Department of **Water**
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# Assessment of the status of river pools in the Avon catchment

Water resource management series

Report No. WRM 47
December 2007

Department of Water
Government of Western Australia

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This is an Avon Catchment Council project delivered by the Department of Water and funded with investment from the Australian and Western Australian Governments through the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality

Department of Water

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Cover photograph: Walyunga Pool, May 2007 (courtesy of Rebekah Esszig)

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# Abbreviations

| | |
|---|---|
| ACC | Avon Catchment Council |
| ANZECC | Australian and New Zealand Environment Conservation Council |
| ARMA | Avon River Management Authority |
| AWC | Avon Waterways Committee (formerly ARMA) |
| DEC | Department of Environment and Conservation (formerly CALM) |
| DoE | Department of Environment |
| RTS | River training scheme |
| WRC | Water and Rivers Commission |

# Summary

The main channel of the Avon River was originally braided, with many small channels interweaving between thickly vegetated islands, and punctuated by numerous deep, shady pools. The Avon is now a highly disturbed river system due to clearing in the catchment for agriculture, the establishment of towns adjacent to the river and the River Training Scheme (RTS).

The Avon River pools form some of the river's most valuable habitats. In an otherwise dry landscape, they provide the only permanent summer refuge and breeding area for waterfowl and water-related fauna. A feature of the middle section of the Avon River, the deeper pools, have high aesthetic, nature conservation, recreational and Aboriginal values.

The Avon River originally had more than 26 major pools, some of which were over 10 m deep. Seven pools have totally filled with sediment and many are almost filled. River pools are under threat from eutrophication, salinisation and sedimentation.

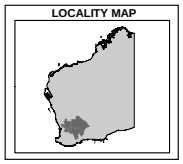
This report describes 42 locally significant pools on the Avon River and three significant pools on the Dale River as identified in the river recovery plan series. By summarising the current information available for each of the pools (see Appendix C) a broad and basic criteria has been developed to prioritise for rehabilitation the pools on the Avon River.

Based on ecological, social and economical values, 16 pools have been nominated as high priority for rehabilitation. They are:

- Walyunga Pool
- Cobblers Pool
- Long Pool
- Jimperding Pool
- Glen Avon Pool
- Katrine Pool
- Burlong Pool
- Tipperary Pool
- Mears Pool
- Railway Pool
- Gwambygine Pool
- Beverley Town Pool
- Eyres Pool
- Boyagarra Pool
- Dwarlacking Pool
- Mandiakon Pool on the Dale River.

***Map 1*** *The Avon Catchment*

# The Avon River Catchment




**LEGEND**

- Major town
- Town
- Major road
- Major river
- Avon River Basin

N

0 20 40 60 80

Kilometres

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

**Project Information**
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**SOURCES**

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

Dataset Name-CUSTODIAN ACRONYM-Metadata Date
Towns - DLI - 08/08/2004
Road Centrelines - DLI - 01/05/2004
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Hydrographic Catchments-Catchments - DOE - 23/3/05
WA Coastline, WRC (poly) - DOE - 01/06/2004

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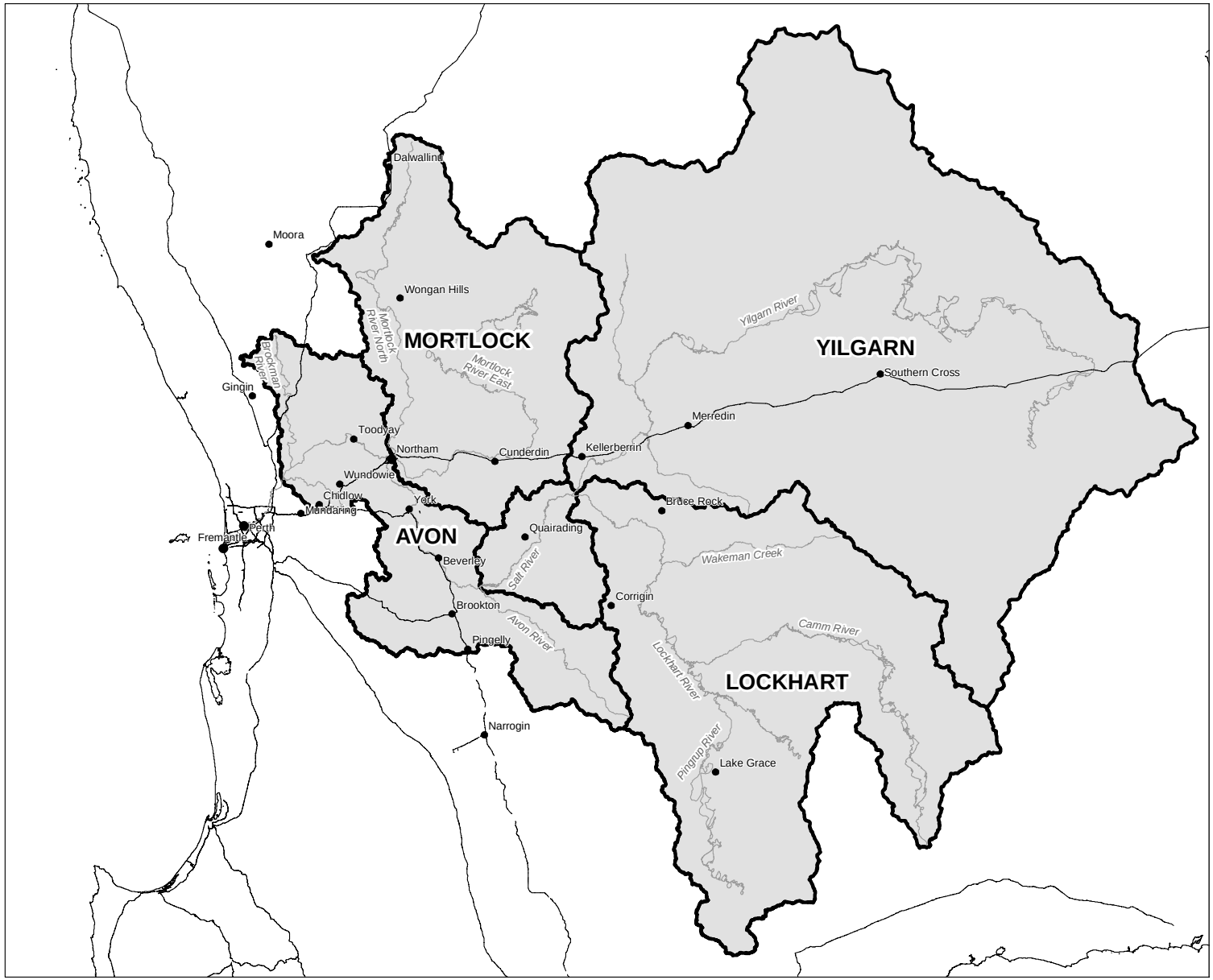


# 1 Introduction

The river pools on the Avon River have been identified as priority assets to the Avon Region. This report is a compilation of all existing information relevant to the river pools along 21 sections of the Avon River as defined in the river recovery plans (RRP). The report can be used as a tool to prioritise those pools for recovery and rehabilitation based on the economical, biological and social values of the pool. The report describes the pools, beginning in the lower Avon in Walyunga National Park and working upstream to Lake Yealering. River pools of the Avon River South Branch and the Dale River have also been considered for prioritisation. The Dale River is a fresher tributary to the Avon with high ecological significance.

River recovery plans have been completed for 21 sections of the Avon River, including the Dale River and Avon River South Branch, as part of the Avon River Management Program. The plans were prepared by the Department of Water in consultation with the Avon Waterways Committee (AWC) and the local community.

The RRPs identify the river pools in each section of the river and list pools considered to be significant in that section (Map 2 highlights the river recovery sections and the location of significant pools). This report has compiled into one document to identify criteria for prioritisation the pool information for each section of the river from the RRP series and other relevant research.

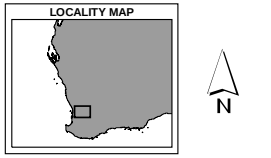
Other major sources of information used in this report included the Avon River Pool Survey conducted by Jim Davies & Associates (JDA) and Ecoscape in 1996 and the Draft Review of the Economic Viability of Sediment Extraction from the Avon River Pools. JDA surveyed 191 km of the Avon River in 1996 detailing the condition of the river assets in 18 river sections. Although the river survey data is dated, it has provided a comprehensive source of information for the 26 river pools surveyed. The economic review was prepared for Department of Water in 2007. It provides information on the economic viability of the removal of sediment from the pools and identifies the bed sediment types, accessibility of the pool, and the distance to Perth as limiting factors when considering pools for recovery.

There were many smaller river pools on the Avon that were not included in the 1996 pool survey. These pools are not well known and there is little documented information about them. For these pools, where possible, local knowledge was drawn upon from the community and the Department of Water.

This project is jointly funded by the Department of Water, Avon Catchment Council, Natural Heritage Trust and the National Action Plan for Salinity and Water Quality and forms part of the council's Natural Resource Management Strategy that focuses on the management of the land, water and biodiversity resources of the Avon River Basin. The report forms part of the Avon Catchment Council Healthy Ecosystems project and is delivered by the Department of Water.

**Map 2** *Avon River pools and recovery sections*

## AVON RIVER pools and recovery sections




**LEGEND**

- Major river
- Minor river
- Main road
- Major town
- Town
- 3 Section number
- Avon River sections
- Pools
- Avon River Basin

0 10 20 30

Kilometres

**Datum and Projection Information**

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

**Project Information**

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Map Author: Tom Lee
Task ID: 6697
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Date: 12th April 2007

**SOURCES**

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

| Dataset Name | CUSTODIAN ACRONYM | Metadata Date |
|---|---|---|
| Towns | DLI | 08/08/2004 |
| Road Centrelines | DLI | 01/05/2004 |
| Hydrology, linear (heirachy) | DOW | 10/02/2005 |
| Hydrographic Catchments | DOE | 23/03/2005 |

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# 2 Background

## 2.1 Avon River

The Avon River is one of the great rivers of Australia. Before becoming part of the Swan Estuary on the coastal plain, the main channel of the Avon River extends over 260 km. Its vast catchment covers an area of 120 000 km$^2$, which stretches from the coastal plain in the west, to Dalwallinu in the north, to the east beyond Southern Cross, and to the south beyond Lake Grace (Harris, 1996) (see Map 1).

