation of Gwambygine pool. While there is little unconsolidated bed sediment load upstream of Oakover Pool, the potential for re-sedimentation by sediments transported from further upstream (including from the Dale River) is unknown.

Removal of the 36 000 $m^3$ from Oakover Pool and 60 000 $m^3$ from Yangedine Pool would cost approximately $0.18m and $0.3m respectively (2001 values) under full contract dredging rates. Some income from sale of the sand removed is possible although the potential is limited due to low demand and high transport costs. The costs could be reduced by use of a small-scale, locally operated dredge.

Non-commercial excavation would be a public cost as there is very limited potential for private funding to excavate river pools. The public cost may be justified if the risk of re-sedimentation is low.

The condition of the Seaton Ross Pool riparian vegetation is declining.

***Action 1.1:*** Arrange formal recognition of the preferred local names for the river pools (Gwambygine, Oakover, Yangedine and Seaton Ross).

***Action 1.2:*** Integrate actions proposed in the Gwambygine Pool Management Plan with this Recovery Plan.

***Action 1.3:*** Measure coarse sediment mobility in the river channel and assess the potential for other coarse sediment to be transported from the Dale River.

***Action 1.4:*** Evaluate lower-cost dredging or excavation options if the risk of re-sedimentation of Oakover and Yangedine pools is shown to be low.

***Action 1.5:*** Arrange fencing to exclude stock from the riparian zone of Seaton Ross Pool but allow stock access to the excavated seepage (Avon Location 22).

## 5.2 Sediments

### Current status

Unconsolidated channel sediments have potential to be mobilised by stream flow causing infill of river pools. This is of concern primarily for Gwambygine Pool with sediments in the channel upstream to Oakover Pool. Management options are considered in the Gwambygine Pool Management Plan.

There are only small areas of unconsolidated coarse sediments within this river section upstream of Oakover Pool. A high proportion of bedload sediment has been stabilised by *Paspalum vaginatum* and other colonising plants. No additional management action is recommended for coarse sediment stabilisation.

The channel banks for Section 11 are the most stable for all of the Avon River. While the banks were considered less stable in Section 12 during the Avon River Survey, recent stabilisation by *P. vaginatum* suggests that there is little potential for this area to now be a source of fine or coarse sediments.

## 5.3 *Paspalum* causing increased flood risk

Salt Water Couch Grass (*Paspalum vaginatum*) is a voracious coloniser of unconsolidated sands in the river channel. It is reported by Recovery Team members to be spreading rapidly. When established, it is very effective in stabilising coarse sediments and trapping mobile sediments. The spread of this introduced perennial plant within the river system could reduce the risk of further erosion of the river channel and sedimentation of river pools.

**Photo 11: *Paspalum vaginatum* stabilising coarse sediment in the river bed.** *Photo courtesy Ecoscape/JDA.*

However, *P. vaginatum* seems restricted to areas with access to soil moisture during summer. It does not colonise well on large coarse sand islands (where moisture retention capacity is low) nor does it invade the adjacent riparian vegetation. The perennial plant is salt-tolerant.

A concern of the Recovery Team is that *P. vaginatum* will extend across the river bed, including areas that are now bare clay, trapping sediments excessively which will restrict stream flow and eventually lead to localised flooding. This process does occur in smaller tributaries to the river.

A contrary view is that in the broad bed of the Avon River, the couch grass will form islands interspersed by smaller stream flow channels. The channels would be retained by the erosive power of the faster flowing water and the full channel would not become significantly restricted. If this process is occurring, the outcome would be a braided river channel, possibly similar in function to that which existed prior to the River Training Scheme.

Determining between these two future scenarios for sediment entrapment is critical to decisions about management. If the future outcome is a braided river channel with stable islands, then the couch grass should be allowed to colonise without restriction assuming that fluvial processes and soil moisture status will determine its extent of growth. With this scenario, the couch grass should not be heavily grazed.

If the future outcome is likely to be localised flooding, then some intervention could be considered. The couch grass could be grazed although at a time and a stocking rate that would not be detrimental to other river vegetation. Some channel maintenance by sediment removal in areas that have become restricted could be considered. All works would require a licence from the Water and Rivers Commission under the Rights in Water and Irrigation Act 1914 (June, 1999).

***Action 3.1*** Arrange monitoring of the colonisation pattern for salt-water couch in the river bed. Detailed site monitoring downstream from Yangedine Pool is suggested.

(Note: the Gwambygine Pool Management Plan proposes a small study of the ecological determinants of couch growth in the river environment. This information should be linked to this monitoring action.)

**Photo 12: Bare river channel bed with early sediment island formation.** *Photo courtesy Ecoscape/JDA.*

## 5.4 Fire

Uncontrolled fire in the river is a significant concern to landholders who want to protect their property, to fire control officers who want to reduce fire risk and the resources required for suppression, and to those interested in the river environment who do not want ecosystem damage.

ARMA has a Fire Policy that recognises fire as a natural factor in the bush but also sees uncontrolled summer fires as a threat to human values. The policy states that fire should be kept out of the riverine ecosystem permanently but in areas identified with high human values, there should be management for fire risk reduction. The policy also includes practical guidelines that are relevant to the Gwambygine-Edwards Crossing section of the Avon River.

The ARMA policy requires a Wildfire Threat Analysis to identify areas of human value at risk.

### Fuel load reduction

The risks of fire in this section of the river are relatively high due to fuel load. Dry annual grasses (especially Wild Oats) are volatile but the dry woody vegetation and leaves with high volatile oils is the major fuel load. Stand densities of up to 1000 stems/Ha were reported from the Avon River Survey (Ecoscape and JDA, 1996). General fuel load reduction for the river is not a feasible option.

The major human values at risk are the 7 dwellings and associated farm sheds, equipment and infrastructure, Gilgering Church, power line poles and items of heritage vale (e.g. remnant poles of the Oakover Crossing bridge). Measures such as the following to reduce annual weeds in the river adjacent to these valued areas are acceptable. A fuel reduction zone on the bank of the river adjacent to the asset and 150 metres either side of it is suggested. A cool late-spring fuel reduction burn, compliant with the Bush Fires Act, is recommended. The frequency should be in accordance with annual fuel load. A control burn about one year in 5 is expected. Herbicides are difficult to apply in the riverine environment, and grazing at that time is at risk of damage to other regenerating vegetation. Canopy closure will eventually suppress annual weeds in other areas. Natural thinning of native plants by competition will eventually occur. The controlled burns will remove the dry material that this process causes in the areas of risk.

**Photo 13: A stand of *Eucalyptus rudis* affected by salinity.** *Photo courtesy Viv Read.*

***Action 4.1:*** Fuel Reduction Zone to be identified for those human value assets at risk from uncontrolled fire. Cool fuel reduction burns are undertaken in these areas at a frequency in accordance with annual fuel load.

### Fire risk reduction

Factors causing some fires have reduced with improved farm machinery and railway rolling stock. The more significant risk of uncontrolled fire ignition is from negligent campers and uninformed hobby farmers. There are very few small land holdings in this section of the river, but they are numerous immediately upstream and downstream. Wilful arson is possible but would be uncommon. Lightning is a consistent risk.

The major requirement is to inform campers and recreational farmers of the risks and consequences of fire, particularly for the period from October to April. Increasing the opportunity for more camping and small farms will increase the fire risk. Clear information about fire is required if new opportunities do occur.

***Action 4.2:*** Regularly disseminate information about the risk of fire to landholders adjacent to the river and surrounding district, particularly to more densely populated areas.

***Action 4.3:*** Erect and maintain clear signage to outline fire risks and restrictions at identified camping, picnic or high use areas (particularly at Reserve 8125 and Edwards Crossing).

### Fire suppression

Effective fire suppression in the river environment is difficult. Wildfire initiated in the river or transgressing from agricultural land can advance rapidly along the river, depending largely upon wind conditions. Fire leaving the river can be controlled by tenders providing there are gates between paddocks and properties. Access across the river is required for intermittent suppression. Access should be suitable for heavy vehicle crossing and be suitable for back-burning into the face of an on-coming fire. A width of approximately 10 metres is proposed. Access tracks are not expected to perform as fire-breaks.

Existing crossings at ‘Oakover’ and ‘Annandale’ provide suitable fire control access. Other potential locations are upstream of Gwambygine Pool (access through Reserve 8125), adjacent to Gilgering Church and at the boundary between Avon Locations 5 and 40 (Young and D. Fleay) on the eastern bank. Installation of additional fire access should be at the discretion of the Chief Fire Control

Officers for the Shires of York and Beverley with advice from ARMA.

Control of fires threatening property may also be assisted by aerial suppression. The use of aerial water bombers is effective in containing small fires to allow ground-based suppression. It is not a method suitable for suppression of large or intense fires. Decisions to employ this approach are made by the responsible Chief Fire Control Officer and the Department of Conservation and Land Management.

***Action 4.4:*** The Recovery Team to ensure that all fences transverse to the river have gates suitable for fire control access and that vehicle access along the river is clear and unhindered.

***Action 4.5:*** The Recovery Team take advice from the Chief Fire Control Officers for the Shires of York and Beverley and ARMA for location and installation of additional fire control access.

## 5.5 Nutrients

### Issue description

Phosphates and nitrates are the major nutrients controlling plant growth in aquatic ecosystems. Where these are present in excess, eutrophic conditions in river pools may occur. The major source of excess nutrients is from agricultural land. Most soils associated with the river environment have high phosphorus retention capacity. Phosphorus transported to waterways is in particulate form attached to soil eroded from catchments. Nitrogen is transported in solution.

### River pool nutrients

The phosphorus load in the sediments and water body of the Avon River pools were measured during the Avon River Pool Survey (JDA, 1997). Both were relatively high for Gwambygine and Seaton Ross pools and relatively low for Oakover and Yangedine pools. The nutrient load is related to the level of fine sediments deposited in the pool. It is difficult to prevent deposition of these sediments and it is not feasible to remove them.

Agricultural practice has changed in recent years in ways that reduce soil loss. Minimising tillage, contour farming, soil-specific management, retaining stubble and avoiding over-grazing all reduce sediment loss. Wide adoption of these practices is required. Further on-farm action is required to implement graded interception drainage on slopes and to rehabilitate waterways. These actions reduce runoff velocity (hence soil loss capacity) and provide in-stream filtration. These are responsibilities of individual farmers and Land Conservation District Committees or catchment groups. No direct action by the river section Recovery Team is required.

Most tributaries to the Gwambygine-Edwards Crossing river section discharge to floodways, not directly to the river channel. This enables filtration of floodwaters. Only Black Jack Creek discharges directly into the river (Gwambygine Pool) causing minor sediment and nutrient problems. Action to address this is proposed in the Gwambygine Pool Management Plan.

### Contribution to Swan-Canning estuary sediments

There has been considerable concern about the contribution of nutrients from the Avon River Basin to the Swan-Canning estuary. This was emphasised as a result of flooding of the Avon River during January 2000. Soil eroded from bare paddocks was transported to the estuary. The warmer fresh, nutrient-rich water overlaid the saline estuary water causing algal bloom conditions such that the river was closed for human use in the metropolitan area. A total load of 35 tonnes of phosphorus and 800 tonnes of nitrogen from the greater Avon catchment measured at Walyunga was deposited in the estuary between 23 January and 1 March. (Muirden, 2000)

Water quality sampling from 1987 to 1992 showed that the Avon River contributed 32% (20 tonnes) on average of the total phosphorus load to the Swan-Canning estuary annually. This compares with 42% (26 tonnes) from the considerably smaller catchment of Ellen Brook (Donahue *et al.*, 1994). For the same period, the Avon River contributed on average 55% (400 tonnes) of the total nitrogen load to the estuary. This compares with 10% (80 tonnes) from Ellen Brook (Donahue *et al.*, 1994). The total phosphorus and total nitrogen status of the Avon River contribution to the Swan-Canning Estuary is considered to be low (SRT, 2000).

While the nutrient load from the Avon River during normal and flood conditions is relatively high, it is from a very extensive catchment area. The nutrient loss per unit area is substantially lower than for Ellen Brook. Agricultural practices in the Avon River Basin that reduce nutrient loss should continue to be encouraged. Due to the extensive nature of the source of nutrients to the Swan Canning

estuary from the Avon, there are no further direct actions that should be undertaken by the Gwambygine-Edwards Crossing river section Recovery Team.