The Avon River flows intermittently, with stream flow commencing in the autumn and drying into a series of pools during the hot and dry summer months typical of a Mediterranean climate. Originally, there were 26 major pools on the Avon River, varying in length from 370 m up to 2 kilometres, a number of which were said to be over 10 m in depth (WRC and ARMA, 1999a). There were also many smaller pool systems.

The Avon River pools form some of the Avon River's most valuable habitats. In an otherwise dry landscape, they provide a permanent summer refuge and breeding area for waterfowl and aquatic fauna. The deeper pools are a feature of the middle section of the Avon River and have high aesthetic, nature conservation, recreational and Aboriginal values.

## 2.2 River training scheme

The Avon catchment has changed significantly since European settlement began in the 1830s. As a result of widespread land clearing and subsequent siltation in the river, there was concern that the frequency and volume of floods was increased. Following a major flood in 1955 the river training scheme (RTS) was initiated. It operated from 1957 to 1972 and cleared the riverbed of sediment, trees and debris to enable the river to flow more rapidly and so reduce the duration of flooding.

The scheme increased the velocity and erosion power of the river which actively encouraged scouring of the riverbed. Millions of tonnes of sediment were mobilised as a result of this. The river pools form natural sand traps and continue to fill with sediment. Seven of the major pools are now totally filled with sediment, and many others are partially filled.

## 2.3 Threats to the Avon River Pools

The Avon River pools form some of the Avon River's most valuable habitats. River pools were once used for recreation in the form of swimming, boating and fishing, The pools also provided a valuable water resource for early settlers who relied on the Avon River water for drinking and watering stock. The ecological and aesthetic values of the pools are now threatened by sedimentation, salinisation and eutrophication.

### Sedimentation

All rivers have the capacity to carry and deposit sediments. A river is in a stable state if the sediments entering the system are equal to the sediment leaving the system (Southwell, 1990). Sedimentation occurs when the sediment load of the river is greater than the capacity of the flow to transport it (Southwell, 1990). In the Avon Catchment, deposition of sediment has occurred in the river pools and in some cases pools have been totally filled.

This report has identified 45 significant river pools on the Avon and Dale Rivers. Of these, seven are filled with sediment and many are under threat of being filled. It is estimated that there is 2 million $m^3$ of sediment in 26 major river pools on the main channel of the Avon River (Advanced Choice Economics and Viv Read & Associates, 2007).

Land clearing in the early 1900s and the RTS are the primary causes of excess sediment in the Avon River System. Surface-water runoff after heavy rains washed the topsoil from the cleared landscape into the river system and the RTS caused bank erosion and mobilised unconsolidated bed sediments. In many reaches of the Avon the main source of sediment in the channel is from the scouring of the riverbed itself and eroding river banks.

Once in the main channel, the sediments are carried downstream by the river flow. Finer sediments are carried in suspension and the coarse sediments are typically rolled along the bed (Pen, 1999). Sediment accumulates as slugs in the channel where the flow velocities are weaker. The unconsolidated sand slugs migrate downstream with river flow, and upon encountering a river pool (deeper section),

### Table 1 Salinity classification table

| **Classification** | **Salinity** (mg/L) | **Conductivity** (mS/m) |
|---|---|---|
| Fresh | 0 – 550 | 0 – 100 |
| Marginal | 550 – 1 100 | 100 – 200 |
| Brackish | 1 100 – 5 000 | 200 – 900 |
| Low Saline | 5 000 – 11 000 | 900 – 2 000 |
| High Saline | 11 000 – 30 000 | 2 000 – 4 500 |
| Hyper-saline | 30 000 – 89 000 | 4 500 – 13 000 |

*Source: Cobb and Ryan, 1999, Avon Catchment Water Quality Snapshot Survey.*

progressively fill it up from the upstream end. Excess sediment in the river system smothers aquatic habitat, increases the scouring action along the banks, fills river pools and contributes to a decline in water quality.

High flow/flood events have the potential to naturally remove the sediment from the pools. Flows in excess of a 30-year-flood event are capable of scouring sediment from pools (Southwell, 1990). No major flood events have occurred since the RTS was undertaken. With drying climate conditions and below average rainfall in the region, flow of the Avon River to date has been incapable of naturally scouring the river pools. To help the river system cope with the increased sediment load the Department of Water recommends removing sediment from the river pools with machinery to restore the pool volume and maintain the ecological and aesthetics of the pools.

Coarse sand removed from a pool is suitable for a range of applications including the construction of paving bricks and concrete manufacturing (Advanced Choice Economics and Viv Read & Associates, 2007). For example, in the past, sediment removed from Katrine Pool was used in the construction of the Great Eastern Highway By-Pass near Northam.

## Salinisation

As a result of extensive land clearing in the Avon Catchment the Avon River has been affected by increased salinity. Water quality monitoring of the river pools was carried out during the 1996 Pool Survey (see Appendix B). Water quality at the majority of pools is classified as low – high saline.

The Australian and New Zealand Environment and Conservation Council Guidelines ANZECC (2000) suggest salinity values for a healthy, freshwater ecosystem should be less than 1000 mg/L. The salinity of the Avon River is much higher and varies from 5000 to 30 000 mg/L depending on the time of year and the site sampled.

Salinisation of the river has contributed to a decline in water quality which threatens the ecology of the river pools. The abundance of aquatic species, such as the freshwater mussel and freshwater cobbler, has declined since the 1940s (Pen, 1999), and the diversity of foreshore vegetation is also deteriorating due to the rising salinity levels. The salt-tolerant she-oak (*Casuarina obesa*) has begun to dominate the less tolerant flooded gum (*Eucalyptus rudis*) and swamp paperbark (*Melaleuca raphiophylla*) (Avon Catchment Council, 2005). Riparian revegetation efforts are also restricted to salt-tolerant species selection in some areas.

## Table 2 Total phosphorous ranges

| State | Total phosphorous (TP) (mg/L) |
|---|---|
| Extreme | > 0.5 |
| Very high | 0.3 – 0.5 |
| High | 0.2 – 0.3 |
| Moderate | 0.1 – 0.2 |
| Low | < 0.1 |

*Source: Donohue, R, Jakowyna, B, Robb, M, 2000. Sources of Nutrients in the Swan Canning rivers.*

## Eutrophication

Algal blooms are a common occurrence in the Avon River pools during the summer months. The decay of algal blooms reduces dissolved oxygen levels in the water placing additional stresses on the river-pool ecosystem. Excessive algal growth is a symptom of nutrient enrichment, a process called eutrophication. In the Avon River Basin, human activity has accelerated the process of eutrophication. The river receives nutrients, in particular nitrogen and phosphorous, from decaying organic matter, farming practices, intensive animal industries and industrial effluents.

Phosphorus is usually the nutrient limiting growth in freshwater systems. Phosphorous can be found in the water in soluble or particulate form. The sum of all soluble phosphorous found in the water is known as total phosphorous (TP). The ANZECC guidelines recommends a TP concentration between 0.01–0.1 mg/L to prevent the eutrophication of rivers and streams (ANZECC, 2000). During the 1996 river-pool survey, phosphorous concentrations in the water and sediment of the pools were measured (see Appendix B). Many of the Avon River pools have average TP concentrations higher than 0.1 mg/L and are threatened by eutrophication.

In waterways, most of the phosphorous is bound (adsorbed) to clay and silt particles in the sediments. As a result, a large amount of phosphorous tends to remain ‘locked’ into the bottom sediments where it is normally unavailable for growth (Thompson and Tracey, 2005). Anoxic conditions of the water can release the phosphorous from the sediment increasing the level of available phosphorous to aquatic plants for growth.

Most pools in the Avon River hold a significant nutrient load, particularly in the nutrient enriched sediments. Pools with a greater proportion of silt/clay in the sediment recorded higher nutrient loads (see Appendix B and C). The sediment nutrient load of each pool needs to be considered when prioritising pools for recovery to ensure adsorbed nutrients are not mobilised during the excavation process.

## 2.4 Indigenous cultural and heritage links to river pools

Waterways were once a prime food source and are still spiritually and culturally significant to Aboriginal people. All waterways are considered to have mythological significance. In traditional dreamtime stories, the Waugal, a serpent-like creature, is said to have created the rivers as it traversed the landscape. The pools on the river signify places the Waugal camped during its travels and are viewed as sacred (Cummins et al. 1999). There are a number of Aboriginal sites in close proximity to or part of the Avon River.

For example 'Burlong Pool was a residing place of the Waugal, the pool has potent symbolic power that is manifest in the world in the form of sickness. Consultation with Northam Elders illustrated that the respect for, and fear of the Waugal, continues amongst the Nyungar community' (Cummins et al. 1999).

Impacts on rivers and tributaries is likely to be of concern to Aboriginal people. Aboriginal sites are protected under the Aboriginal Heritage Act 1972–1980 and potential sites should not be disturbed without consent from the Department of Indigenous Affairs. Where a project will affect a significant site, all efforts must be made to consult with the necessary Aboriginal communities to ensure the significance of the site is protected.

The significant value placed upon waterways, in particular river pools, was reinforced in the recently released Avon Catchment Council document *Ballardong Noongar Budjar 'Healthy Country – Healthy People'* which complements the Avon Catchment Council's Natural Resource Management Strategy. This document encourages partnerships in natural resources management activities with the Noongar people to ensure Noongar specific projects in the Avon River Basin are implemented and managed appropriately.

# 3 Lower Avon

This section focuses on the Avon River from the upstream boundary of the Avon Valley National Park to Walyunga Pool, just downstream of the Wooroloo Brook confluence. The Lower Avon River Recovery Plan section is where the Avon River descends the Darling Scarp onto the Swan Coastal Plain where it becomes the Swan River. There are concerns that if the pools upstream of this section of the river fill with sediment, it is possible that the sediments will be discharged into the Swan River and adversely impact upon the health of the river (Viv Read & Associates in press).

The Draft Lower Avon Recovery Plan has been prepared and sent to stakeholders for comment. The Recovery Plan for this section will be finalised by the end of August 2007 (Viv Read & Associates in press).

There is little information available for the river pools on this section of the Avon River. Pools that have been identified by the lower Avon RRP include (Viv Read & Associates in press):

- Walyunga Pool
- Bungarah Pool
- Boongarup Pool
- Moondyne Pool.

If river-pool restoration works are proposed for any of the pools within Walyunga National Park or Avon Valley National Park consultation with Department of Conservation and Environment (DEC) and the appropriate Aboriginal Elders will be a critical part of this process to ensure the relevant approvals are obtained prior to any on-ground works being undertaken (Viv Read & Associates in press).

## 3.1 Walyunga Pool

Walyunga Pool is in Walyunga National Park at the base of the Darling Scarp. Riparian vegetation remains intact with high conservation values associated with the national park. The pool has significant social and Aboriginal cultural values. Although there is little information for Walyunga Pool, given the location and Aboriginal significance, the pool is considered a high priority for recovery (Viv Read & Associates in press).

Walyunga Pool is located in the transition zone where the Avon River becomes the Swan River and is considered to be under threat of sedimentation. Jim Davies and Associates are currently undertaking an assessment of Walyunga Pool and pools immediately upstream for Department of Water to determine sediment filling rates.

The pool may detain sediment that descends from the scarp. If so, recovery and maintenance of this pool can protect the Swan River by reducing the volume of sediment being transported into the system.

# 4 Section 1 and 2—Avon Gorge and Deepdale Valley

Section 1 and 2 covers 22 km of the Avon River between the Avon Valley National Park and Deepdale Road. There are four significant pools within these sections of the Avon River. They are:

- Cobblers Pool
- Long Pool
- Jimperding Pool
- Deepdale Pool.

The river pools in the 'Deepdale Valley' section have filled with coarse sediments. Deepdale Pool is full and Jimperding Pool has filled substantially. The main source of the course sediment is expected to be from erosion of the riverbed and banks downstream from Extracts Weir. The 'Avon Gorge' section of the river was not altered during the river training scheme so it has retained a braided stream channel with dense vegetation that arrests sediment movement.

Seven other smaller pools in these sections are well known to the local community although many are now filled with sediment. These include:

- Crooked Pool
- Diving Pool
- Markey Pool
- Duck Pool (just upstream of Cobblers Pool)
- Grandfathers Pool
- Rocky Basin Pool
- Cut-throat Pool (now known as the 'Super-chute' by canoeists).

## 4.1 Cobblers Pool

Cobblers Pool is located approximately 3 km downstream of Long Pool. It is the last major river pool before the Avon River becomes the Swan River and descends on the Swan Coastal Plain. This pool is best known as the over-night campsite for the Avon Descent. The pool is 350 m long and 2.5 m deep with limited sediment infill (WRC and AWC, 2002a). Sediment can be described as medium/coarse sand over rock (Advanced Choice Economics and Viv Read & Associates 2007). This pool was not included in the survey in 1996.

## 4.2 Long Pool

Long Pool is located downstream of Long Pool Crossing, approximately 3 km upstream of Cobblers Pool. When surveyed in 1996, the length of this pool was approximately 1 km with an average depth of 1.5 m along the whole pool (Davies et al. 1996). Long Pool is confined by a rock bar at the downstream end below which is the confluence of Malkup Brook. Sediments of the pool are described as predominantly coarse sand with 35% clay/silt upstream (Davies et al. 1996). There is also a rock outcrop within the pool.

Long Pool was more than 4 m deep at the upstream end in 1981 (WRC and AWC, 2002a). Survey information in 1996 showed that the pool varied in depth from 1.5 m to 3 m and was about half filled with coarse sand (Davies et al. 1996). Local observations indicate that this pool is rapidly filling with sediment (WRC and AWC, 2002a).

Long pool retains significant river values. The Department of Water's river recovery plan identified this pool as a suitable demonstration site for sediment extraction. It was estimated that 2000 $m^3$ of sediment was removed by an excavator during the summer of 2004/2005 (Toodyay Friends of the River, 2006). Preliminary surveys carried out by Department of Water in the summer of 2004/2005 indicate that the excavated area had been refilled by the winter flows of that year.

A river management plan for this pool is currently being developed for Department of Water by Jim Davies and Associates.

## 4.3 Jimperding Pool

Jimperding Pool is located next to the intersection of River Road and Cobblers Pool Road. During the 1996 survey, Jimperding Pool was approximately 920 m in length and generally less than 0.5 m deep (Davies et al. 1996). This has decreased from a depth of 3.1 m in 1977. Sediment in the pool is dominated by medium/coarse sand with a few samples showing 35% silt/clay (Davies et al. 1996). During the 1996 survey, the pool was half filled with medium/coarse sand. The central section of the pool was filled and there was an unfilled section in the upstream and downstream ends of the pool.

This pool has good access for machinery and a considerable amount of medium/ coarse sand for extraction.

## 4.4 Deepdale Pool

Deepdale pool is approximately 2 km upstream of the Folewood Road and River Road intersection. This pool marks the downstream extent of the river training scheme. Prior to the RTS, Deepdale Pool was used for swimming, fishing (for cobbler and mullet) and was suitable for stock water. The pool filled with sediment soon after the RTS was completed in this section and the survey of 1977 noted the pool was full (WRC and AWC, 2002a).

The sediment in this pool is described as sand and although there has been no nutrient analysis, the sediment nutrient load can be assumed to be quite low (Davies et al. 1996). The ecological value of the pool is considered to be low given it is filled with sediment and can no longer sustain a healthy aquatic ecosystem. Limited access to the site by machinery also dictates this pool's lower priority for recovery.

## 4.5 Photos of pools in Section 1 and 2

*Deepdale Pool in 1950s prior to RTS (Photo courtesy Helen Heath)*

*Deepdale Pool filled with sediment (Photo courtesy Viv Read)*

*Sediment filling Long Pool (Photo courtesy Viv Read)*

*Sediment in the downstream end of Jimperding Pool (Photo courtesy Viv Read)*

*Sediment extraction at Long Pool, Feb 2005 (Photo courtesy Bernard Kelly)*

*Sediment extraction at Long Pool, Feb 2005 (Photo courtesy Bernard Kelly)*

# 5 Section 3—Toodyay

This section of the Avon River channel includes the Toodyay townsite. It is approximately 10 km in length from Deepdale Road to downstream of the Goomalling Street bridge. No significant river pools have been identified in this section of the Avon River and therefore this section is not considered in this report.

# 6 Section 4 and 5—Toodyay to Northam

This section of the Avon River includes a channel length of 29 km from the Northam Town Pool Weir to the Goomalling Road bridge. There are five significant pools within these sections of the Avon River. They are:

- Red Banks Pool
- Millards Pool
- Glen Avon Pool
- Katrine Pool
- Egoline Pool.

The river pools in this section of the river are visible and attractive to the public. Complete infill of these pools would be a significant loss of public amenity.

Glen Avon and Millards pools are the longest pools on the river. Glen Avon pool has one of the largest unfilled pool volumes (325 000 $m^3$) (WRC and AWC, 2002b). Only Wilberforce pool, between Northam and York, has a higher unfilled volume.

While some pools have filled with sediment, new pools are being scoured. Permanent scour pools are now located downstream of Glen Avon Weir (known locally as Tink's Pool), downstream of Extracts Weir, at the confluence of Harpers Brook (known as Lloyd's Pool), and downstream from the weir in Northam (WRC and AWC, 2002b).

## 6.1 Red Banks Pool

Red Banks Pool is downstream of the Bindi-Bindi Toodyay Road bridge. This is the only major pool on the Avon River that is circular due to active erosional processes caused by a conspicuous rock bar. There is only limited information available about this pool, however it is known that the pool was formed by the substantial raising in the late 1950s of the old Whitefield's Crossing (now known as Extracts Weir) to provide water for a tanning factory. The pool was popular for swimming. It remains deep (approximately 5 m) and has very steep (cliff-face) banks (5–8 m above the water level) (Davies et al. 1996). It is likely that this pool is self-scouring and may increase in size with time.

The bed material of the pool is bedrock with significant volumes of larger rocks (Davies et al. 1996). As this pool is self-scouring, it is unlikely that any recovery work will be necessary at this site.

### Table 3 Phosphorous (P) in river pool sediment and water

| River pool | **Total mass of P in sediments** (kg) | **Total mass of P in water** (kg) | **Average P concentration in water** (mg/L) |
|---|---|---|---|
| Katrine | 510 | 1.85 | 0.13 |
| Glen Avon | 16 296 | 80.00 | 0.60 |
| Millards | 8 232 | 16.10 | 0.20 |
| Red Banks | | 0.30 | 0.20 |

*Source: Davies et al., 1997, Avon River Survey 1996.*

## 6.2 Millards Pool

This significant pool was 1.7 km long and noted as being nearly 4 m deep in 1996 (Davies et al. 1996). Bed sediment analysis carried out during the 1996 pool survey found that the pool bed was predominately course sand while some samples in the downstream section comprised of silt and clay (Davies et al. 1996). Nutrient levels in the sediments were quite high (refer to Table 3). Disturbance of the sediments in this pool could release nutrients stored in the sediments causing algal blooms and eutrophic conditions in the pool.

The pool is controlled by Extracts Weir which was originally constructed to impound water for use in a former tannery located at the current industrial site. The pool has a 500 m-long sand slug in the upstream end, including some gravel that may have washed from road works for Sinclair's Crossing.

## 6.3 Glen Avon Pool

Glen Avon Pool is downstream from Viveash Crossing. Records from the 1996 survey indicate this pool is of significant length (over 1 km), and water volume with a depth of 3.76 m (Davies et al. 1996). Coarse sediment has been deposited in Katrine Pool rather than Glen Avon although some are now being deposited at the upstream end. Sediment in Glen Avon Pool is primarily silt and clay with a very high nutrient load (Davies et al. 1996). Monitoring has shown that blue-green algae growth is minimal suggesting that the nutrients remain fixed in the sediments (see Table 3). Disturbance of the sediments in this pool could cause algal blooms and eutrophic conditions in the pool.

The original crossing at the downstream end of Glen Avon Pool was known as McDermott's Crossing. Last used in the 1920s, it was a natural rock bar which was raised by half a metre in the 1970s to protect Glen Avon Pool and the Katrine Bridge footings. The pool is maintained by this constructed weir. Removal of the weir would cause massive channel erosion that would destroy the pool and would probably mobilise sediments now contained within Katrine Pool. The weir has been damaged during past flood events and has been repaired on a number of occasions.