***Action 5.1:*** Encourage the Avon Working Group and ARMA to develop nutrient loss targets from the Avon River Basin and clearly state 'Best Practice' agriculture to achieve these targets. These bodies, with agricultural industry support should then publicly promote the private efforts within the agricultural industry undertaken to reduce off-site impacts of nutrient loss.

## 5.6 Salinity

### Issue description

#### *Increasing stream salinity*

Rising groundwater since the clearing of natural vegetation for agriculture has cause stream flow salinity to increase. This process will continue as further land is salinised. Only major land use change to a system based on perennial plants can significantly reduce the predicted extent of salinity. The effect of increased stream salinity on existing river pools is not well known.

Significant groundwater drainage or pumping schemes for salinity control on land adjacent to the Gwambygine-Edwards Crossing river section are not expected because of the limited effects of salinity in this area. Proposals for large-scale drainage schemes in other parts of the Avon River Basin are expected. The potential impact of these on the river environment is not well understood. Recommendations to assess some of these affects are made in the Gwambygine Pool Management Plan.

#### *River channel salinity*

Saline seepage from the banks and bed of the river is common. This may have occurred prior to land clearing in some places but has undoubtedly increased with rising regional groundwater tables. There are no monitored wells or piezometers in the Avon River to quantify this trend.

Localised salinity may be exacerbated by altered channel characteristics following the River Training Scheme. The lowered river bed has effectively drained the fresh perched groundwater aquifers of the adjacent floodplain. Less frequent flooding results in less recharge to these aquifers. These changed hydraulic conditions probably allow greater salinisation of river bed soils and the likely cause of very low regeneration of *E. rudis* and *M. raphiophylla.*

If these processes are occurring, there is further risk that seepages that are now relatively fresh will become saline.

Survey and monitoring is required to establish the temporal and spatial extent of localised salinity.

***Action 6.1:*** Install and regularly monitor transects of groundwater wells across the bed and floodplain of the river at approximately 4 locations within the Gwambygine-Edwards Crossing river section. Hydrogeological interpretation of the local landscape is required to select appropriate sites. A 5 year monitoring period is recommended.

A similar action is recommended in the Gwambygine Pool Management Plan.

#### *Release of saline water from Yenyenning Lakes*

The Yenyenning Lakes Management Committee makes decisions, in consultation with ARMA, WRC and CALM, for occasional release of water from the lakes through a gate at Qualandary Crossing. Released water does affect some farm operations by reducing access and stock movements across the river. It may also affect aquatic ecosystems in river pools if high salinity water was released without less saline stream flow in the Avon River. The potential impact at Gwambygine Pool is to be assessed.

***Action 6.2:*** The Yenyenning Lakes Management Committee be requested to inform downstream landholders of their intentions to release saline water from the lakes.

## 5.7 Riparian zone vegetation

### Issue description

Management of the riparian zone vegetation is a high priority for the Recovery Team and for ARMA. The intention is to allow vegetation to regenerate in near to natural conditions without there being significant weeds or unwanted animals.

#### *Natural regeneration*

Fencing the river to control stock access is the most effective management tool. If control burns are used to reduce fire risk in selected areas and couch proves to be not causing a flooding problem, there are no substantial reasons to have livestock in the river environment. The net benefit to river rehabilitation by not grazing is high.

**Photo 14: Spiny Rush in a tributary to the Avon River.** *Photo courtesy Viv Read.*

Natural regeneration can be enhanced. There is potential for rapid regeneration following fire or soil disturbance (perhaps due to removing topsoil with weed seed). Smoked water is also suggested. Trials for both are suggested.

If nursery stock plants are to be used for revegetation, local provenances should be used. Natural regeneration should be favoured over revegetation in the river environment.

***Action 7.1:*** Arrange fencing for areas where stock have access to the river. Financial support for materials from ARMA is recommended.

***Action 7.2:*** Arrange natural regeneration trials that include fire, smoked water and soil disturbance to enhance natural regeneration are recommended.

### *Weeds*

The river environment does have a wide range of weeds that are detrimental to agriculture and to the river ecosystem (see Appendix Three). Most agricultural weeds in the river are also common on agricultural land. The major concern is about the river becoming a conduit for the spread of Patterson Curse (*Echium plantagineum*) and Soursob (*Oxalis pes-caprae*). Spot-spray control with appropriate herbicides is recommended. This will require all landowners adjacent to the river to survey the riparian zone for outbreaks of these weeds.

There is a significant threat to the river environment by the rapid spread of Spiny Rush (*Juncus acutus*). This rush currently chokes smaller tributaries and is a contaminant to wool. It is very invasive in the South Branch of the Avon River and probably has the potential to become a significant weed in the river in the Gwambygine-Edwards Crossing river section. There seems to be no acceptable control available for this weed. It would be particularly difficult to control if established in the river. Control would be easier in the smaller tributaries where it now exists.

Although not recorded during the river survey, Bridal Creeper does occur. This should be eradicated. The Toodyay 'Friends of the River' group should be consulted for effective eradication methods.

***Action 7.3:*** River-side landowners to regularly survey the riparian zone for infestation of new agricultural weeds. The Recovery Team to arrange systematic eradication of any outbreak. ARMA to arrange assistance as required.

***Action 7.4:*** Arrange trials for the control of Spiny Rush (*Juncus acutus*) in tributaries adjacent to the Avon River. Sites on Avon Location 0 (Hill) are well suited for trials.

***Action 7.5:*** Eradicate Bridal Creeper with methods successfully applied in the Avon River at Toodyay.

#### *Feral animals*

Foxes and rabbits are the main concern to farmers. Systematic shooting and baiting is the most appropriate form of control.

The Recovery Team suspects that introduced rats (*Rattus rattus*) are a significant threat to wildlife. These would be difficult to control in a targeted way.

## 5.8 Public access

### Issue description

There is very little opportunity for public access to the Gwambygine-Edwards Crossing river section because of private ownership of most land.

#### *Visitors*

There are limited visitor facilities in the small reserve at the intersection of the great Southern Highway and the Top Beverley Road. Visitation at this site could be encouraged by signage. This provides an opportunity to communicate good river management practice to visitors.

Significant visitor facilities exist downstream of this river section at Gwambygine Park and upstream in the town of Beverley. Additional sites are not required.

#### *Recreation*

The river is occasionally used for passive recreation, including canoeing. ARMA's Recreation Policy is appropriate here and provides practical guidelines. Canoeing is a good way to understand and enjoy the river. Signage at appropriate sites would discourage mal-practice (litter, fires etc.). Fencing transverse to the river is a public risk.

***Action 8.1:*** Signage to be erected at the Edwards Crossing reserve that welcomes visitors, provides information about river management and warns about the risk of fires. Further information about the detrimental effect of canoeing on water bird breeding (late spring) and the risk due to river fencing is required.

## 5.9 Pollutants

### Issue Description

The most significant potential pollutant is agricultural chemicals from discarded containers. Current arrangements ("Drum Musters") in the Shires of Beverley and York are the best method of control. The potential impact on the river by chemical drum disposal should be publicised.

The practice of disposing farm rubbish into the river or adjacent tributaries has substantially reduced in recent years. Where it continues, landholders should be encouraged to find alternative sites on the property or use municipal facilities.

***Action 9.1:*** The Shires of Beverley and York be advised of the benefit of the "Drum Muster" program in relation to river management and be requested to locally publicise the risk of agricultural chemicals and other farm rubbish to the river environment.

## 5.10 River crossings

### Issue description

Existing river crossings for the 'Oakover' and 'Annandale' properties are required for farm management. These facilities are not significantly affecting river functions.

Additional crossings for fire control access are to be considered. All additional crossings should be installed with advice from ARMA and in accordance with the Rights in Water and Irrigation Act 1914 (June, 1999).

## 5.11 Heritage values

### Issue description

Land adjacent to the Gwambygine-Edwards Crossing section of the Avon River was some of the first settled for agriculture in Western Australia. Some Recovery Team members have family links with early settlement. Reflections on the past have contributed to the future Vision for the river.

The river was significant in development of the social and cultural heritage of this area. It is of local and broader interest that information about this heritage is preserved

***Action 11.1:*** The Recovery Team initiate and seek funding for an oral/written history of the inter-relatedness between the river and early settlement.

**Photo 15: Remains of sheep holding pens.** *Photo courtesy Viv Read.*

## 5.12 Aquatic ecosystem management

The Avon River channel and pools are significant aquatic ecosystems in a considerably altered semi-arid landscape. While the structure and function of these ecosystems are not yet well known, occasional surveys have shown them to be biologically abundant and diverse (River Conservation Society, 1999).

The major risks to the river pool ecosystems are from sedimentation, excess nutrients and increased salinity. The resilience of these ecosystems to such perturbations is yet to be established.

The York-based River Conservation Society with support from ARMA, the Water and Rivers Commission and other interested groups have initiated a range of studies focussed on Gwambygine Pool in order to better understand the river ecosystems. A Management Plan prepared for this pool establishes it as a priority for scientific enquiry about the ecological function of aquatic ecosystems in river pools. Information about ecosystem management from these studies will have relevance to other pools, particularly Seaton Ross pool.

Oakover Pool would have little aquatic ecosystem value in its current state. Yangedine Pool is limited by shallow depth.

## 5.13 Flood mitigation

### Issue description

While there is some concern about Salt Water Couch causing increased flooding by trapping sediment (5.3), it is not considered to be a significant issue at present.

## 5.14 Subdivisions and development

### Issue description

Intensified land use increases potential for uncontrolled fire and pollution in the river. Proposals for land subdivision or development are submitted to the appropriate Shire for approval. ARMA provides advice under statutory arrangements to local government on proposals that have potential to impact on waterways. These arrangements are adequate for the Gwambygine-Edwards Crossing river section.

## 5.15 Water use regulation

### Issue description

Reform of the Rights in Water and Irrigation Act 1914 (June, 1999) will not affect water use in this area. The Avon River was proclaimed under this Act in order to implement the River Training Scheme. The most significant implications of the Act now are for control over disturbance of the river bed.

## 5.16 Integrated management and links to catchments

### Issue description

Management of land in water catchments of tributaries that discharge into the river is significant. Processes for integrated catchment management incorporating landcare principles and best land management practice are well developed in the Avon River Basin. The Avon Working Group (AWG), of which ARMA has membership, leads these processes. The Avon Catchment Network (ACN) based in Northam provides effective information networking for integrated land and water management.

The effects of land management on the river are at a scale that is too large for local influence by the Gwambygine-Edwards Crossing river section Recovery Team.

The team can influence ARMA to adequately represent river management issues through membership of AWG.

## 5.17 Education and awareness

### Issue Description

The effects of the River Training Scheme and agriculture on the Avon River have been well publicised. Recent river management initiatives by landholders, the River Conservation Society and ARMA also require extensive publicity to assure others that the river is receiving appropriate management. There is also a need to inform the local community and the broader community about the condition and the values of the river. While ARMA has primary responsibility for this role, the Gwambygine-Edwards Crossing river section Recovery Team can promote similar information locally.

Key messages that the Recovery Team can promote through local information and signage are:

- The Gwambygine-Edwards Crossing river section is being managed cooperatively by landholders and local community along the river according to a Recovery Plan
- The river section from Gwambygine to Edwards Crossing (17.9 km) has 4 significant river pools. Gwambygine and Seaton Ross pools are in relatively good condition. Oakover and Yangedine pools are now substantially filled with sediment.
- The Dale River discharges into this section of the river. The relatively fresh flow for most of the year is important to the river pool ecosystems.
- The river is almost all fenced in this section. There is active regeneration of riparian vegetation in some parts. River bed sediments are being stabilised.
- Landholders adjacent to the river aim for sustainable land management and adopted better cultivation and water management practices that will assist the river.
- Gwambygine Pool is being studied to assess the impact of nutrients and increasing salinity on the river ecosystem.
- Fire is a substantial threat to the river and adjacent property.
- Farm chemicals can pollute the river. Dispose of chemical containers where there is no risk of pollution. “Drum Musters” are arranged by the Shires of Beverley and York.
- Canoeing is enjoyable but can disturb breeding water birds during September-November.

***Action 17.1:*** Prepare an information sheet that contains a map of this section of the river, the key messages and a summary of the Recovery Plan (Vision, Objectives and Actions for each key Management Issue) for local distribution.

***Action 17.2:*** Signs with key messages be erected where there may be public access (e.g. the reserve at Edwards Crossing).