## 6.4 Katrine Pool

Katrine Pool is located on the Avon River adjacent to Viveash reserve, a popular picnic area. Medium-coarse sand has filled over two-thirds of the pool volume (total sediment volume of 62 000 $m^3$) (WRC and AWC, 2002b). A relatively small amount of sediment (3800 $m^3$) was excavated in 2001 for use in construction of the Great Eastern Highway By-pass. A survey of pool sediments shows that some are well suited for construction and other engineering works (Golder Associates 1999). It is expected that if Katrine Pool fills completely, Glen Avon Pool downstream will fill more rapidly.

The river recovery plan for this section identifies that the best opportunity for effective detention of sediment in this section of the river would be to remove existing sediment in Katrine Pool (WRC and AWC, 2002b). This will continue to trap the sediment at Katrine, reducing the risk of further infill to Glen Avon Pool and maintaining the aesthetics of the river.

## 6.5 Egoline Pool

Egoline Pool is approximately 6 km downstream of the Great Eastern Highway Bypass bridge. This previously popular pool, once used for swimming, picnics and occasionally water skiing, filled with coarse sediment soon after the river training scheme (WRC and AWC, 2002b). In addition, there is a sand slug extending for a length of 2.5 km which suggests that this section of the river has lower velocity stream flow causing sediment deposition. The source of this slug is thought to be from RTS and the influence of Wongamine Brook.

The large unconsolidated sand slug has the potential to contribute to the sediment load of downstream pools if it is mobilised in a large flow event. If sediment is not extracted from this pool, stabilising the slug with vegetation should be considered.

## 6.6 Photos of pools in Section 4 and 5

*Red Banks Pool – self scouring (Photo courtesy Viv Read)*

*Weir at the downstream end of Glen Avon Pool (Photo courtesy Bernard Kelly)*

*Katrine Pool (Photo courtesy Martin Revell)*

*Sediment removal from Katrine Pool looking upstream (Photo courtesy Martin Revell)*

# 7 Section 6—Northam

This river section is approximately 10 km long and includes Northam and extends upstream to the Spencer's Brook Bridge. This river section has been a trial and demonstration site for river stabilisation techniques. There are two significant pools in this section of the river:

- Northam Town Pool
- Burlong Pool.

This section of the Avon also contains an area of 'untrained' river upstream of the Avon bridge, known as the 'West Northam Forest'. A walk trail from the Avon Bridge to the Poole Street pipe bridge provides community with the opportunity to enjoy a relatively natural part of the river featuring braided channels and a dense vegetated floodway. The 'forest' also restricts sediment movement into Northam Town Pool by reducing the flow of the river and trapping sediments along the vegetated islands.

## 7.1 Northam Town Pool

Northam Pool is located in the centre of the town of Northam. The pool is one of the town's major attractions providing a valuable aesthetic and recreational resource. The pool length was just over 1 km with an average depth of 1 m in 1996 (Davies et al. 1996). Water is retained in the pool during the summer months by a weir downstream of the Peel Street bridge.

Bed sediment of the pool is almost entirely silt/clay with a higher sand content closer to the sand bars (Davies et al. 1996). Total phosphorous in the water varies from 0.10 mg/L to 0.17 mg/L. There is a high nutrient content in the sediments which is to

*Aerial photograph of 'West Northam Forest' (on the right), an untrained section of the Avon River, with the Northam Town Pool (on the left) (Photo courtesy of Bernard Kelly)*

be expected from clay/organic matter (Davies et al. 1996). Algal blooms are common in the Town Pool, particularly in the summer months when the flushing is reduced.

In 1995 a sediment management plan was prepared for the Northam Town Council by the Waterways Commission (now Department of Water) staff on behalf of the Avon River Management Authority (ARMA) focusing on developing strategies for sediment management and maintaining the water quality and aesthetics of the Town Pool.

As a result of public concern for the pool and recommendations made in the management plan, a dredging project was undertaken by the Town of Northam in partnership with Department of Water, formerly Water and Rivers Commission. 50 000 $m^3$ of sediment was removed from the Town Pool in August 2000 to deepen the pool and improve the overall health and aesthetics of the pool. Sediment was removed from the left hand side of the channel from the Avon bridge to the Peel St Bridge and the width of the channel was dredged downstream of the Peel Street bridge to the weir. The sediment removed from the pool was not suitable for resale and was stockpiled offsite.

Other rehabilitation work carried out at this site includes the installation of an aerator in the pool near the ‘Swinging Bridge’ to improve the water quality of the pool by aerating the water, and the construction of a vegetated island immediately downstream of the Avon Bridge to trap and immobilise sediment.

## 7.2 Burlong Pool

Burlong Pool is located approximately 10 km upstream of Northam Town Pool and was completely filled with coarse sand sediment by the 1960s (WRC and ARMA, 1999). Prior to the river training scheme the pool was over 4 m deep. It was once an important recreational area for the people of Northam who regularly swam in the pool.

Unconsolidated sediment slugs upstream of the pool are the greatest contributors to the sediment in Burlong Pool. A strategy is currently in place to trap and remove sediment from Burlong Pool to restrict the flow of sediment downstream to the Northam Town Pool.

Sediment traps were constructed at the downstream end of the pool in the summer of 1997/1998 and a rock crossing/riffle was constructed at the upstream end of the pool in May 1998 to assist stabilisation of the bed sediment and control the sedimentation of the pool. The pool-management strategy allows for a dredging contractor to remove sediment each year (10 000 $m^3$/yr) from the two sand traps, in the vicinity of the upstream and downstream ends of the former pool.

## 7.3 Photos of pools in Section 6

*Aerator on Northam Town Pool looking upstream, 2006*
*(Photo courtesy Rebekah Esszig)*

*Dredge in Northam Town Pool downstream of the Peel Street Bridge, August 2000*
*(Photo courtesy Martin Revell)*

*Dredge at Burlong Pool*
*(Photo courtesy Bernard Kelly)*

*Riffle constructed upstream of Burlong Pool to trap sediment (Photo courtesy Bernard Kelly)*

*Screening plant which receives sand from the Burlong dredge (Photo courtesy Bernard Kelly)*

*Stockpile of sediment removed from Burlong Pool in 2000 (Photo courtesy Bernard Kelly)*

# 8 Section 7, 8 and 9—Spencers Brook to Mile Pool

This section covers 29 km of the Avon River between York and Spencers Brook. There were nine significant pools within these sections of the Avon River:

- Jangaling Pool (also known as Muresk Pool)
- Wilberforce Pool
- Church Pool (also known as Mackie, Chapel or Sermon Pool)
- Little Pool
- Hamersley Pool (little information available)
- Tipperary Pool
- Meares 5-Mile Pool
- Three-mile Pool
- Mile Pool.

Information for Hamersley Pool and Three-mile pool is not available. Three-mile pool is located on an anabranch to the Avon River and has not been significantly affected by the river training scheme (WRC and AWC, 2002c). Previous surveys have assumed it to be filled with sediment because it was not found on the main channel.

All pools in this section have become considerably shallower (WRC and AWC, 2002c). Jangaling Pool and Little Pool have completely filled with sediment. Only Wilberforce Pool has maintained significant depth (maximum depth was 4.35 m in 1996). Wilberforce Pool has an unfilled volume of 164 000 $m^3$. It has the highest unfilled volume of all Avon River pools (WRC and AWC, 2002c).

## 8.1 Jangaling Pool (Muresk Pool)

Jangaling Pool is located approximately 1.5 km upstream of the Spencers Brook bridge. This pool was popular for swimming among many, including students at Muresk, until the early 1970s. This pool filled quickly following the river training scheme and was completely filled with course sand when surveyed in 1992 (WRC and AWC, 2002c).

## 8.2 Wilberforce Pool

Wilberforce Pool is located downstream of the Wilberforce Road bridge. The pool remains as a long pool (820 m) and had an average depth greater than 3 m in the 1996 survey (Davies et al. 1996). The bed of the pool is mostly clay. Sedimentation of this pool has been minimal because Church Pool, approximately 3 km upstream, detains mobilised coarse sediments. The unfilled volume was measured as more than 95% of total pool volume during the 1996 pool survey (WRC and AWC, 2002c).

## 8.3 Church Pool (Mackies Pool)

Church Pool is located several kilometres upstream of Wilberforce Road bridge. This pool is referred to as Mackies Pool in surveys and reports but is known locally as Church Pool due to a church previously located on the bank. The pool was surveyed in 1996 and found to be 2.4 m deep and 750 m long (Davies et al. 1996). This pool has a 400 m coarse sand slug in the upstream section and it is now quite shallow. Sediment in the downstream section of the pool is 85% clay/silt (Davies et al. 1996).

One tributary (approximately 700 ha catchment area) discharges directly to Church Pool. The gradient of this tributary is relatively high (an average of 2.4%). It is actively eroding and contributing to the sediment load of the pool (WRC and AWC, 2002c).

## 8.4 Little Pool

The location of this pool is 1.5 km downstream from the Burges Siding bridge, although it is not well known. It was approximately 1 km in length but was filled with sediment by 1976 (WRC and AWC, 2002c). This pool was not surveyed in 1996.

## 8.5 Tipperary Pool

Tipperary Pool is located upstream of Burges Crossing. Records from the 1996 pool survey indicate that this formerly substantial pool was 340 m long and 1.5 m deep and only 15% of total pool volume was unfilled with sediment (WRC and AWC, 2002c). The sediment bed of the pool is generally silt and clay with an increasing sand content moving upstream (Davies et al. 1996).

A significant tributary, Ironbark Creek with a catchment area of approximately 1800 ha was identified to be discharging directly to the pool (WRC and AWC, 2002c). This tributary has an average gradient of 1.56% and has been actively eroding and could be contributing to the sediment load of the pool. Considerable sections of the tributary channel are stabilised by the invasive weed sharp rush (*Juncus acutus*).

Fringing vegetation is of minimal width although it has been enhanced by the 30-metre-wide revegetation of agricultural land along the western bank. This was carried out by the River Conservation Society, York in the early 1990s.

## 8.6 Meares Pool (Meares 5-Mile Pool)

Meares Pool is attractive and suitable for public access from Mackies Crossing, located at the downstream end of the pool. Cobbler were last caught in the pool in 1966 (WRC and AWC, 2002c).

The pool has been affected by the RTS. The length of this pool has not decreased significantly but it is quite shallow. The river-pool survey indicates 70% of the pool

has been filled with an estimated sediment volume of 30 000 $m^3$ (Advanced Choice Economics and Viv Read & Associates, 2007). This pool has medium to coarse sand sediments with less than 10% silt/clay (Davies et al. 1996). Most sediment has accumulated on the eastern bank.

With good public access to the pool from Mackies Crossing, removal of sediment from this pool could increase public amenity values.

## 8.7 Mile Pool

There is limited information for Mile Pool. This pool is located downstream from the York townsite. Surveys show that this small pool has reduced in length, although it retains a significant depth and is locally popular for picnics (WRC and AWC, 2002c). This pool could be self-scouring.

## 8.8 Photos of pools in Section 7, 8 and 9

*Tipperary Pool in May 1999*
*(Photo courtesy Viv Read)*

*Meares Pool at Mackie Siding*
*(Photo courtesy Bernard Kelly)*

# 9 Section 10—York

This section of the Avon River flows from the Gwambygine Bridge to the northern end of the York townsite. There were four river pools in this section of the Avon River:

- Blands (Town) Pool
- Railway Pool
- Cold Harbour
- Mt Hardy Pool.

Mt Hardy Pool and Cold Harbour Pool have completely filled with coarse sand sediment. They were not included in the 1996 pool survey.

In 2002 excavation work was undertaken upstream of Balladong Bridge, in Parkers Reach, and at Railway Pool to create a sediment trap to detain river sediments and prevent them from being transported further downstream to Blands Pool, a popular tourist location, where removal would be significantly more difficult and costly.

## 9.1 Blands (Town) Pool

Blands Pool is located between the Balladong Road bridge and Mongers Crossing in York. This section of the river has high public access with a river walk trail on the foreshore from Balladong Street to Mongers Crossing. It is also a popular recreation site for picnics at the Avon Park in the townsite.

Bed sediment of the pool is medium/coarse sand with 20% silt/clay at either end of the pool with a high clay content (>90%) towards the centre of the pool (Davies et al. 1996).

A management plan for Blands Pool was developed in 2000. One of the aims of the plan was to identify and combat sediments entering the pool. Parkers Reach, upstream of Blands Pool, was choked with a sediment slug. The shire was keen to have the sediment removed before the winter flows carried the sediments into the Town Pool. The pool project was undertaken as a partnership with the Shire of York and the Water and Rivers Commission (WRC). In April 2002 the sand slug was removed and the river channel redefined.

Reconstruction of a stone crossing (at the old Mongers Bridge site) was carried out by the WRC during the autumn of 2002, in partnership with Green Corps and the Shire of York. Repairing the riffle effectively raised the level of Blands Pool by 400 mm.

## 9.2 Railway Pool

This pool is immediately upstream of the railway bridge, 1 km from the York townsite. Railway Pool was not surveyed in the 1996 survey. Railway Pool is maintained to trap sediment, reducing the risk of infill for Blands Pool. The Department of Water has surveyed the pool and found the pool is approximately 170 m long with an average depth >2 m and almost half filled with coarse sand.

In April 2002, 100 m of the river pool was excavated on the upstream side of the railway bridge and 3300 $m^3$ of coarse sediment was extracted from the pool. In April 2006 Department of Water surveyed the pool and observed a sand slug in the upstream section of the pool. Future work at this pool could include revegetation work to stabilise the banks that were disturbed during excavation.

## 9.3 Photos of pools in Section 10

*Blands Pool in York*
*(Photo courtesy Bernard Kelly)*

*Railway Pool looking upstream*
*(Photo courtesy Nina King)*

*Excavation of Railway Pool in 2002*
*(Photo courtesy Nina King)*

*Restoring the depth to Railway Pool 2002*
*(Photo courtesy Nina King)*

# 10 Section 11 and 12—Gwambygine to Edwards Crossing

This section of the Avon river is 17.9 km long beginning at Seaton Ross Bridge at Edwards Crossing, downstream of Gwambygine Road East Crossing, between the townsites of York and Beverley. There are four significant pools in this section of the River. They are:

- Gwambygine Pool
- Oakover Pool (Fleays Pool)
- Yangedine Pool (also known as Avondale or Brouns Pool)
- Seaton Ross Pool (Robins Pool).

There is little information available for Oakover, Yangedine and Seaton Ross pools.

## 10.1 Gwambygine Pool

Gwambygine Pool is located 13 km south of York. It is one of the few Avon River pools remaining in good condition. The pool has a maximum depth of 4 m, making it the deepest pool upstream of York (WRC and ARMA, 2001a). Gwambygine Park is located on a reserve adjacent to the Avon River just downstream of the pool. The park has excellent visitor facilities. Gwambygine Park is an ‘Avon Ascent’ site established for environmental education.

This pool has been of focal interest for the River Conservation Society, York (RCSY). Projects initiated for the pool include: fencing, revegetation of the foreshore and channel upstream of the pool, biological surveys, vegetation condition assessments, water quality monitoring and bird surveys. A biological survey completed by RCSY in 1999 also provides useful information on the aquatic fauna of the pool. A management plan for Gwambygine Pool has been prepared in consultation with local land owners and the River Conservation Society, York.

Sediment consists of silt/clay throughout the pool except at the upstream section toward a sand slug where medium coarse sand dominates (Davies et al. 1996). Sediment has been removed from the pool with a long reach excavator on two occasions. In May 1996, 8300 $m^3$ of sediment was removed, and in May 1999 another 4060 $m^3$ was extracted (WRC and ARMA, 2001a). While some coarse sediment has been removed, there is further potential for increased sedimentation from unconsolidated sand slugs upstream of the pool. Since 2002, some stabilisation of these slugs, using various methods, has been attempted with varying degrees of success.

## 10.2 Oakover Pool

Oakover Pool is 100 m downstream of Oakover Crossing. This pool is reported to have filled considerably with coarse sediments within two years of the river training scheme (WRC and ARMA, 2001c). The sediments are mostly silt/clay becoming medium coarse sand at the upstream end of the pool (Davies et al. 1996). Small, shallow pools of water occur between bars of sediment. The potential for sediment in Oakover Pool to transfer to Gwambygine Pool is low because the energy during flood flow is inadequate to scour the pool (WRC and ARMA, 2001c).

## 10.3 Yangedine Pool

Yangedine Pool is next to Avondale Park on the Great Southern Highway. This pool has filled significantly (90%) with coarse sediment and the pool depth was generally less than 0.25 m during the 1996 pool survey (Davies et al. 1996). Salinity of the pool measured 2900 mg/L (Davies et al. 1996). The relatively low salinity is probably due to fresh inflow from the Dale River.

## 10.4 Seaton Ross Pool

Seaton Ross Pool is downstream of the Avon Road bridge on the Top Beverley York Road. Survey information shows that the pool was 1 km long with a depth of 2.65 m (Davies et al. 1996). This pool is half filled by coarse sediments although it does have high, (>40%) fine sediment deposition (Advanced Choice Economics and Viv Read & Associates, 2007).

## 10.5 Photos of Gwambygine Pool

*Gwambygine Pool (Photo courtesy Peter Kata)*

*Removal of sediment from Gwambygine Pool, 1999 (Photo courtesy Peter Kata)*

# 11 Section 13—Edwards Crossing to Beverley Townsite

This section of the river is 6.81 km long from Beverley townsite to Edwards Crossing. There are two once-magnificent pools in this section of the river.

- Speldhurst Pool
- Beverley Town Pool.

## 11.1 Speldhurst Pool

Speldhurst Pool is located upstream of Edwards Crossing. Prior to the river training scheme the pool was close to 600 m long. Records from the 1996 River Pool Survey indicate that the pool had reduced in size to 220 m and has a depth of 1.4 m (Davies et al. 1996). Bed sediments consist of coarse sand with 20–30% silt/clay (Davies et al. 1996).

No work has been done on Speldhurst Pool, which now contains a huge slug of sediment, and has retreated back from its downstream boundary due to sediment deposition over the years (WRC and AWC, 2002d).

## 11.2 Beverley Town Pool

The Beverley Town Pool is a major feature of the town of Beverley. The pool is located upstream from the Vincent Street Bridge and the downstream boundary is at a rock weir constructed in 1993. The Shire of Beverley has taken a close interest in the Town Pool over many years. Engineering surveys have been completed and there have been projects to assist summer water retention, and to create an attractive picnic area.

In 1992 a sediment slug encroaching at the upstream end of the pool had advanced to approximately 350 m of the weir (DoE, 1999). In 1993, 1600 $m^3$ of sediment was removed from the downstream section of the pool in an effort to improve water quality and restore the aesthetic value of the area (DoE, 1999).

Bed sediments vary in the pool. There is a mixture with 55–70% medium sand in some sections and 85–95% silt and clay in others (Davies et al. 1996). The 1996 survey estimated 70% of the Beverley Town Pool to be filled with sediment.

In 1999 a Sediment Management Plan was developed for the pool. A riffle was also constructed upstream of the pool to trap sediments and minimise sedimentation to the main pool area.

## 11.3 Photos of Beverley Town Pool

*Beverley Town Pool in looking upstream from Vincent Street bridge*
*(Photo courtesy Fred Bremner)*

*A dragline removing sediment from Beverley Town Pool in 1993*
*(Photo courtesy Fred Bremner)*

# 12 Section 14, 15 and 16—Beverley to Qualandary Crossing

This section includes 40 km of the Avon River from the outflow of Yenyening Lakes below Qualandary Crossing to upstream of the Beverley townsite. Along most of this river section the adjoining lands are broadacre farming properties. This section of the Avon River is degraded and the pools are threatened. According to the river recovery plan for this section there were once 29 pools on this section of the river (WRC and AWC, 2002e).

The pools such as Jurakine and Eyres Pool varied in size from small billabongs and waterholes to large pools over a kilometre in length. Four pools were nominated for recovery in the river recovery plans. They are:

- Eyres Pool
- Kokeby Pool
- Jurakine Pool
- Green Pool.

These pools were not included in the Avon River Survey in 1996 and there is a lack of information available for the four pools. Actions in the RRP for this section of the Avon River suggest riffles and sediment traps should be installed in the river upstream of the four priority pools when funds are available. The recovery plan also nominated Green Pool as a potential demonstration recovery site.