## 5.18 Recovery team structure

### Issue Description

The interim Recovery Team that has contributed to the preparation of the Gwambygine-Edwards Crossing Recovery Plan should continue to meet on a regular basis in order to arrange implementation of actions of the plan. Because there are only few properties along this section of the river, all landholders should be considered members. Further membership of the team by representatives of the River Conservation Society, ARMA and the Water and Rivers Commission is recommended.

The proposed Recovery Team should be informally structured but should have an identified leader. This role should be undertaken by a landholder. The role could be transferred to another team member each year. It is recommended that the Recovery Team have at least one meeting for all members each year. Smaller group meetings with respect to specific management issues could occur by arrangement.

The key roles of the Recovery Team could be:

- Review the Recovery Plan Implementation Schedule and arrange for further management action
- Arrange and coordinate fire control strategy
- Coordinate response to new weed infestation
- Brief new people in the district on river management requirements.

***Action 18.1:*** The interim Recovery Team continue on a permanent basis with membership of all landholders and representatives of the River Conservation Society, ARMA and Water and Rivers Commission meeting at least annually.

# 6 Implementation of the recovery plan

An appropriate Implementation Schedule is outline in the following Table.

| Action | Priority (1) | Responsibility and resources required (2) | Notes |
|---|---|---|---|
| **River Pools** | | | |
| ***Action 1.1:*** Arrange formal recognition of the preferred local names for the river pools (Gwambygine, Oakover, Yangedine and Seaton Ross). | **M** | GERT/WRC no cost | Fax map with proposed names to 'Geographic Names Committee' (DOLA). Follow-up with letter including new and original names. Consult with Shire. |
| ***Action 1.2:*** Implementation of actions proposed in the Gwambygine Pool Management Plan be integrated with this Recovery Plan. | **H-M** | RCS/WRC Costs according to actions. | Many actions proposed in the Management Plan are relevant to other parts of this river section. |
| ***Action 1.3:*** Measure coarse sediment mobility in the river channel and assess the potential for other coarse sediment to be transported from the Dale River. | **H** | WRC 0.025 FTE. | Regular sampling suggested at Oakover and near the Dale/Avon confluence. |
| ***Action 1.4:*** Evaluate lower-cost dredging options if the risk of re-sedimentation of Oakover and Yangedine pools is shown to be low. | **L** | WRC/GERT Costs to be compared against contract rates. | This option should be developed in association with local government also considering other river sections. |
| ***Action 1.5:*** Arrange fencing to exclude stock from the riparian zone of Seaton Ross Pool but allow stock access to the excavated seepage (Location 22). | **H** | GERT/WRC Materials to be supplied by ARMA. | WRC River Fencing Survey will show distance required. |
| ***Paspalum*** **causing increased flood risk** | | | |
| ***Action 3.1:*** Arrange monitoring of the colonisation pattern for salt-water couch in the river bed. Detailed site monitoring downstream from Yangedine Pool is suggested. | **H** | WRC/GERT | WRC Revegetation officer should establish set monitoring site in consultation with GERT members (contact Peter and Duncan Young). Results of proposed study for the Gwambygine Pool Management Plan should be related to this monitoring program. |
| **Fire** | | | |
| ***Action 4.1:*** Fuel Reduction Zone to be identified for those human value assets at risk from uncontrolled fire. Cool fuel reduction burns are undertaken in these areas at a frequency in accordance with annual fuel load. | **H** | GERT/WRC | Advice to be sought from Chief Fire Control Officers. |
| ***Action 4.2:*** Information about the risk of fire be regularly disseminated to landholders adjacent to the river and surrounding district, particularly to more densely populated areas. | **M** | GERT/SoB/SoY | Action 4.2: Information about the risk of fire be regularly disseminated to landholders adjacent to the river and surrounding district, particularly to more densely populated areas. |
| ***Action 4.3:*** Clear signage to outline fire risks and restrictions be erected and maintained at identified camping, picnic or high use areas (particularly at Reserve 8125 and Edwards Crossing). | **H** | WRC/GERT Incorporate with other signage. | Advice to be sought from Chief Fire Control Officers. |

**Implementation Schedule continued overleaf…**

**… Implementation Schedule continued**

| Action | Priority (1) | Responsibility and resources required (2) | Notes |
|---|---|---|---|
| ***Action 4.4:*** The Recovery Team to ensure that all fences transverse to the river have gates suitable for fire control access and that vehicle access along the river is clear and unhindered. | **M** | GERT<br>On-farm cost. | |
| ***Action 4.5:*** The Recovery Team take advice from the Chief Fire Control Officers for the Shires of York and Beverley and ARMA for location and installation of additional fire control access. | **H** | WRC/GERT | Negotiations for cost-sharing between ARMA, Shires and landholders according to perceived benefits to be derived. |
| **Nutrients** | | | |
| ***Action 5.1:*** The Avon Working Group and ARMA be encouraged to develop nutrient loss targets from the Avon River Basin and clearly state 'Best Practice' agriculture to achieve these targets. These bodies, with agricultural industry support should then publicly promote the private efforts within the agricultural industry undertaken to reduce off-site impacts of nutrient loss. | **M** | ARMA/WRC | Close negotiations with Swan River Trust and Swan Canning Clean-up Program staff required. |
| **Salinity** | | | |
| ***Action 6.1:*** Install and regularly monitor transects of groundwater wells across the bed and floodplain of the river at approximately 4 location within the Gwambygine-Edwards Crossing river section. Hydrogeological interpretation of the local landscape is required to select appropriate sites. A 5 year monitoring period is recommended. | **H** | WRC<br>Approx $5000 | GERT and RCS members could assist with monitoring. Link to salinity risk assessment for Gwambygine Pool. |
| ***Action 6.2:*** The Yenyenning Lakes Management Committee be requested to inform downstream landholders of their intentions to release saline water from the lakes. | **H** | GERT/ARMA | Yenyenning Lakes Management Plan is due for review. This issue needs to be considered. |
| **Riparian Zone Vegetation** | | | |
| ***Action 7.1:*** Arrange fencing for areas where stock have access to the river. Financial support for materials from ARMA is recommended. | **H** | GERT/WRC | Link to ***Action 1.5*** |
| ***Action 7.2:*** Arrange natural regeneration trials that include fire, smoked water and soil disturbance to enhance natural regeneration are recommended. | **H** | WRC/GERT<br>Low project costs. | WRC Revegetation Officer should design trial in consultation with landowners and RCS members. Link to Gwambygine Pool Management Plan. |
| ***Action 7.3:*** River-side landowners to regularly survey the riparian zone for infestation of new agricultural weeds. The Recovery Team to arrange systematic eradication of any outbreak. ARMA to arrange assistance as required. | **H** | GERT | Should be reported on annually at Recovery Team meetings. |
| ***Action 7.4:*** Arrange trials for the control of Spiny Rush (*Juncus acutus)* in tributaries adjacent to the Avon River. Sites on Avon Location 0 (Hill) are well suited for trials. | **H** | WRC/GERT<br>Approx. $500. | Liaise with WRC Revegetation Officer and Dr Luke Pen (WRC). Some risk of increased tributary erosion by attempts to eradicate. Need to look at replacement with other species. |

**Implementation Schedule continued overleaf…**

**… Implementation Schedule continued**

| Action | Priority (1) | Responsibility and resources required (2) | Notes |
|---|---|---|---|
| ***Action 7.5:*** Eradicate Bridal Creeper with methods successfully applied in the Avon River at Toodyay. | **H** | GERT/ARMA | |
| **Public Access** | | | |
| Action 8.1: Signage to be erected at the Edwards Crossing reserve that welcomes visitors, provides information about river management and warns about the risk of fires. Further information about the detrimental effect of canoeing on water bird breeding (late spring) and the risk due to river fencing is required. | **M** | ARMA/GERT Approx. $1000 (for all signage) | Similar information required for Reserve 8125. Link to information required for fire risk awareness. |
| **Pollutants** | | | |
| ***Action 9.1:*** The Shires of Beverley and York be advised of the benefit of the 'Drum Muster' program in relation to river management and be requested to locally publicise the risk of agricultural chemicals and other farm rubbish to the river environment. | **M** | GERT | |
| **Heritage Values** | | | |
| ***Action 11.1:*** The Recovery Team initiate and seek funding for an oral/written history of the inter-relatedness between the river and early settlement. | **L** | GERT | Possible to gain small grant from Oral History Unit at Murdoch University. |
| **Education and Awareness** | | | |
| ***Action 17.1:*** Prepare an information sheet that contains a map of this section of the river, the key messages and a summary of the Recovery Plan (Vision, Objectives and Actions for each key Management Issue) for local distribution. | **H** | WRC/GERT Low cost. | Format could be used for annual Recovery Team reporting i.e. progress on completion of actions. |
| ***Action 17.2:*** Signs with key messages be erected where there may be public access (e.g. the reserve at Edwards Crossing). | **H** | ARMA/GERT included in costs for ***Action 8.1***. | |
| **Recovery Team Structure** | | | |
| ***Action 18.1:*** The interim Recovery Team continue on a permanent basis with membership of all landholders and representatives of the River Conservation Society, ARMA and the Water and Rivers Commission meeting at least annually. | **H** | GERT | Arrange reporting procedure to ARMA through ARMA member. |

**(1)** **H** = highest priority, **M** = medium and **L** = lower priority.

**(2)** GERT = Gwambygine-Edwards Crossing Recovery Team
RCS = River Conservation Society Inc.
SoB = Shire of Beverley
SoY = Shire of York
ARMA = Avon River Management Authority
WRC = Water and Rivers Commission
AWG = Avon Working Group
ACN = Avon Catchment Network

# 7 Recovery plan summary

***VISION***

*The Gwambygine–Edwards Crossing Recovery Team has the following vision for river management: The Avon River between Gwambygine Road East and Edwards Crossing) looks well managed as a natural river that has retained its characteristic meanders, remaining pools, vegetation and links with the past. Wildlife breeds and takes refuge there. The river engenders happy memories and inspires hope for the future.Threats to the river ecosystem by sediments, nutrients, salinity, weeds and fire are well understood. The river is fenced to manage stock access. Bed load sediments affecting river pools are controlled and revegetation to combat potential salinity is thriving. Actions for river management are according to voluntary Management Agreements between landholders and the Avon River Management Authority (ARMA).The landscape adjacent to the river is managed in a sustainable way. Risks to the river by new development are minimised through appropriate planning. Adjacent landowners are recognised and supported for their river management effort. The local and broader community also continue to enjoy the Avon River well into the future.*

The ***five objectives*** identified for management through the recovery planning process are:

- To retain the natural attributes and river characteristics where-ever possible
- To understand the processes that have caused the river to deteriorate
- To reduce the risk of further river degradation
- To arrange consistent management of the river between current landholders and land managers, and for future owners or managers
- To communicate good river management to others.

## Actions for Key Management Issues

### River Pools

***Action 1.1:*** Arrange formal recognition of the preferred local names for the river pools (Gwambygine, Oakover, Yangedine and Seaton Ross).

***Action 1.2:*** Implementation of actions proposed in the Gwambygine Pool Management Plan be integrated with this Recovery Plan.

***Action 1.3:*** Measure coarse sediment mobility in the river channel and assess the potential for other coarse sediment to be transported from the Dale River.

***Action 1.4:*** Evaluate lower-cost dredging options if the risk of re-sedimentation of Oakover and Yangedine pools is shown to be low.

***Action 1.5:*** Arrange fencing to exclude stock from the riparian zone of Seaton Ross Pool but allow stock access to the excavated seepage (Location 22).

### *Paspalum* causing increased flood risk

***Action 3.1:*** Arrange monitoring of the colonisation pattern for salt-water couch in the river bed. Detailed site monitoring downstream from Yangedine Pool is suggested.

### Public Access

***Action 8.1:*** Signage to be erected at the Edwards Crossing reserve that welcomes visitors, provides information about river management and warns about the risk of fires. Further information about the detrimental effect of canoeing on water bird breeding (late spring) and the risk due to river fencing is required.

### Fire

***Action 4.1:*** Fuel Reduction Zone to be identified for those human value assets at risk from uncontrolled fire. Cool fuel reduction burns are undertaken in these areas at a frequency in accordance with annual fuel load.

***Action 4.2:*** Information about the risk of fire be regularly disseminated to landholders adjacent to the river and surrounding district, particularly to more densely populated areas.