## 12.1 Photos of pools in Section 14, 15 and 16

*Eyres Pool (Photo courtesy Phyllis Graham)*

*Jurakine Pool (Photo courtesy Phyllis Graham)*

# 13 Section 17—Yenyening Lakes

This section covers the Yenyening Lakes on the Salt River. The lake system is located approximately 25 km north east of Brookton, 137 km from Perth. The Yenyening Lakes system is at the foot of the Salt River which drains the Lockhart and Yilgarn catchments (an area of approximately 88 300 km$^2$), covering most of the Avon River Basin (WRC, 2002). The highly saline water of Salt River flows into Yenyening Lakes which discharges into the Avon River at Qualandary Crossing.

The lake system does not have significant river pools and will not be referred to in this report. A separate management plan was developed in 1996 (reviewed in 2002) for Yenyening Lakes. The Yenyening Lakes Management Committee is responsible for implementing the strategy.

*Aerial photo of Ski Lake, part of the Yenyening Lake system (Photo courtesy Bernard Kelly)*

# 14 Section 18—Avon River South Branch

This section covers 18.5 km of the Avon River South Branch which occurs between the town of Brookton and the locality of Mt Kokeby. There are no remaining river pools in the Avon River South Branch. One Mile Pool located downstream from Brookton was popular for recreation but is now filled with coarse sediment. Many other smaller pools, some suitable for swimming, once existed on the river, although their location is now obscured by sediment (WRC and ARMA, 2001b).

There are extensive coarse sediments that have accumulated in the channel bed of the Avon River South Branch. These originate from erosive processes in the channel bed following the river training scheme, and from sediments transported from adjacent tributaries. This is evident from coarse sediment deposition at the confluence of tributaries and the river. The sediment load in the channel is high and generally unconsolidated.

## 14.1 One Mile Pool

One Mile Pool is downstream of the Brookton townsite. Although now filled with sediment, the site remains attractive due to extensive rock outcropping and a river meander. Some people remember swimming in One Mile Pool, which is within walking distance of the town. This pool was once deep enough for diving into from a four-metre-high tower (see photo to the left) but is now filled with sediment (WRC and ARMA, 2001b).

*Remnants of a diving board structure at One Mile Pool (Photo courtesy Viv Read)*

The Seabrook Aboriginal Corporation, which has freehold title to the river in this location, has a strong interest in rehabilitating this site for general community use. A walk trail either side, or perhaps both sides, of the river between town and the pool has been suggested.

Previously, a significant deterrent to development of this site for public access has been the discharge of effluent to the river from the town wastewater treatment plant situated upstream of the pool. The effluent being discharged contributes to increased nutrient levels of the water downstream.

Department of Water is working on a project in partnership with the Shire of Brookton to construct a nutrient stripping zone at the treatment plant site.

The wetland will be designed to detain and strip nutrients from the effluent being discharged from the plant before it enters the Avon River.

With plans in place to minimise the impacts on water quality by waste-water being discharged from the treatment plant, recovery of One Mile Pool began in May 2007. Approximately 3000 $m^3$ of coarse sediment was removed from the pool using a long-reach excavator in an effort to restore the depth and enhance the ecological and recreational values of the pool. The Department of Water has also developed a revegetation plan for this site. Planting began in July 2007 in partnership with the Seabrook Aboriginal Corporation.

## 14.2 Photos of One Mile Pool

*One Mile Pool looking upstream prior to sediment removal. (Photo courtesy Prue Dufty)*

*Weir-like structure at the downstream end of One Mile Pool. (Photo courtesy Prue Dufty)*

*Long-reach excavator removing sediment from the pool. (Photo courtesy Michael Allen)*

*One Mile Pool with depth restored after sediment removal*
*(Photo courtesy Michael Allen)*

# 15 Section 19—Aldersyde–Kweda

This section covers 60 km of the Upper Avon River, 25 km east of the town of Brookton, from Yenyening Lakes upstream to Squires Road. The influence of the RTS in this section of the Avon is from Qualandary crossing to Aldersyde. Upstream of Aldersyde the river was not altered by the RTS.

There are 10 major pools on this section of the Avon River that are locally well known. Many of the pools were used for picnics, swimming, water supply, the past practice of sheep-washing (e.g. at Stock Pool) and the now illegal sport of duck-shooting (Viv Read & Associates, 2006b). Six pools are considered to be a priority for on-going management. They are:

- Boyagarra Pool
- Dwardadine Pool
- Quandadine Pool
- Dwarlacking Pool
- Jangerin Pool.

These pools were not included in the river survey of 1996 and as a result there is little information relating to them. A detailed management plan has been prepared for Boyagarra Pool and a restoration program was implemented following the release of the management plan in 1999.

The remaining four pools have been substantially filled with sediment and may not be feasible to recover. These pools are:

- Bullrush Pool
- Beardlucking Pool
- Stock Pool
- Neuralgin Pool
- Little Dwarlacking Pool.

During a river and foreshore survey conducted by Viv Read & and Associates for Department of Water, a further 25 river pools that are less well known were locally identified. Three of the smaller remnant pools are located downstream of Aldersyde while 22 are located upstream in the unaltered section of the River (Viv Read & Associates, 2006b). Given the number of small pools identified in the upstream section of the river, unaltered by the RTS, it is possible that many more smaller pools could have been lost in the downstream section of the river as a result of the RTS.

## 15.1 Boyagarra Pool

Boyagarra Pool is located upstream of Qualandary Crossing, 19 km north-east of Brookton. The pool is approximately 600 m long and had a maximum depth of 3 m prior to infilling (Viv Read & Associates, 2006b). Sediments of the pool consist of medium coarse sands upstream and high silt/clay content downstream (Viv Read & Associates, 2006b).

*A Management Plan for the Rehabilitation of Boyagarra Pool* was completed in 1999 for the Water and Rivers Commission (now Department of Water) by the Centre for Water Research at the University of Western Australia. This pool has been used as a demonstration and trial site for restoration techniques in the Avon waterways. Restoration works at this site have been underway with the Friends of Boyagarra Pool since February 2000 and include revegetation of the banks, floodplain and adjoining land, removal of excess sediment from the pool, fencing of a section of the river and installation of logs on the banks for native fish habitat. In 2001 and 2002 approximately 6000 $m^3$ of coarse sediment was removed from the pool.

Surveys of Boyagarra Pool after the removal of sediment show that there has been little infill of the pool due to reforming of the original braided structure of the upstream channel (Viv Read & Associates, 2006b). It was noted in the Department of Water's RRP (2006c) that the sediment load is depleted downstream of the Boyagarra Pool and this may limit the opportunity for channel rehabilitation.

## 15.2 Dwardadine Pool

Located upstream of Dangin Mears Rd crossing. There is easy public access to this pool and remnants of fringing vegetation including *Eucalyptus rudis*. The pool is approximately 250 m long with a water depth of 2 m (Viv Read & Associates, 2006a). The sediments of the pool have not been determined.

## 15.3 Quandadine Pool

Quandadine Pool is located approximately 500 m south of the Kweda townsite, and can be accessed via Kweda Road. According to field observation carried out by Viv Read & Associates (2006a), this pool could have originally been over 1.5 km in length. The type of sediment in the pool is unknown but there appears to be a significant sand slug at the upstream end of the pool. The upstream section of the pool is completely filled with sediments but the downstream end appears to have remained relatively deep with a depth of approximately 1–2 m.

Remnant vegetation present on the left-hand side of the pool, facing upstream, is of high conservation value and the majority of the natural vegetation is on vacant Crown reserve. There is an opportunity here for the formation of a river conservation reserve.

## 15.4 Dwarlacking Pool

Dwarlacking Pool is located upstream from the intersection of Wilson Road and Dwarlacking Road. This pool was a popular swimming and picnic site for the local community (Viv Read & Associates, 2006b). Remnants of an old diving board structure can be seen in the photo on page 36.

This site remains an attractive public place with Crown reserves on either side of the river. Evidence suggests there is fresh seepage in the upstream reach of the pool, keeping the pool environment relatively healthy (Viv Read & Associates 2006a).

Field observations carried out by Viv Read & Associates (2006a) indicate the pool has substantially filled with sediments but could have a water depth greater than 2 m in some sections. The type of sediment in the pool is unknown.

## 15.5 Jangerin Pool

Jangerin Pool is located downstream of Squires Road crossing. Limited information regarding the condition of this pool is available. The pool appears to be deep with limited sediment infill (Viv Read & Associates, 2006a). The pool features a stabilised island that joins up with the Crown reserve on the left-hand side bank when the water levels are low. Livestock have access to the right-hand side of the bank, which is causing erosion, and the riparian vegetation is sparse.

## 15.6 Photos of pools in Section 19

*Boyagarra Pool (Photo courtesy Martin Revell)*

*Dwardadine Pool (Photo courtesy Viv Read)*

*Remnants of a diving board structure at Dwarlacking Pool (Photo courtesy Viv Read)*

*Jangerin Pool (Photo courtesy Viv Read)*

# 16 Section 20—Upper Avon River, Yealering Lakes

The Yealering Lakes section is located within the Shires of Corrigin and Wickepin, approximately 250 km south-east of Perth. The lakes form the headwaters of the Avon River.

The Yealering Lakes section of the Avon River differs from the other river recovery plan sections in that it is focused on the management of the lakes, including the major tributaries and their surface-water catchments. The condition of the Avon River channel in this section is not well known. River pools are not considered to be locally significant in this section, therefore this section of the Avon is not referred to in this report.

*An aerial photo of Lake Yealering (Photo courtesy Jenny Davis)*

# 17 The Dale River

The Dale River catchment is 1367 km$^2$ located west of the town of Beverley (Department of Water, 2006). The Dale River joins the Avon River approximately 10 km downstream of Beverley, delivering relatively fresh water to the Avon River system. Unlike the Avon River the Dale was not affected by the river training scheme and the basic structure of pools linked by braided channels is still in place.

The river recovery plan for the Dale River identifies 25 named pools on the Dale River that vary in size and importance (Department of Water, 2006). There is limited information on the location and size of all 25 pools on the Dale. The Department of Water's RRP (2006b) also suggests that they are all virtually filled or are filling with sand and clay sediment. The active erosion of the banks is the major source of sediment in the Dale River.

*Mile Pool (Photo courtesy Kate Gole)*

The Dale river recovery plan nominates three river pools as 'demonstration pools' where a program of rehabilitation and pool protection could be undertaken. These pools are:

- Waterhatch Pool
- Mile Pool
- Mandiakon Pool.

Mile Pool and Mandiakon Pool are fed by relatively-fresh groundwater, emanating from deep sandy soils unaffected by salinity (Department of Water, 2006). Protection of groundwater is essential for the long-term health of these pools and should be considered in future management strategies.

No work has been done to remove sediment or to minimise sediment inflow into any of the Dale River pools. There is good road access to all three pools although further investigation is needed to determine the type and amount of sediment in each pool.

# 18 River pool recovery

Efforts to recover river pools on the Avon River have already taken place. In consultation with local government authorities, community groups, indigenous stakeholders, landholders and neighbours, management plans have been prepared and/or recovery work has been undertaken at the following pools:

- Long Pool
- Katrine Pool
- Northam Town Pool
- Burlong Pool
- Blands Pool
- Railway Pool
- Gwambygine Pool
- Beverley Town Pool
- Boyagarra Pool
- One Mile Pool, Brookton.

The recovery of the river pools aims to restore the pools as near to their natural state as possible. Management options for the pools may include removal and disposal of existing sediment, installing sediment traps (riffles) to minimise infill, stabilising unconsolidated channel sediment with vegetation, fencing and revegetation of the surrounding riparian zone, and monitoring and maintenance.

## 18.1 Sediment extraction

Removing sediment from the pool can restore the original depth of the pool to maintain aquatic habitat with a functioning ecosystem during the drying summer months. Preference for extraction is given to pools with good machinery accessibility and pools containing coarse sand sediments which have commercial value. If there is water in the pool, sediment can be removed by dredge or long reach excavator. If the pool is dry or filled with sediment, an excavator or front-end loader can be used. Sediment extracted from the pool is stockpiled so it can be transported offsite.

## 18.2 Sediment control

Controlling channel sediment involves installing sediment traps such as riffles and snags and stabilising unconsolidated channel sediment with vegetation. Riffles and snags contribute to channel stability by reducing the velocity of flow, forcing sediment deposition and thereby trapping sediment upstream of the riffle structure.

## 18.3 Revegetation

Vegetative buffer strips along the foreshore can slow runoff and stop suspended sediment from being transported into the river. Instream vegetation can slow water flow, prevent bank erosion, detain soil and sediment and provide valuable habitat for fauna.

## 18.4 Fencing

Fencing both sides of the river and river pools is an important management option. Fencing protects existing riparian vegetation allowing for revegetation and natural regeneration and also excludes stock from the waterway. The better the riparian vegetation, the greater the possibility that sediments in surface run-off will be trapped prior to entering the waterway.

## 18.5 Monitoring and maintenance

Monitoring and maintenance is an important step in evaluating and maintaining the success of the recovery project. Monitoring may include testing the water quality of the pool to identify changes, conducting fauna surveys, checking the success rate of revegetation plantings or surveying the pool to assess the rate of infill. Maintenance could include weed control, repairing constructed riffles or extracting more sediment to retain the depth of the pool.

## 18.6 The approval process

Before undertaking a river pool recovery project there is an approval process that needs to be considered. The river pool recovery process must involve consultation with relevant land holders, the Aboriginal community, local government authorities and state government agencies such as Department of Water and DEC.

Written consent must be sought from Aboriginal Elders, and relevant licences and permits need to be obtained from the appropriate local government authority or state government agency before work commences.

For more information on river restoration management options refer to the Water and Rivers Commission River Restoration Manual.

## 18.7 Photos of recovery work

*Sediment being removed from Railway Pool and transported off site*
*(Photo courtesy Nina King)*

*Riffle constructed upstream of Beverley Town Pool to trap sediment*
*(Photo courtesy Bernard Kelly)*

*Revegetation work on the edge of Boyagarra Pool to stabilise the banks*
*(Photo courtesy Brendan Oversby)*

*Fencing at Boyagarra Pool to protect riparian vegetation and exclude stock*
*(Photo courtesy Bernard Kelly)*

# 19 River pool prioritisation

All information available for the significant river pools, as identified by the RRPs, has been summarised in Appendix C. Taking into consideration that only 26 of the major river pools were surveyed in 1996, and the format used when preparing the RRPs has changed over the years, information available for the individual river pools varies. Based on the information available and the management options for recovery, the following selection criteria have been used to prioritise the river pools.

## 19.1 Ecological value

Although the ecological value of the Avon River pools is recognised, little is understood about the complex ecology of individual pools. For the purpose of prioritising the pools, a pool is ecologically significant if it has one or more of the following:

- significant depth to retain water and provide habitat during the summer months;
- foreshore vegetation capable of sustaining a variety of terrestrial fauna;
- located adjacent to a reserve.

## 19.2 Community value

Pools with a strong community focus and significant social value are recognised as a priority for management.

## 19.3 Ease of access

Access to some of the Avon River pools is limited from a main road. Good road access to the pool is important for machinery and to transport the river sands offsite.

## 19.4 Protection of downstream assets

Protection of downstream assets refers to the pools along the Avon River that are currently trapping sediment, preventing downstream pools from filling. For example, Burlong Pool traps sediment and protects Northam Town Pool from infill. Maintaining the depth of these pools can minimise the threat to downstream assets of sedimentation.

## 19.5 Sediment type

Preference for sediment removal will be given to pools that have marketable coarse sands. At present, pools with a high concentration of finer sediments are less likely to be considered for sediment extraction. However, if some use and/or financial gain can be made by on-selling fine sediment some time in the future, then this may increase the opportunities for removing the finer sediments. The removal of fine

sediments can also release nutrients into the water body when disturbed and would need to be managed correctly to reduce this impact.

Table 4 has been used as a basic tool to prioritise the pools on the Avon River using the ecological, social and economic criteria mentioned above. Generally, pools with four or more criteria have been allocated high priority for rehabilitation. Those with three criteria are of medium priority and two or less, low priority. The table lists the pools in order of high, medium or low in upstream order. Based on ecological, social and economical values, 16 pools have been nominated as high priority for rehabilitation. They are:

- Walyunga Pool
- Cobblers Pool
- Long Pool
- Jimperding Pool
- Glen Avon Pool
- Katrine Pool
- Burlong Pool
- Tipperary Pool
- Meares Pool
- Railway Pool
- Gwambygine Pool
- Beverley Town Pool
- Eyres Pool
- Boyagarra Pool
- Dwarlacking Pool
- Mandiakon Pool on the Dale River.

Pool prioritisation is subject to change and dependant on consultation with community, local government, Aboriginal groups and agencies.

### Table 4 Avon River pool prioritisation

| River pool | Ecological value | Community value | Ease of access | Protection of D/S assets | Sand or coarse sediments | Priority |
|---|---|---|---|---|---|---|
| **Walyunga Pool** | ✓ | ✓ | No data | ✓ | No data | **H** |
| **Cobblers** | ✓ | ✓ | ✓ | ✓ | ✓ | **H** |
| **Long** | ✓ | ✓ | ✓ | ✓ | ✓ | **H** |
| **Jimperding** | | ✓ | ✓ | ✓ | ✓ | **H** |
| **Glen Avon** | ✓ | ✓ | ✓ | | ✓ | **H** |
| **Katrine** | ✓ | | ✓ | ✓ | ✓ | **H** |
| **Burlong *** | | ✓ | ✓ | ✓ | ✓ | **H** |
| **Tipperary** | ✓ | ✓ | ✓ | | ✓ | **H** |
| **Meares** | ✓ | ✓ | ✓ | | ✓ | **H** |

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*

| River pool | Ecological value | Community value | Ease of access | Protection of D/S assets | Sand or coarse sediments | Priority |
|---|---|---|---|---|---|---|
| **Railway** | ✓ | | ✓ | ✓ | ✓ | **H** |
| **Gwambygine *** | ✓ | ✓ | ✓ | | ✓ | **H** |
| **Beverley Town *** | ✓ | ✓ | ✓ | | ✓ | **H** |
| **Eyres** | ✓ | ✓ | ✓ | ✓ | No data | **H** |
| **Boyagarra *** | ✓ | ✓ | | | ✓ | **H** |
| **Dwarlacking** | ✓ | ✓ | ✓ | | No data | **H** |
| **Mandiakon**** | ✓ | ✓ | ✓ | | ✓ | **H** |
| **Boongarup Pool** | No data | ✓ | No data | ✓ | No data | **M** |
| **Deepdale** | | ✓ | | ✓ | ✓ | **M** |
| **Wilberforce** | ✓ | ✓ | | | ✓ | **M** |
| **Church** | | ✓ | | ✓ | ✓ | **M** |
| **Cold Harbour** | | ✓ | | ✓ | ✓ | **M** |
| **Mt Hardy** | | ✓ | | ✓ | ✓ | **M** |
| **Oakover** | | ✓ | ✓ | | ✓ | **M** |
| **Yangedine** | | ✓ | ✓ | | ✓ | **M** |
| **Kokeby** | ✓ | ✓ | ✓ | | No data | **M** |
| **Jurakine** | ✓ | ✓ | | ✓ | No data | **M** |
| **Green** | ✓ | ✓ | | ✓ | No data | **M** |
| **Mile**** | ✓ | | ✓ | | ✓ | **M** |
| **Bungarah Pool** | No data | No data | No data | No data | No data | **L** |
| **Moondyne Pool** | No data | No data | No data | No data | No data | **L** |
| **Red Banks** | ✓ | ✓ | N/A | | | **L** |
| **Millards** | | | ✓ | | ✓ | **L** |
| **Egoline** | | | | | ✓ | **L** |
| **Northam *** | ✓ | ✓ | ✓ | | | **L** |
| **Jangaling** | | ✓ | | | ✓ | **L** |
| **Little** | | | | | No data | **L** |
| **Mile** | ✓ | ✓ | | No data | No data | **L** |
| **Blands *** | ✓ | ✓ | | | ✓ | **L** |
| **Seaton** | | ✓ | | | | **L** |
| **Speldhurst** | | ✓ | | | ✓ | **L** |
| **One-Mile** | | ✓ | | | ✓ | **L** |
| **Dwardadine** | | ✓ | ✓ | | No data | **L** |
| **Quandadine** | ✓ | | ✓ | | No data | **L** |
| **Jangerin** | ✓ | | | | No data | **L** |
| **Waterhatch**** | ✓ | ✓ | ✓ | | ✓ | **L** |