***Action 4.3:*** Clear signage to outline fire risks and restrictions be erected and maintained at identified camping, picnic or high use areas (particularly at Reserve 8125 and Edwards Crossing).

***Action 4.4:*** The Recovery Team to ensure that all fences transverse to the river have gates suitable for fire control access and that vehicle access along the river is clear and unhindered.

***Action 4.5:*** The Recovery Team take advice from the Chief Fire Control Officers for the Shires of York and Beverley and ARMA for location and installation of additional fire control access.

## Actions for Key Management Issues

### Nutrients

***Action 5.1:*** The Avon Working Group and ARMA be encouraged to develop nutrient loss targets from the Avon River Basin and clearly state 'Best Practice' agriculture to achieve these targets. These bodies, with agricultural industry support should then publicly promote the private efforts within the agricultural industry undertaken to reduce off-site impacts of nutrient loss.

### Salinity

***Action 6.1:*** Install and regularly monitor transects of groundwater wells across the bed and floodplain of the river at approximately 4 locations within the Gwambygine – Edwards Crossing river section. Hydrogeological interpretation of the local landscape is required to select appropriate sites. A 5 year monitoring period is recommended.

***Action 6.2:*** The Yenyenning Lakes Management Committee be requested to inform downstream landholders of their intentions to release saline water from the lakes.

### Riparian Zone Vegetation

***Action 7.1:*** Arrange fencing for areas where stock have access to the river. Financial support for materials from ARMA is recommended.

***Action 7.2:*** Arrange natural regeneration trials that include fire, smoked water and soil disturbance to enhance natural regeneration are recommended.

***Action 7.3:*** River-side landowners to regularly survey the riparian zone for infestation of new agricultural weeds. The Recovery Team to arrange systematic eradication of any outbreak. ARMA to arrange assistance as required.

***Action 7.4:*** Arrange trials for the control of Spiny Rush (*Juncus acutus*) in tributaries adjacent to the Avon River. Sites on Location 0 (Hill) are well suited for trials.

***Action 7.5:*** Eradicate Bridal Creeper with methods successfully applied in the Avon River at Toodyay.

### Education and Awareness

***Action 17.1:*** Prepare an information sheet that contains a map of this section of the river, the key messages and a summary of the Recovery Plan (Vision, Objectives and Actions for each key Management Issue) for local distribution.

***Action 17.2:*** Signs with key messages be erected where there may be public access (e.g. the reserve at Edwards Crossing).

### Recovery Team Structure

***Action 18.1:*** The interim Recovery Team continue on a permanent basis with membership of all landholders and representatives of the River Conservation Society, ARMA and the Water and Rivers Commission meeting at least annually.

# References

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# Appendix one
# Management sections of the Avon River

| Section Name | Section Number | Description | Length (km) |
|---|---|---|---|
| Cobblers Pool | 1 | Upstream from Avon Valley National Park to confluence with Jimperding Brook | 11.23 |
| Deepdale | 2 | Confluence of Jimperding Brook to Crossing of Deepdale Road | 8.14 |
| Toodyay | 3 | Deepdale Road to Goomalling Road Bridge, including all of Toodyay Town upstream of the bridge on the south bank of the river | 9.16 |
| Extracts | 4 | Goomalling Bridge to Glen Avon Weir | 11.3 |
| Katrine | 5 | Glen Avon Weir to Northam Town Weir | 17.45 |
| Northam | 6 | Northam Town Weir to confluence with Spencer's Brook | 10.13 |
| Muresk | 7 | Spencer's Brook to Wilberforce Crossing | 8.75 |
| Wilberforce | 8 | Wilberforce Crossing to Burges Siding | 9.08 |
| York | 9 | Burges Siding to Balladong Road Bridge | 12.05 |
| Cold Harbour | 10 | Balladong Bridge to Gwambygine East Road | 11.40 |
| **Gwambygine** | **11** | **Gwambygine East Road to Oakover Crossing** | **5.83** |
| **Dale River** | **12** | **Oakover Crossing to Edwards Crossing** | **12.09** |
| Beverley | 13 | Top Beverley Road to Beverley-Mawson Road | 6.81 |
| Kokeby | 14 | Beverley-Mawson Road Bridge to confluence with Avon River South Branch | 21.67 |
| Jurakine | 15 | Avon River South Branch to Johnson Road | 5.51 |
| Qualandary Crossing | 16 | Johnson Road to Qualandary Crossing | 12.17 |
| Yenyenning Lakes | 17 | Upstream from Qualandary Crossing | Indeterminate |
| Brookton | 18 | Confluence Avon River South Branch to Brookton Townsite | 18.46 |

# Appendix two
# Major confluences and pools for each section of the Avon River

| Section | Confluences | Pools |
|---|---|---|
| 1 | Julimar Spring (3.0), Mortigup Brook (6.5), Munnapin Brook (8.0), Malkup Brook. | Cobbler (9.0), Long (10.5 - 11.0). |
| 2 | Jimperding Brook (2.5). | Diving (2.5 - 3.0), Deepdale (8.0 - 8.5). |
| 3 | Toodyay Brook (5.0), Boyagerring Brook (8.5). | Nil |
| 4 | Harper Brook (aka Seven Springs) (2.5). | Lloyds (2.0), Millard (3.0 - 5.0). |
| 5 | Mistake Creek (4.0), Wongamine Brook (13.5), Mortlock River (17.5). | Glen Avon (0.5 - 1.5), Katrine (5.5 -6.5), Egoline (7.5 - 8.5). |
| 6 | Spencers Brook (6.10). | Northam (0.5 - 1.0), Burlong (4.3 - 5.0). |
| 7 | Heal Brook (7.0). | Wilberforce (7.5). |
| 8 | Salmon Gully (5.0). | Mackie (3.5 - 4.0), Tipperary (8.5). |
| 9 | Nil | Tipperary (0.5 - 1.0), Meares (3.5), 5 Mile (?), York 1 Mile (9.5), York Town (11.0) |
| 10 | Bland Brook (0.5), Mackie River (6.5). | Mt Hardy (2.5), Cold Harbour (4.0). |
| **11** | **Nil** | **Gwambygine (1.0 - 1.5), Oakover (also known as Fleays) (5.5).** |
| **12** | **Dale River (6.5).** | **Yangedine (aka Avondale or Brouns) (4.5), Seaton Ross (aka Robins) (10.0 - 10.5).** |
| 13 | Nil | Speldhurst (2.0). |
| 14 | Wannering (6.0). | Beverley (0.5), Eyres (6.5 - 7.0). |
| 15 | Turkey Cock Gully (1.5), South and Eastern Branches of the Avon River (5.0), Monjerducking Gully (6.0). | Nil |
| 16 | Bally Bally Gully (6.0). | Nil |
| 17 | Separate assessment | Separate assessment |
| 18 | Mangiding Brook (8.5). | Nil |

**Note:**

**The number in parenthesis refers to the distance (in kilometres) at which the confluence or pool is located from the downstream boundary of each section.**

# Appendix three
# Summary survey information for River Sections 11 and 12

(Information contained in *Avon River Survey Volume 2: Section Condition Summaries and Condition Matrices*, an unpublished report prepared by Ecoscape (Australia) Pty Ltd and Jim Davies and Associates Pty Ltd for the Avon River Management Authority, 1996)

## SUMMARY FOR SECTION 11
## Gwambygine East Road to Oakover (length: 5.83 km)

### I Main overstorey species present

All three overstorey species are present throughout the section, with nearly all sections being dominated by *Casuarina obesa*. Two transect sections were dominated by *Melaleuca rhaphiophylla* (11/1.5 and 11/5.5). *Eucalyptus rudis* was present at all of the transects as a woodland-open forest. At the transects dominated by *Casuarina obesa*, the *Melaleuca rhaphiophylla* was present as a woodland.

### II Vegetation death

There was no significant level of vegetation death observed at any transects in this section.

### III Fencing

The majority of the transects in this section were fenced on both banks (11/0.5, 11/2.0–11/4.0, 11/5.0 and 11/5.5). There were two transects which had fencing present on only one side of the riparian zone (11/1.5 and 11/4.5), and only one transect (11/1.0) which was not fenced on both side of the riparian zone. Most of the fencing present was in a good to medium condition.

### IV Other native species present

The native understorey species present which act to stabilise the rivers' banks are; *Atriplex prostrata, Frankenia pauciflora, Sarcocornia quiqueflora* and *Sporobolus virginicus*. *Juncus pallidus* is also present on the banks. The other species present composing the overstorey are; *Acacia acuminata, A. saligna, Eucalyptus loxophleba* and *Hakea preissii*.

### V Weed species present

Annual grass species were present throughout this section as well as: Tall Fleabane (*Conyza albida*), Stinkwort (*Dittrichia graveolens*), Corn Gromwell (*Buglossoides arvensis*), Soursob (*Oxalis pes-caprae*), Sorrel (*Rumex acetosella*) and an unidentified succulent weed in the *Amaranthaceae* Family. Saltwater couch (*Paspalum vaginatum*) is also present at most of the transects growing on the river banks. With the native understorey species present, this provides increased river bank stability.

### VI Vegetation condition

(according to the 1995 Pen and Scott assessment for the condition of river bank vegetation).

There were three different vegetation conditions in this section, each vegetation condition being assigned to one third of the total transect sections. Transect numbers 11/1.5 to 11/2.5 inclusive were given a vegetation condition of B1–B2, which shows that the understorey vegetation at these transects were comprised of an equal amount of native and weed species. Transect numbers (11/0.5, 11/0.1, 11/4.0 and 11/5.5) were rated as B3-C1 for their vegetation weed species, and there was no surface erosion present.

### VII Regeneration

Both *Eucalyptus rudis* and *Melaleuca rhaphiophylla* had a nil regeneration rate, with only very few transects showing a low regeneration rate for both these species (11/0.5, 11/2.0, 11/2.5, 11/3.5 and 11/4.5). The regeneration of *Casuarina obesa* was the highest of all three of the overstorey species, with the majority of transects having

a medium rate of regeneration (100–500 plants/ha). All of the regenerating individuals at all transects formed mixed aged stands.

### VIII Disturbance factors

There was no disturbance apparent in this section from grazing of the riparian vegetation by livestock. This is possibly due to the presence of fencing in a good condition along the entire section. There was evidence of fire on the right bank at transect number 11/4.0. Transect number 11/4.5 showed evidence of rubbish dumping from a private household onto the bank of a confluence entering the main channel at this point. There was a kangaroo sighted in the riparian zone at transect number 11/3.5.

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## SUMMARY FOR SECTION 12
## Oakover to Top Beverley Road (length: 12.09 km)

### I Main overstorey species present

All three overstorey species are present throughout the section, but *Casuarina obesa* dominates at most of the transects. *Eucalyptus rudis* is present in a woodland at nearly all transects, but at a few (12/0.5, 12/6.5, 12/7.5, 12/8.5, 12/8.5–12/9.5 and 12/11.0) there were no individuals of *E. rudis* present on one or both banks. Transect numbers 12/0.5–12/2.5, 12/3.5, 12/4.0 and 12/5.0–12/8.5 were all dominated by *C. obesa* and only two transects (12/4.5 and 12/11.5) had *Melaleuca rhaphiophylla* as their dominant species.

### II Vegetation death

Approximately one-third of the transects surveyed in this section had a significant level of vegetation death recorded. It was mostly the *Eucalyptus rudis* that was seen to be dead or dying, but there was also death of *Melaleuca rhaphiophylla* and minimal death of *Casuarina obesa* and understorey species. At most of these transects, there was very little regeneration of overstorey species. There transects that showed most death of vegetation were; 12/5.0, 12/6.5, 12/7.0, 12/8.0 and 12/9.0–12/10.5 inclusive.

### III Fencing

Many of the transects in this section were fenced on both side of the riparian zone (12/1.5-12/8.0 inclusive). The rest of the transects either had no fence present at all (12/8.5, 12/9.0, 12/10.0 and 12/10.5) or fencing present on only one side of the riparian vegetation (12/0.5, 12/1.0, 12/9.5, 12/11.0 and 12/11.5). All fencing present was in a good to medium condition.

### IV Other native species present

The native understorey species present which stabilise the rivers' banks are: *Atriplex prostrata, Frankenia pauciflora, Sarcocornia quinqueflora* and *Sporobolus virginicus. Juncus pallidus* is also present amongst the riparian vegetation. The other species present composing the overstorey are; *Acacia acuminata, A. saligna, Eucalyptus loxophleba* and *Hakea preissii*.

### V Weed species present

Annual grass species were present throughout this section as well as: Blowfly Grass (*Briza maxima*), Tall Fleabane (*Conyza albida*), Stinkwort (*Dittrichia graveolens*), Spiny Rush (*Juncus acutus*), Soursob (*Oxalis pes-caprae*), Corn Cromwell (*Buglossoides arvensis*), Sorrel (*Rumex acetosella*) and an unidentified succulent weed in the Amaranthaceae Family. Saltwater couch (*Paspalum vaginatum*) is also present at most of the transects, growing on the river banks. With the native understorey species present, this provides increased river bank stability.

### VI Vegetation condition

(according to the 1995 Pen and Scott assessment for the condition of river bank vegetation).

Transect numbers 12/1.0-12/2.0, 12/4.5, 12/5.0, 12/6.0, 12/6.5 and 12/8.5 were given a vegetation condition rating of B2-B3 indicating that the understorey vegetation was chiefly comprised of weeds (very little native species) and there was no surface erosion present. The remaining transects (12/8.0, 12/9.0, 12/10.0, 12/11.0 and 12/11.5) were given a vegetation condition rating of C1–C2, indicating that all understorey species were weeds and there was some exposed soil due to surface erosion.

## VII Regeneration

*Eucalyptus rudis* had mostly a nil regeneration rate at all the transects. There were only a few transects which showed a low regeneration rate for this species (12/1.0, 12/1.5, 12/3.0, 12/3.5, 12/4.5, 12/6.5, 12/7.0 and 12/11.5). *Melaleuca rhaphiophylla* had a low rate of regeneration over all the transect (1–100 plants/ha). *Casuarina obesa* again was seen to have the highest rate of regeneration of all three overstorey species. It was classed as having a medium to high rate of regeneration (100 – 500 plants/ha to 500 –1000 plants/ha). All regenerating individuals at all transects formed mixed aged stands, except for an even aged stand of *C. obesa* at transects 12/1.0 and 12/5.0.

## VIII Disturbance factors

Approximately half of the transects in this section showed evidence of livestock in the river and grazing of the riparian vegetation. These were transect numbers 12/4.5, 12/5.0, 12/6.5 –12/10.0 and 12/11.0. Livestock present in the river were both cattle and sheep. Presence of feral animals was observed at some of the transects in this section. At transect number 12/2.0 there was evidence of rabbits (a rabbit warren). There was no rubbish dumping, service corridors or evidence of fire in this section.

# Appendix four
# Summary of streamflow records for Broun's Farm gauging station

## Brouns Farm wq statistics

| **Reference** (bold text)/ Variable | Variable Id | Unit | Minimum | Maximum | Average | No. of readings | First reading | Last Reading |
|---|---|---|---|---|---|---|---|---|
| **615014** | | | | | | | | |
| Acidity ($CaCO_3$) | 287 | mg/L | 2.273 | 6.818 | 4.545 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| Al (tot) | 29 | mg/L | 0.050 | 0.680 | 0.353 | 6 | 15 Jun 1995 | 02 Feb 2000 |
| Alkalinity ($CO_3$) | 154 | mg/L | 1.000 | 1.000 | 1.000 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| Alkalinity ($HCO_3$) | 277 | mg/L | 39.000 | 120.000 | 70.000 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| Alkalinity total $CaCO_3$ | 23 | mg/L | 18.000 | 260.000 | 148.206 | 70 | 09 Jun 1976 | 11 Nov 1998 |
| Analysis completion date | 1256 | ddmmmyyyy | | | | 0 | 24 Mar 1976 | 02 Feb 1999 |
| As (sol) | 340 | mg/L | 0.000 | 0.000 | 0.000 | 1 | 04 Dec 1995 | 04 Dec 1995 |
| BOD | 25 | mg/L | 5.000 | 5.000 | 5.000 | 1 | 31 May 1994 | 31 May 1994 |
| Batch number | 1255 | (none) | 6055.000 | 29732.000 | 21396.255 | 1517 | 24 Mar 1976 | 02 Feb 1999 |
| CDO | 27 | mg/L | 6.710 | 23.000 | 13.961 | 17 | 20 Jun 1994 | 02 Feb 2000 |
| $CO_3$ (sol) | 332 | mg/L | 0.000 | 12.000 | 1.135 | 37 | 06 Aug 1980 | 25 Aug 1988 |
| Ca (sol) | 353 | mg/L | 41.000 | 221.000 | 137.744 | 43 | 06 Aug 1980 | 02 Feb 2000 |
| Cl (sol) | 284 | mg/L | 982.000 | 9325.898 | 4705.800 | 299 | 24 Mar 1976 | 02 Feb 2000 |
| Colour (TCU) | 20 | (none) | 29.000 | 140.000 | 82.000 | 8 | 20 May 1999 | 18 Feb 2000 |
| Colour (hazen) | 1059 | Hu | 25.000 | 100.000 | 51.600 | 20 | 30 Aug 1977 | 12 Oct 1986 |
| Colour (true) | 1181 | Hu | 5.000 | 150.000 | 48.865 | 275 | 09 Jun 1976 | 02 Feb 1999 |
| Cond calc 25 deg C | 21 | µS/m | 954000.062 | 1791000.000 | 1266750.031 | 4 | 21 Nov 1994 | 20 Jun 1996 |
| Cond uncomp (in situ) | 1165 | µS/m | 415000.000 | 2430000.000 | 1101526.230 | 103 | 28 Sep 1983 | 17 Oct 2000 |
| Cond uncomp (lab) | 1163 | µS/m | 259000.000 | 4560000.000 | 1325777.208 | 1518 | 24 Mar 1976 | 18 Feb 2000 |
| Date sample received | 1257 | ddmmmyyyy | | | | 0 | 05 May 1992 | 02 Feb 1999 |
| Discharge rate | 1271 | $m^3/s$ | 10.107 | 10.107 | 10.107 | 1 | 13 Aug 1979 | 13 Aug 1979 |
| Fe (tot) | 38 | mg/L | 0.140 | 0.680 | 0.336 | 13 | 05 May 1992 | 18 Feb 2000 |
| **615014** | | | | | | | | |
| Groundwater level (SLE) | 1307 | m | 10.793 | 10.840 | 10.817 | 2 | 12 Jul 1995 | 20 Jun 1996 |
| $HCO_3$ (sol) | 333 | mg/L | 52.000 | 302.000 | 174.378 | 37 | 06 Aug 1980 | 25 Aug 1988 |
| Hardness (tot) | 278 | mg/L | 66.000 | 3650.000 | 1898.994 | 70 | 09 Jun 1976 | 11 Nov 1998 |
| K (sol) | 354 | mg/L | 9.000 | 22.000 | 17.000 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| K (tot) | 40 | mg/L | 7.000 | 31.000 | 19.325 | 40 | 06 Aug 1980 | 11 Nov 1998 |
| Lab analysis number | 1264 | (none) | 205897.000 | 9602644.000 | 1061494.943 | 140 | 05 May 1992 | 02 Feb 1999 |
| Mg (sol) | 356 | mg/L | 91.000 | 542.000 | 339.744 | 43 | 06 Aug 1980 | 02 Feb 2000 |
| Mn (tot) | 43 | mg/L | 0.033 | 0.260 | 0.099 | 13 | 05 May 1992 | 18 Feb 2000 |
| N (ox sol) | 1024 | mg/L | 0.002 | 1.187 | 0.595 | 2 | 20 May 1999 | 02 Jun 1999 |
| N (tot kjeldahl) | 5 | mg/L | 0.648 | 3.100 | 1.210 | 62 | 31 May 1994 | 02 Jun 1999 |

**Continued overleaf ...**

**... continued**

| **Reference** (bold text)/ Variable | Variable Id | Unit | Minimum | Maximum | Average | No. of readings | First reading | Last Reading |
|---|---|---|---|---|---|---|---|---|
| N (tot ox) | 4 | mg/L | 0.002 | 3.400 | 0.272 | 61 | 31 May 1994 | 02 Feb 1999 |
| N (tot) | 6 | mg/L | 0.648 | 5.314 | 1.401 | 72 | 30 Jun 1994 | 17 Oct 2000 |
| $NH_3$-N/$NH_4$-N (sol) | 582 | mg/L | 0.005 | 0.650 | 0.061 | 47 | 31 May 1994 | 23 Jul 1998 |
| $NO_2$-N (sol) | 2 | mg/L | 0.005 | 0.034 | 0.014 | 6 | 23 May 1995 | 23 Jul 1998 |
| $NO_3$ (sol) | 467 | mg/L | 1.000 | 19.000 | 4.405 | 37 | 06 Aug 1980 | 25 Aug 1988 |
| $NO_3$-N (sol) | 3 | mg/L | 0.200 | 1.400 | 0.600 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| Na (sol) | 357 | mg/L | 464.000 | 3530.000 | 2109.395 | 43 | 06 Aug 1980 | 02 Feb 2000 |
| O - DO (in situ) | 1033 | mg/L | 3.700 | 14.300 | 8.680 | 15 | 20 Jul 1999 | 17 Oct 2000 |
| O Do | 63 | mg/L | 3.500 | 10.400 | 8.313 | 8 | 23 Jun 1997 | 02 Feb 1999 |
| O Do % | 62 | % | 107.000 | 107.000 | 107.000 | 1 | 17 Sep 1998 | 17 Sep 1998 |
| P (tot) | 8 | mg/L | 0.012 | 0.290 | 0.049 | 79 | 31 May 1994 | 17 Oct 2000 |
| P total soluble | 1176 | mg/L | 0.017 | 0.017 | 0.017 | 1 | 15 Aug 1997 | 15 Aug 1997 |
| **615014** | | | | | | | | |
| $PO_4$-p (sol) | 179 | mg/L | 0.001 | 0.050 | 0.011 | 45 | 09 Jun 1994 | 23 Jul 1998 |
| S (tot) | 158 | mg/L | 88.200 | 147.000 | 124.400 | 3 | 15 Jun 1995 | 11 Nov 1998 |
| $SO_4$ (sol) | 50 | mg/L | 180.000 | 320.000 | 266.667 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| $SO_4$ (tot) | 541 | mg/L | 100.000 | 776.000 | 368.081 | 37 | 06 Aug 1980 | 25 Aug 1988 |
| Si (sol) | 1045 | mg/L | 1.100 | 3.300 | 2.033 | 3 | 05 Nov 1999 | 02 Feb 2000 |
| $SiO_2$ reactive (sol) | 14 | mg/L | 3.000 | 13.000 | 8.263 | 40 | 06 Aug 1980 | 11 Nov 1998 |
| Static water level | 1053 | m | 6.607 | 7.328 | 6.915 | 3 | 20 Jul 1999 | 09 Nov 1999 |
| Suspended solids (EDI) | 1154 | mg/L | 11.140 | 82.560 | 42.800 | 9 | 18 Jun 1976 | 25 Aug 1977 |
| Suspended solids (ETR) | 1155 | mg/L | 7.550 | 23.830 | 15.217 | 8 | 10 Aug 1976 | 27 Sep 1976 |
| Suspended solids (gulp) | 1156 | mg/L | 110.000 | 110.000 | 110.000 | 1 | 31 May 1994 | 31 May 1994 |
| Suspended solids (pump) | 1157 | mg/L | 2.200 | 268.300 | 8.969 | 110 | 06 Sep 1976 | 03 Sep 1980 |
| Suspended solids < 63u (EDI) | 1149 | mg/L | 5.000 | 457.000 | 62.907 | 27 | 19 May 1978 | 22 Jan 1982 |
| Suspended solids < 63u (ETR) | 1150 | mg/L | 8.860 | 1608.000 | 189.924 | 16 | 23 Jun 1980 | 25 Jan 1982 |
| Suspended solids < 63u (gulp) | 1151 | mg/L | 4.230 | 261.650 | 46.131 | 25 | 22 Aug 1977 | 01 Aug 1986 |
| Suspended solids < 63u (pump) | 1159 | mg/L | 1.380 | 1168.900 | 27.740 | 925 | 04 Jul 1977 | 30 Jul 1987 |
| Suspended solids > 63u (EDI) | 1160 | mg/L | 0.600 | 49.300 | 9.019 | 27 | 19 May 1978 | 22 Jan 1982 |
| Suspended solids > 63u (ETR) | 1158 | mg/L | 0.440 | 363.000 | 38.348 | 16 | 23 Jun 1980 | 25 Jan 1982 |
| Suspended solids > 63u (gulp) | 1152 | mg/L | 0.810 | 8.170 | 2.940 | 11 | 19 May 1978 | 26 Sep 1978 |
| Suspended solids > 63u (pump) | 1153 | mg/L | 0.110 | 2.050 | 0.963 | 9 | 19 May 1978 | 01 Oct 1981 |
| TDSalts (sum of ions) | 1218 | mg/L | 1759.000 | 11807.000 | 7480.676 | 37 | 06 Aug 1980 | 25 Aug 1988 |
| TDSolids (calc @180°C-by cond) | 1222 | mg/L | 3264.000 | 13108.000 | 7559.933 | 30 | 09 Jun 1976 | 03 Sep 1980 |
| TSS | 16 | mg/L | 2.000 | 31.000 | 13.692 | 13 | 17 Aug 1999 | 17 Oct 2000 |
| **615014** | | | | | | | | |
| Transaction number | 1241 | (none) | 82365.000 | 1998307.000 | 1935842.469 | 226 | 24 Mar 1976 | 14 Oct 1998 |
| Turbidity | 64 | NTU | 0.290 | 325.000 | 12.122 | 889 | 17 Aug 1976 | 23 May 2000 |
| Turbidity (JCU) | 1193 | JTU | 0.320 | 25.000 | 22.620 | 31 | 09 Jun 1976 | 03 Sep 1980 |
| Water level (SLE) | 1275 | m | 9.766 | 13.039 | 10.299 | 520 | 24 Mar 1976 | 17 Oct 2000 |
| Water level status | 1316 | (none) | | | | 0 | 10 Aug 1977 | 17 Oct 2000 |
| Water temperature (in situ) | 59 | deg C | 7.900 | 32.800 | 16.334 | 376 | 24 Mar 1976 | 17 Oct 2000 |
| Water temperature (test) | 1166 | deg C | 15.000 | 26.600 | 24.376 | 1520 | 24 Mar 1976 | 18 Feb 2000 |
| pH | 22 | (none) | 6.500 | 8.900 | 7.772 | 260 | 09 Jun 1976 | 18 Feb 2000 |
| pH (in situ) | 1168 | (none) | 4.500 | 9.300 | 8.022 | 23 | 31 Oct 1984 | 17 Oct 2000 |

# Brouns Farm nutrient data

**AVON RIVER — BROUNS FARM 615014**

| Collected date | N (ox sol) mg/L | N (tot kjeld) mg/L | N (tot ox) mg/L | N (tot) mg/L | $NH_3$-N/ $NH_4$-N (sol) mg/L | $NO_2$-N (sol) mg/L | $NO_3$ (sol) mg/L | $NO_3$-N (sol) mg/L | Na (sol) mg/L | O - DO (in situ) mg/L | O Do mg/L | P (tot) mg/L | P total soluble mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13:03 06.08.1980 | | | | | | | 1.000 | | 2520.000 | | | | |
| 15:16 20.05.1981 | | | | | | | 3.000 | | 2190.000 | | | | |
| 14:31 27.05.1981 | | | | | | | 18.000 | | 2440.000 | | | | |
| 12:38 05.06.1981 | | | | | | | 19.000 | | 1720.000 | | | | |
| 17:01 23.07.1981 | | | | | | | 9.000 | | 610.000 | | | | |
| 13:10 26.08.1981 | | | | | | | 2.000 | | 3320.000 | | | | |
| 14:14 22.01.1982 | | | | | | | 11.000 | | 464.000 | | | | |
| 11:48 04.06.1982 | | | | | | | 1.000 | | 1600.000 | | | | |
| 09:00 09.06.1982 | | | | | | | 5.000 | | 1650.000 | | | | |
| 09:00 10.06.1982 | | | | | | | 7.000 | | 2820.000 | | | | |
| 09:02 21.06.1982 | | | | | | | 5.000 | | 3190.000 | | | | |
| 09:05 24.06.1982 | | | | | | | 8.000 | | 3100.000 | | | | |
| 13:23 08.07.1982 | | | | | | | 2.000 | | 2910.000 | | | | |
| 09:26 15.07.1982 | | | | | | | 3.000 | | 3210.000 | | | | |
| 09:31 20.07.1982 | | | | | | | 3.000 | | 2760.000 | | | | |
| 11:59 21.07.1982 | | | | | | | 3.000 | | 2160.000 | | | | |
| 09:00 22.07.1982 | | | | | | | 5.000 | | 1970.000 | | | | |
| 09:11 30.07.1982 | | | | | | | 4.000 | | 2610.000 | | | | |
| 09:13 31.07.1982 | | | | | | | 4.000 | | 2580.000 | | | | |
| 09:25 09.08.1982 | | | | | | | 5.000 | | 1670.000 | | | | |
| 12:26 11.08.1982 | | | | | | | 4.000 | | 2270.000 | | | | |
| 09:39 18.08.1982 | | | | | | | 3.000 | | 2490.000 | | | | |
| 09:40 19.08.1982 | | | | | | | 4.000 | | 2150.000 | | | | |
| 09:42 20.08.1982 | | | | | | | 4.000 | | 2650.000 | | | | |
| 09:43 21.08.1982 | | | | | | | 3.000 | | 2040.000 | | | | |
| 09:48 24.08.1982 | | | | | | | 4.000 | | 1910.000 | | | | |
| 09:55 28.08.1982 | | | | | | | 3.000 | | 2300.000 | | | | |
| 12:42 30.08.1982 | | | | | | | 1.000 | | 2500.000 | | | | |
| 14:08 16.09.1982 | | | | | | | 2.000 | | 1940.000 | | | | |
| 13:09 02.08.1983 | | | | | | | 3.000 | | 1200.000 | | | | |
| 16:01 18.08.1983 | | | | | | | 2.000 | | 1320.000 | | | | |
| 12:48 10.11.1983 | | | | | | | 1.000 | | 3530.000 | | | | |
| 15:33 30.11.1983 | | | | | | | 1.000 | | 2800.000 | | | | |
| 10:30 01.08.1985 | | | | | | | 3.000 | | 1820.000 | | | | |
| 15:18 24.02.1986 | | | | | | | 4.000 | | 2140.000 | | | | |
| 15:53 15.07.1986 | | | | | | | 2.000 | | 1070.000 | | | | |
| 12:07 25.08.1988 | | | | | | | 1.000 | | 1170.000 | | | | |
| 09:15 31.05.1994 | | 2.200 | 0.800 | | 0.650 | | | | | | | 0.200 | |
| 10:39 09.06.1994 | | 2.500 | 0.610 | | 0.200 | | | | | | | 0.100 | |
| 11:50 20.06.1994 | | 1.200 | 0.050 | | 0.050 | | | | | | | 0.050 | |
| 10:30 30.06.1994 | | 1.900 | 0.266 | 2.166 | 0.015 | | | | | | | 0.070 | |
| 11:00 10.08.1994 | | 1.140 | 0.040 | 1.180 | 0.012 | | | | | | | 0.033 | |
| 12:00 14.09.1994 | | 1.100 | 0.021 | 1.121 | 0.010 | | | | | | | 0.046 | |
| 09:17 27.09.1994 | | 1.020 | 0.011 | 1.031 | 0.034 | | | | | | | 0.039 | |
| 09:15 04.10.1994 | | 0.993 | 0.010 | 1.003 | 0.081 | | | | | | | 0.039 | |
| 15:40 12.10.1994 | | 1.120 | 0.036 | 1.156 | 0.005 | | | | | | | 0.039 | |
| 11:10 24.10.1994 | | 1.440 | 0.018 | 1.458 | 0.015 | | | | | | | 0.048 | |
| 10:30 31.10.1994 | | 0.927 | 0.052 | 0.980 | 0.016 | | | | | | | 0.044 | |
| 12:10 07.11.1994 | | 0.814 | 0.002 | | 0.017 | | | | | | | 0.033 | |
| 10:05 14.11.1994 | | 0.778 | 0.006 | 0.784 | 0.011 | | | | | | | 0.031 | |
| 09:55 21.11.1994 | | 0.987 | 0.043 | 1.030 | 0.024 | | | | | | | 0.050 | |
| 09:51 28.11.1994 | | 0.987 | 0.018 | 1.005 | | | | | | | | 0.035 | |
| 11:30 05.12.1994 | | 1.170 | 0.016 | 1.186 | 0.013 | | | | | | | 0.035 | |

**Continued overleaf ...**

**... continued**

| Collected date | N (ox sol) mg/L | N (tot kjeld) mg/L | N (tot ox) mg/L | N (tot) mg/L | $NH_3$-N/ $NH_4$-N (sol) mg/L | $NO_2$-N (sol) mg/L | $NO_3$ (sol) mg/L | $NO_3$-N (sol) mg/L | Na (sol) mg/L | O - DO (in situ) mg/L | O Do mg/L | P (tot) mg/L | P total soluble mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10:25 15.05.1995 | | 2.100 | 0.330 | | 0.570 | | | | | | | 0.120 | |
| 12:22 23.05.1995 | | 1.040 | 0.155 | 1.195 | 0.035 | 0.010 | | | | | | 0.043 | |
| 09:31 29.05.1995 | | 1.345 | 0.426 | 1.772 | 0.079 | 0.034 | | | | | | 0.052 | |
| 10:15 07.06.1995 | | 0.959 | 0.060 | 1.019 | 0.076 | | | | | | | 0.035 | |
| 09:28 12.06.1995 | | 1.590 | 2.049 | 3.639 | 0.269 | | | | | | | 0.085 | |
| 12:48 15.06.1995 | | | 1.870 | | | | | | 1870.000 | | | | |
| 11:49 12.07.1995 | | 1.430 | 0.530 | | 0.060 | | | | | | | 0.170 | |
| 12:00 17.07.1995 | | 1.400 | 0.835 | 2.235 | 0.082 | | | | | | | 0.048 | |
| 10:30 24.07.1995 | | 1.429 | 1.109 | 2.538 | 0.035 | | | | | | | 0.069 | |
| 09:47 07.08.1995 | | 1.345 | 0.261 | 1.606 | 0.025 | | | | | | | 0.042 | |
| 09:40 14.08.1995 | | 1.231 | 0.159 | 1.390 | 0.028 | | | | | | | 0.071 | |
| 09:54 21.08.1995 | | 1.294 | 0.010 | 1.304 | 0.014 | | | | | | | 0.039 | |
| 09:49 28.08.1995 | | 1.180 | 0.194 | 1.375 | 0.066 | | | | | | | 0.029 | |
| 12:00 04.09.1995 | | 1.010 | 0.019 | 1.029 | 0.019 | | | | | | | 0.022 | |
| 10:05 13.09.1995 | | 1.160 | 0.011 | 1.171 | 0.013 | | | | | | | 0.055 | |
| 10:16 18.09.1995 | | 1.110 | 0.019 | 1.129 | 0.013 | | | | | | | 0.037 | |
| 11:43 25.09.1995 | | 0.973 | 0.019 | 0.992 | 0.022 | | | | | | | 0.016 | |
| 10:41 03.10.1995 | | 1.730 | 0.069 | 1.799 | 0.034 | | | | | | | 0.017 | |
| 09:36 09.10.1995 | | 0.777 | 0.050 | 0.827 | 0.019 | | | | | | | 0.026 | |
| 12:44 16.10.1995 | | 1.043 | 0.011 | 1.054 | 0.007 | | | | | | | 0.031 | |
| 08:24 25.10.1995 | | 1.268 | 0.018 | 1.287 | 0.005 | | | | | | | 0.052 | |
| 08:23 31.10.1995 | | 1.240 | 0.022 | 1.262 | 0.005 | | | | | | | 0.012 | |
| 11:30 06.11.1995 | | 1.219 | 0.011 | 1.230 | 0.008 | | | | | | | 0.046 | |
| 11:39 14.11.1995 | | 0.959 | 0.140 | 1.099 | 0.014 | | | | | | | 0.037 | |
| 08:42 21.11.1995 | | 0.999 | 0.010 | 1.009 | 0.010 | | | | | | | 0.042 | |
| 08:27 28.11.1995 | | 0.985 | 0.023 | 1.008 | 0.016 | | | | | | | 0.040 | |
| 11:14 04.12.1995 | | 1.102 | 0.017 | 1.119 | 0.005 | | | | | | | 0.026 | |
| 10:22 12.12.1995 | | 1.065 | 0.050 | 1.115 | 0.041 | | | | | | | 0.026 | |
| 16:00 20.06.1996 | | 3.100 | 1.970 | | | | | | | | | 0.290 | |
| 11:45 26.06.1996 | | 1.914 | 3.400 | 5.314 | | | | | | | | 0.080 | |
| 11:15 23.06.1997 | | 0.847 | 0.050 | 0.847 | | | | | | | 8.600 | 0.019 | |
| 14:45 18.07.1997 | | 0.732 | 0.003 | 0.735 | | | | | | | 10.400 | 0.018 | |
| 14:14 06.08.1997 | | 1.089 | 0.050 | 1.089 | | | | | | | | 0.063 | |
| 14:40 15.08.1997 | | 0.942 | 0.315 | 1.257 | 0.013 | | | | | | 5.600 | 0.038 | 0.017 |
| 10:35 12.09.1997 | | 0.910 | 0.025 | 0.935 | 0.036 | 0.005 | | | | | 3.500 | 0.033 | |
| 11:35 10.10.1997 | | 0.889 | 0.032 | 0.922 | 0.032 | 0.011 | | | | | | 0.035 | |
| 09:30 06.11.1997 | | 1.226 | 0.044 | 1.270 | 0.060 | 0.015 | | | | | | 0.055 | |
| 08:00 22.04.1998 | | 0.732 | 0.008 | 0.740 | | | | | | | | 0.029 | |
| 16:45 23.07.1998 | | 0.697 | 0.112 | 0.809 | 0.013 | 0.006 | | | 2440.000 | | | 0.027 | |
| 15:15 18.08.1998 | | 0.963 | 0.006 | 0.970 | | | | | | | 9.800 | 0.023 | |
| 14:43 26.08.1998 | | 0.872 | 0.010 | 0.882 | | | | | | | 10.100 | 0.032 | |
| 13:20 17.09.1998 | | 1.236 | 0.010 | 1.246 | | | | | | | | 0.036 | |
| 16:00 14.10.1998 | | 0.861 | 0.008 | 0.869 | | | | | | | | 0.023 | |
| 13:45 11.11.1998 | | 0.732 | 0.050 | 0.732 | | | | | 1700.000 | | 8.900 | 0.032 | |
| 12:11 02.02.1999 | | 1.688 | 0.029 | 1.717 | | | | | | | 9.600 | 0.036 | |
| 14:56 20.05.1999 | 0.002 | 0.648 | | 0.648 | | | | | | | | 0.023 | |
| 12:07 02.06.1999 | 1.187 | 1.712 | | 2.899 | | | | | | | | 0.068 | |
| 13:04 20.07.1999 | | | | 3.200 | | | | | | 10.700 | | 0.032 | |
| 12:37 17.08.1999 | | | | 1.200 | | | | | | 10.300 | | 0.021 | |
| 13:00 02.09.1999 | | | | 1.200 | | | | | | 9.700 | | 0.050 | |
| 13:31 14.09.1999 | | | | 1.100 | | | | | | 9.800 | | 0.030 | |
| 12:20 14.10.1999 | | | | 0.930 | | | | | | | | 0.024 | |
| 10:55 05.11.1999 | | | | | | | | 0.200 | 1200.000 | 6.500 | | | |
| 13:45 09.11.1999 | | | | 1.100 | | | | | | 8.800 | | 0.030 | |
| 12:55 07.12.1999 | | | | 1.100 | | | | | | | | 0.027 | |
| 12:20 05.01.2000 | | | | 1.800 | | | | | | 14.300 | | 0.054 | |
| 13:40 27.01.2000 | | | | 3.100 | | | | 1.400 | 1300.000 | 3.700 | | 0.077 | |
| 12:55 02.02.2000 | | | | 2.100 | | | | 0.200 | 1400.000 | | | 0.057 | |
| 18:55 02.02.2000 | | | | | | | | | | 4.000 | | | |
| 16:00 18.02.2000 | | | | 1.700 | | | | | | 6.400 | | 0.078 | |
| 12:35 29.02.2000 | | | | 2.300 | | | | | | 8.900 | | 0.100 | |
| 12:40 30.03.2000 | | | | 1.800 | | | | | | 12.100 | | 0.046 | |
| 13:30 26.04.2000 | | | | 1.700 | | | | | | 8.600 | | 0.050 | |
| 13:58 23.05.2000 | | | | 0.930 | | | | | | | | 0.014 | |
| 12:20 12.07.2000 | | | | 1.600 | | | | | | 10.400 | | 0.014 | |
| 11:50 17.10.2000 | | | | 0.820 | | | | | | 6.000 | | 0.012 | |

# Brouns Farm monthly flow

**Water and Rivers Commission** **HYMONTH V60 Output 17.10.2001**

**Station 615014 AVON RIVER — BROUNS FARM Station 615014**
**Var from 10.00 STAGE — SL in metres**
**Var to 140.00 Mean Stream discharge in cubic metres/second**
**Figures are for period ending 2400 hours.**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean monthly | Median monthly | Missing days | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0.000 | 0.005 | 0.000 | 0.026 | 0.067 | 0.844" | 1.990" | 1.236" | 0.369" | 0.800 | 0.144 | 0.002 | 0.457" | 0.106" | 0 | 1980 |
| 1981 | 0.000 | 0.117 | 0.013 | 0.036 | 5.231 | 20.17 | 13.62' | 21.98 | 2.891 | 0.360 | 0.691 | 0.020 | 5.428' | 0.525' | 0 | 1981 |
| 1982 | 2.952 | 0.102 | 0.012 | 0.015 | 0.090 | 1.165 | 2.077 | 4.074 | 2.174 | 0.711 | 0.539 | 0.054 | 1.164 | 0.625 | 0 | 1982 |
| 1983 | 0.000 | 0.000 | 0.000 | 0.007 | 0.048 | 17.32 | 70.50 | 34.16 | 31.45 | 1.469 | 1.071 | 0.091 | 13.01 | 0.581 | 0 | 1983 |
| 1984 | 0.319 | 0.000 | 0.059 | 0.260 | 5.719 | 4.873 | 5.611 | 5.896 | 8.702 | 0.743 | 0.256 | 0.021 | 2.705 | 0.531 | 0 | 1984 |
| 1985 | 0.004 | 0.000 | 0.008 | 0.067 | 0.069 | 0.340 | 3.819 | 5.917 | 1.619 | 0.295 | 0.145 | 0.010 | 1.024 | 0.107 | 0 | 1985 |
| 1986 | 0.000 | 1.136 | 0.151" | 0.032" | 0.545 | 10.88 | 9.660 | 14.42 | 2.343 | 0.417 | 0.159 | 0.008 | 3.313" | 0.481" | 0 | 1986 |
| 1987 | 0.000 | 0.000 | 0.000 | 0.052 | 0.474 | 1.049 | 4.882 | 5.200 | 1.231 | 0.300 | 0.055 | 0.006 | 1.104 | 0.178 | 0 | 1987 |
| 1988 | 0.000 | 0.000 | 0.000 | 0.085 | 0.530 | 6.133 | 12.38 | 9.392 | 2.619 | 1.751 | 0.069 | 0.560 | 2.794 | 0.545 | 0 | 1988 |
| 1989 | 0.006 | 0.005 | 0.003 | 0.011 | 0.660 | 3.417 | 21.98 | 4.712 | 1.325 | 0.359 | 0.075 | 0.002 | 2.714 | 0.217 | 0 | 1989 |
| 1990 | 7.379 | 20.74 | 2.225 | 1.274 | 1.366 | 1.219 | 7.444 | 5.026 | 1.146 | 0.367 | 0.041 | 0.003 | 4.020 | 1.320 | 0 | 1990 |
| 1991 | 0.002' | 0.003' | 0.001 | 0.009 | 0.021 | 1.855 | 8.338 | 11.76 | 2.424 | 0.223 | 0.050 | 0.002 | 2.057' | 0.036' | 0 | 1991 |
| 1992 | 0.000 | 0.010 | 0.045 | 0.590 | 0.076 | 4.844 | 10.34 | 20.58 | 32.31' | 7.455 | 0.155 | 0.008 | 6.369' | 0.373' | 0 | 1992 |
| 1993 | 0.001 | 0.176 | 0.669 | 0.182 | 0.574 | 2.266 | 4.711 | 7.237 | 4.595 | 0.607 | 0.224 | 0.002 | 1.770 | 0.590 | 0 | 1993 |
| 1994 | 0.000 | 0.000 | 0.000 | 0.004 | 0.540 | 4.101' | 7.349 | 6.102' | 1.414' | 0.087 | 0.003 | 0.000 | 1.633' | 0.045' | 0 | 1994 |
| 1995 | 0.000 | 0.000 | 0.000 | 0.004 | 0.169 | 3.229 | 17.10 | 7.287 | 2.683 | 2.897 | 0.078 | 0.004 | 2.788 | 0.124 | 0 | 1995 |
| 1996 | 0.000 | 0.000 | 0.000 | 0.002 | 0.008 | 6.917 | 48.95 | 28.72 | 4.991 | 1.140 | 1.103 | 0.019 | 7.655 | 0.561 | 0 | 1996 |
| 1997 | 0.001 | 0.011 | 0.742 | 1.088 | 0.215 | 1.208 | 1.584 | 5.525 | 5.278 | 0.414 | 0.025 | 0.006 | 1.341 | 0.578 | 0 | 1997 |
| 1998 | 0.000 | 0.000 | 0.003 | 0.014 | 0.084 | 2.475* | 4.098 | 8.207* | 10.00 * | 0.767 | 0.033 | 0.008 | 2.141* | 0.058* | 0 | 1998 |
| 1999 | 0.007 | 0.001 | 0.006 | 0.012 | 1.339" | 8.467" | 22.73 | 16.28 | 11.66 | 5.088 | 0.251 | 0.576* | 5.535* | 0.958* | 0 | 1999 |
| 2000 | 47.21* | 43.70* | 4.845 | 0.094 | 0.140 | 1.302 | 11.36 | 5.841 | 5.364 | 0.145 | 0.021 | 0.004 | 10.00 * | 3.074* | 0 | 2000 |
| 2001 | 0.000 | 0.003 | 0.005 | [0.010] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [0.004] | [0.004] | 252 | 2001 |
| | | | | | | | | | | | | | | | 252 | **Total** |
| **Mean** | 2.631* | 3.001* | 0.399" | [0.176] | 0.855" | 4.956* | 13.83" | 10.93 * | 6.505* | 1.257 | 0.247 | 0.067* | [3.592] | | | **Mean** |
| **Med** | 0.000* | 0.003* | 0.005" | [0.029] | 0.215" | 3.229* | 8.338" | 7.237* | 2.683* | 0.607 | 0.144 | 0.008* | | [0.350] | | **Med** |
| **Max** | 47.21* | 43.70 * | 4.845" | [1.274] | 5.719" | 20.17* | 70.50" | 34.16* | 32.31* | 7.455 | 1.103 | 0.576* | [13.01 ] | | | **Max** |
| **Min** | 0.000* | 0.000* | 0.000" | [0.002] | 0.008" | 0.340* | 1.584" | 1.236* | 0.369* | 0.087 | 0.003 | 0.000* | [0.004] | | | **Min** |
| **OK** | 100% | 100% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | | | **OK** |
| **Cnt** | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 22 | | | **Cnt** |

**NOTES**

All recorded data is continuous and reliable except where the following tags are used:

" ... Good record — Corrections/Estimations a

' ... Very good record — Corrections applied

* ... Estimated record

[ ... Not available

**Water and Rivers Commission** **HYMONTH V60 Output 17.10.2001**

**Station 615014 AVON RIVER — BROUNS FARM Station 615014**
**Var from 10.00 STAGE — SL in metres**
**Var to 140.00 Mean Stream discharge in cubic metres/second**
**Figures are for period ending 2400 hours.**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual max | Missing days | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0.000 | 0.126 | 0.005 | 0.226 | 0.509 | 4.992" | 6.001" | 2.275" | 0.949" | 6.477 | 1.564 | 0.018 | 6.477" | 0 | 1980 |
| 1981 | 0.000 | 0.766 | 0.127 | 0.126 | 195.5 | 171.5 | 106.6‘ | 73.74 | 8.116 | 1.408 | 30.14 | 0.068 | 195.5‘ | 0 | 1981 |
| 1982 | 61.76 | 0.741 | 0.077 | 0.020 | 1.469 | 3.777 | 8.320 | 11.89 | 7.857 | 3.608 | 9.364 | 0.420 | 61.76 | 0 | 1982 |
| 1983 | 0.004 | 0.000 | 0.000 | 0.031 | 0.075 | 280.5 | 324.5 | 93.71 | 139.8 | 4.365 | 5.907 | 0.297 | 324.5 | 0 | 1983 |
| 1984 | 5.028 | 0.004 | 0.254 | 1.166 | 28.65 | 14.80 | 16.41 | 16.12 | 122.5 | 2.037 | 1.342 | 0.041 | 122.5 | 0 | 1984 |
| 1985 | 0.033 | 0.000 | 0.072 | 0.362 | 0.178 | 0.704 | 18.52 | 15.46 | 4.010 | 0.717 | 1.773 | 0.035 | 18.52 | 0 | 1985 |
| 1986 | 0.000 | 11.40 | 1.013" | 0.085" | 3.318 | 96.95 | 82.60 | 125.5 | 5.072 | 1.564 | 0.698 | 0.025 | 125.5“ | 0 | 1986 |
| 1987 | 0.000 | 0.000 | 0.004 | 0.271 | 5.460 | 2.800 | 109.0 | 21.47 | 2.850 | 0.933 | 0.165 | 0.055 | 109.0 | 0 | 1987 |
| 1988 | 0.004 | 0.000 | 0.000 | 2.554 | 1.665 | 21.93 | 126.9 | 50.20 | 15.52 | 15.16 | 0.166 | 5.178 | 126.9 | 0 | 1988 |
| 1989 | 0.037 | 0.110 | 0.024 | 0.061 | 5.710 | 22.75 | 45.76 | 14.46 | 5.367 | 0.946 | 0.471 | 0.007 | 45.76 | 0 | 1989 |
| 1990 | 232.8 | 64.84 | 7.569 | 3.928 | 8.480 | 2.880 | 28.65 | 24.07 | 2.077 | 0.792 | 0.157 | 0.008 | 232.8 | 0 | 1990 |
| 1991 | 0.004' | 0.010' | 0.004 | 0.059 | 0.064 | 5.759 | 31.36 | 87.52 | 9.297 | 0.471 | 0.194 | 0.024 | 87.52‘ | 0 | 1991 |
| 1992 | 0.001 | 0.182 | 0.339 | 7.141 | 0.188 | 37.51 | 28.30 | 65.99 | 56.98‘ | 17.03 | 0.427 | 0.036 | 65.99‘ | 0 | 1992 |
| 1993 | 0.003 | 4.187 | 14.23 | 0.462 | 4.187 | 18.38 | 10.76 | 28.89 | 17.07 | 2.331 | 2.137 | 0.011 | 28.89 | 0 | 1993 |
| 1994 | 0.000 | 0.000 | 0.000 | 0.008 | 4.070 | 16.91‘ | 21.07 | 65.16‘ | 8.977’ | 0.218 | 0.009 | 0.002 | 65.16‘ | 0 | 1994 |
| 1995 | 0.000 | 0.000 | 0.000 | 0.007 | 1.523 | 21.67 | 87.84 | 19.05 | 13.10 | 35.62 | 0.360 | 0.068 | 87.84 | 0 | 1995 |
| 1996 | 0.003 | 0.000 | 0.000 | 0.004 | 0.738 | 44.65 | 210.4 | 118.0 | 14.60 | 3.824 | 11.33 | 0.055 | 210.4 | 0 | 1996 |
| 1997 | 0.008 | 0.225 | 25.26 | 11.89 | 0.471 | 3.312 | 3.126 | 20.06 | 30.04 | 1.862 | 0.050 | 0.014 | 30.04 | 0 | 1997 |
| 1998 | 0.000 | 0.000 | 0.008 | 0.023 | 0.540 | 7.369* | 13.00 | 123.5* | 62.77* | 5.166 | 0.071 | 0.015 | 123.5* | 0 | 1998 |
| 1999 | 0.118 | 0.004 | 0.027 | 0.018 | 23.23“ | 24.67“ | 77.90 | 61.40 | 35.69 | 23.84 | 3.842 | 38.17* | 77.90* | 0 | 1999 |
| 2000 | 210.2* | 114.9* | 12.37 | 0.400 | 0.241 | 3.103 | 70.51 | 16.17 | 32.46 | 0.508 | 0.036 | 0.010 | 210.2* | 0 | 2000 |
| 2001 | 0.002 | 0.007 | 0.007 | [0.014] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [0.014] | 252 | 2001 |
| | | | | | | | | | | | | | | 252 | **Total** |
| **Mean** | 23.18* | 8.978* | 2.791" | [1.312] | 13.63“ | 38.43* | 67.99“ | 50.22* | 28.34* | 6.138 | 3.343 | 2.122* | [107.1 ] | | **Mean** |
| **Med** | 0.003* | 0.008* | 0.025" | [0.105] | 1.523" | 16.91* | 31.36“ | 28.89* | 13.10* | 2.037 | 0.471 | 0.035* | | | **Med** |
| **Max** | 232.8* | 114.9* | 25.26“ | [11.89 ] | 195.5“ | 280.5* | 324.5“ | 125.5* | 139.8* | 35.62 | 30.14 | 38.17* | [324.5 ] | | **Max** |
| **Min** | 0.000* | 0.000* | 0.000" | [0.004] | 0.064" | 0.704* | 3.126" | 2.275* | 0.949* | 0.218 | 0.009 | 0.002* | [0.014] | | **Min** |
| **OK** | 100% | 100% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | | **OK** |
| **Cnt** | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 22 | | **Cnt** |

**NOTES**

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" ... Good record — Corrections/Estimations applied

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* ... Estimated record

[ ... Not available

**Water and Rivers Commission** **HYMONTH V60 Output 17.10.2001**

**Station 615014 AVON RIVER — BROUNS FARM Station 615014**
**Var from 10.00 STAGE — SL in metres**
**Var to 140.00 Mean Stream discharge in cubic metres/second**
**Figures are for period ending 2400 hours.**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual max | Missing days | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0.000 | 0.000 | 0.000 | 0.000 | 0.016 | 0.117" | 0.574" | 0.616" | 0.161" | 0.067 | 0.018 | 0.000 | 0.000" | 0 | 1980 |
| 1981 | 0.000 | 0.000 | 0.000 | 0.000 | 0.029 | 3.405 | 2.156' | 5.480 | 0.702 | 0.085 | 0.062 | 0.000 | 0.000' | 0 | 1981 |
| 1982 | 0.000 | 0.010 | 0.001 | 0.008 | 0.018 | 0.080 | 0.575 | 1.373 | 0.482 | 0.101 | 0.051 | 0.004 | 0.000 | 0 | 1982 |
| 1983 | 0.000 | 0.000 | 0.000 | 0.000 | 0.031 | 0.049 | 10.08 | 9.867 | 4.365 | 0.221 | 0.173 | 0.026 | 0.000 | 0 | 1983 |
| 1984 | 0.004 | 0.000 | 0.000 | 0.036 | 0.422 | 2.561 | 2.940 | 3.143 | 1.508 | 0.148 | 0.036 | 0.008 | 0.000 | 0 | 1984 |
| 1985 | 0.000 | 0.000 | 0.000 | 0.002 | 0.038 | 0.121 | 0.583 | 1.790 | 0.707 | 0.088 | 0.021 | 0.000 | 0.000 | 0 | 1985 |
| 1986 | 0.000 | 0.000 | 0.051" | 0.014" | 0.013 | 0.158 | 3.413 | 4.618 | 0.642 | 0.116 | 0.016 | 0.000 | 0.000" | 0 | 1986 |
| 1987 | 0.000 | 0.000 | 0.000 | 0.004 | 0.062 | 0.124 | 0.649 | 1.606 | 0.485 | 0.063 | 0.009 | 0.000 | 0.000 | 0 | 1987 |
| 1988 | 0.000 | 0.000 | 0.000 | 0.000 | 0.056 | 0.408 | 2.453 | 2.556 | 1.071 | 0.142 | 0.008 | 0.001 | 0.000 | 0 | 1988 |
| 1989 | 0.000 | 0.000 | 0.000 | 0.002 | 0.014 | 0.946 | 8.369 | 2.449 | 0.365 | 0.094 | 0.007 | 0.000 | 0.000 | 0 | 1989 |
| 1990 | 0.000 | 5.297 | 0.102 | 0.072 | 0.530 | 0.475 | 0.435 | 1.907 | 0.535 | 0.076 | 0.004 | 0.002 | 0.000 | 0 | 1990 |
| 1991 | 0.000' | 0.001' | 0.000 | 0.002 | 0.009 | 0.064 | 1.680 | 2.005 | 0.471 | 0.044 | 0.003 | 0.000 | 0.000' | 0 | 1991 |
| 1992 | 0.000 | 0.000 | 0.000 | 0.021 | 0.030 | 0.054 | 3.663 | 4.707 | 17.03 ‘ | 0.324 | 0.036 | 0.002 | 0.000’ | 0 | 1992 |
| 1993 | 0.000 | 0.000 | 0.002 | 0.032 | 0.032 | 0.278 | 2.306 | 2.631 | 1.255 | 0.059 | 0.011 | 0.000 | 0.000 | 0 | 1993 |
| 1994 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.427' | 2.077 | 1.343' | 0.149' | 0.008 | 0.001 | 0.000 | 0.000' | 0 | 1994 |
| 1995 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.098 | 0.834 | 3.265 | 0.485 | 0.062 | 0.004 | 0.001 | 0.000 | 0 | 1995 |
| 1996 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.012 | 5.061 | 5.734 | 2.590 | 0.233 | 0.042 | 0.007 | 0.000 | 0 | 1996 |
| 1997 | 0.000 | 0.000 | 0.010 | 0.098 | 0.060 | 0.305 | 0.244 | 0.905 | 0.772 | 0.050 | 0.013 | 0.000 | 0.000 | 0 | 1997 |
| 1998 | 0.000 | 0.000 | 0.000 | 0.007 | 0.014 | 0.077* | 1.385 | 0.698* | 1.690* | 0.071 | 0.012 | 0.003 | 0.000* | 0 | 1998 |
| 1999 | 0.000 | 0.000 | 0.000 | 0.009 | 0.012" | 0.407" | 6.457 | 4.865 | 4.910 | 0.244 | 0.021 | 0.002* | 0.000* | 0 | 1999 |
| 2000 | 0.013* | 0.244* | 0.100 | 0.070 | 0.100 | 0.104 | 0.631 | 2.449 | 0.499 | 0.032 | 0.008 | 0.000 | 0.000* | 0 | 2000 |
| 2001 | 0.000 | 0.001 | 0.002 | [0.006] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] | [0.000] | 252 | 2001 |
| | | | | | | | | | | | | | | 252 | **Total** |
| **Mean** | 0.001* | 0.252* | 0.012" | [0.017] | 0.071" | 0.489* | 2.694" | 3.048* | 1.947* | 0.111 | 0.027 | 0.003* | [0.000] | | **Mean** |
| **Med** | 0.000* | 0.000* | 0.000" | [0.005] | 0.029" | 0.124* | 2.077" | 2.449* | 0.702* | 0.085 | 0.013 | 0.000* | | | **Med** |
| **Max** | 0.013* | 5.297* | 0.102" | [0.098] | 0.530" | 3.405* | 10.08 “ | 9.867* | 17.03 * | 0.324 | 0.173 | 0.026* | [0.000] | | **Max** |
| **Min** | 0.000* | 0.000* | 0.000" | [0.000] | 0.002" | 0.012* | 0.244" | 0.616* | 0.149* | 0.008 | 0.001 | 0.000* | [0.000] | | **Min** |
| **OK** | 100% | 100% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | | **OK** |
| **Cnt** | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 22 | | **Cnt** |

**NOTES**

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" ... Good record — Corrections/Estimations applied

' ... Very good record — Corrections applied

* ... Estimated record

[ ... Not available

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Avon River Management Authority

254 Fitzgerald Street
Northam
Western Australia 6401

Telephone (08) 9622 7055
Facsimile (08) 9622 7155

Water and Rivers Commission

Hyatt Centre
3 Plain Street
East Perth
Western Australia 6004

Telephone (08) 9278 0300
Facsimile (08) 9278 0301
Website www.wrc.wa.gov.au