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*

# Appendix A: Management sections of the Avon River

| Section name | Section number | Description | Length (km) |
|---|---|---|---|
| **Lower Avon** | 0 | Upstream boundary of Avon Valley National Park to Walyunga Pool, confluence of Wooroloo Brook | ~34.00 |
| **Avon Gorge** | 1 | Upstream from Avon Valley National Park to confluence with Jimperding Brook | 11.23 |
| **Deepdale Valley** | 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 on the south bank of the river | 9.16 |
| **Extracts** | 4 | Goomalling Bridge to Glen Avon Weir | 11.30 |
| **Katrine** | 5 | Glen Avon Weir to Northam Town Weir | 17.45 |
| **Northam** | 6 | Northam Town Weir to confluence with Spencers Brook | 10.13 |
| **Muresk** | 7 | Spencers 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 |
| **Yenyening Lakes** | 17 | Yenyening Lakes on Salt River (not part of the Avon River) | |
| **Brookton** | 18 | Confluence of the Avon River South Branch to Brookton townsite | 18.46 |
| **Aldersyde–Kweda** | 19 | Qualandary Crossing to Squires Road Crossing | 60.00 |
| **Yealering** | 20 | Squires Road Crossing to Lake Yealering | ~28.00 |
| **Dale River** | | Confluence of the Dale with the Avon near York Williams Road, Upstream near McCallum Road. | ~70.00 |

# Appendix B: Water quality of river pools

| River pool | Total phosphorus mass in the sediment (kg) | Average total phosphorus mass in the water (kg) | Average total phosphorus in the water (mg/L) | Salinity (TDS) (mg/L) |
|---|---|---|---|---|
| **Walyunga Pool** | No data | No data | No data | No data |
| **Bungarah Pool** | No data | No data | No data | No data |
| **Boongarup Pool** | No data | No data | No data | No data |
| **Moondyne Pool** | No data | No data | No data | No data |
| **Cobblers** | No data | No data | 0.208 | No data |
| **Long** | 1679.04 | 1.674 | 0.028 | 7891 |
| **Jimperding** | 1236.48 | 0.276 | 0.025 | 9152 |
| **Deepdale** | Dry | Dry | Dry | Dry |
| **Red Banks** | No data | 0.389 | 0.017 | 7003 |
| **Millards** | 8232.00 | 16.134 | 0.197 | 16955 |
| **Glen Avon** | 16296.00 | 80.465 | 0.605 | 14373 |
| **Katrine** | 510.72 | 1.849 | 0.129 | 18157 |
| **Egoline** | Dry | Dry | Dry | Dry |
| **Northam** | 8659.20 | 10.784 | 0.129 | 20787 |
| **Burlong** | Dry | Dry | Dry | Dry |
| **Jangaling** | Dry | Dry | Dry | Dry |
| **Wilberforce** | 5156.16 | 5.639 | 0.056 | 12100 |
| **Church** | 4428.00 | 6.278 | 0.135 | 16500 |
| **Little** | Dry | Dry | Dry | Dry |
| **Tipperary** | 2856.00 | 1.676 | 0.176 | 25520 |
| **Meares** | 638.40 | 1.341 | 0.133 | 21442 |
| **Mile** | No data | No data | No data | No data |
| **Blands** | 4805.28 | 4.095 | 0.081 | 15081 |
| **Railway** | No data | No data | No data | No data |
| **Cold Harbour** | Dry | Dry | Dry | Dry |
| **Mt Hardy** | Dry | Dry | Dry | Dry |
| **Gwambygine** | 5068.80 | 19.415 | 0.237 | 9482 |
| **Oakover** | 1882.56 | 0.514 | 0.056 | 4048 |
| **Yangedine** | 600.00 | 0.664 | 0.044 | 2800 |
| **Seaton** | 5184.00 | 12.586 | 0.203 | 20510 |

| River pool | Total phosphorus mass in the sediment (kg) | Average total phosphorus mass in the water (kg) | Average total phosphorus in the water (mg/L) | Salinity (TDS) (mg/L) |
|---|---|---|---|---|
| **Speldhurst** | 1003.20 | 0.817 | 0.102 | 34262 |
| **Beverley Town** | 2232.00 | 1.235 | 0.081 | 30748 |
| **Eyres** | No data | No data | No data | No data |
| **Kokeby** | No data | No data | No data | No data |
| **Jurakine** | No data | No data | No data | No data |
| **Green** | No data | No data | No data | No data |
| **One-Mile** | No data | No data | No data | No data |
| **Boyagarra** | No data | No data | *0.044* | *15807* |
| **Dwardadine** | No data | No data | *0.046* | *22966* |
| **Quandadine** | No data | No data | No data | No data |
| **Dwarlacking** | No data | No data | No data | No data |
| **Jangerin** | No data | No data | No data | No data |
| **Mandiakon**** | No data | No data | No data | No data |
| **Mile**** | No data | No data | No data | *2992* |
| **Waterhatch**** | No data | No data | *0.016* | *5706* |

*Source: Davies et al. (1997)*

*Notes: Values in italics represents data that has been collected at that site during 2006 by Department of Water staff and averaged.*

*Pools marked with ** are on the Dale River.*

*Davies et al. converted TP concentrations to TP mass assuming a channel width of 40 m and 0.3 m thickness of bed sediment at the calculated TP concentration.*

# Appendix C: Collation of river pool data

| River pool | Length (m) | Depth (m) | % Full sediment | Estimated sand volume ($m^3$) | Pool sediments | Availability of land | Road access | Distance to Perth (km) | Method of extraction | Previous sediment removal | Channel condition | Adjacent land use | Risk of infill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Walyunga | No data | No data | No data | No data | No data | Public | unknown | 43 | unknown | No | unaffected RTS | Walyunga National Park | Med |
| Bungarah | No data | No data | No data | No data | No data | Public | unknown | 43 | unknown | No | unaffected RTS | Walyunga National Park | Med |
| Boongarup | No data | No data | No data | No data | No data | Public | unknown | 44 | unknown | No | unaffected RTS | Walyunga National Park | Med |
| Moondyne | No data | No data | No data | No data | No data | unknown | unknown | 70 | unknown | No | unaffected RTS | Avon Valley National Park | High |
| Cobblers | No data | 0.82 | 10 | ~5 000 | Predominantly shallow medium/coarse sand over rock. | Private | good | 80 | N/A | No | unaffected RTS | Farm/Boral | Low |
| Long | 1060 | 3.19 | 40 | 50 000 | Predominantly coarse sand, upstream samples showing 40–60% clay/silt | Private | good | 85 | f/e loader | Yes | unaffected RTS | Farm | High |
| Jimperding | 920 | < 0.50 | > 50 | ~100 000 | Dominated by medium/coarse sand with a few samples showing 35% clay/silt | Private | good | 90 | f/e loader | No | uncon-solidated sediment | Farm | High |
| Deepdale | Filled | Filled | 100 | ~150 000 | Coarse sand | Private | poor | 95 | f/e loader | No | filled | Farm | ~ |
| Red Banks | 400 | 4.41 | No data | No data | Bed material has a hard crust, samples could not be taken | Private | N/A | 90 | N/A | No | self-scouring pool | Lloyd's Reserve D/S | Low |

*Source: Davies et al. 1997; Advance Choice Economics and Viv Read & Associates, 2007.*

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*
*Adjacent landuse: 'Res' is short for reserve*

| River pool | Length (m) | Depth (m) | % Full sediment | Estimated sand volume ($m^3$) | Pool sediments | Availability of land | Road access | Distance to Perth (km) | Method of extraction | Previous sediment removal | Channel condition | Adjacent land use | Risk of infill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Millards | 1750 | 3.93 | 70 | 150 000 | Upstream samples medium coarse sand, downstream high (>90%) clay/silt | Public | good | 91 | dredge | No | No data | Industry/ Farm | |
| Glen Avon | 1750 | 3.76 | 15 | 30 000 | Downstream samples high clay/silt changing to 70% medium/coarse sand content upstream | Private | good | 97 | dredge | No | No data | Farm | Low |
| Katrine | 280 | 1.96 | 80 | 65 000 | Generally medium/coarse sand with ~5% clay/silt | Public | good | 98 | f/e loader | Yes | No data | Viveash & Wilkerson Res | |
| Egoline | Filled | Filled | 100 | 160 000 | Coarse sand | Private | poor | 103 | f/e loader | No | filled, sand slug | Farm | ~ |
| Northam * | 1100 | 1.20 | 70 | 230 000 | Predominantly silt/clay (>60%) with high sand content near weir | Public | good | 97 | dredge | Yes | No data | Residential | |
| Burlong * | ~1000 | <2.00 | unknown | 65 000 | Sand | Public/ Private | good | 99 | dredge | Yes | No data | Reserves/ Farm | High |
| Jangaling | Filled | Filled | 100 | 70 000 | Sand | Private | poor | 105 | f/e loader | No | filled | Farm | ~ |
| Wilberforce | 820 | 4.35 | 5 | 10 000 | Silt/clay downstream. Upstream has higher sand content and 40% gravel at upstream end | Private | poor | 111 | N/A | No | No data | Farm | |
| Church | 750 | 2.40 | 35 | 100 000 | 85% silt/clay in the downstream section. Increasing sand content moving upstream. | Private | poor | 79 | dredge | No | No data | Farm | |
| Little | Filled | Filled | 100 | No data | No data | Private | poor | 76 | unknown | No | filled | Sm Crown Res RHS / Farm | |

*Source: Davies et al. 1997; Advance Choice Economics and Viv Read & Associates, 2007.*

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*
*Adjacent landuse: 'Res' is short for reserve*

| River pool | Length (m) | Depth (m) | % Full sediment | Estimated sand volume ($m^3$) | Pool sediments | Availability of land | Road access | Distance to Perth (km) | Method of extraction | Previous sediment removal | Channel condition | Adjacent land use | Risk of infill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tipperary | 340 | ~1.00 | 95 | 160 000 | Generally silt/clay with an increasing sand content moving upstream | Private | good | 74 | dredge | No | No data | Farm | |
| Meares | 350 | 1.25 | 70 | 30 000 | Generally medium/coarse sand with less than 10% silt/clay | Private | good | 83 | dredge | No | No data | Farm | |
| Mile | ~200 | ~< 2.00 | No data | No data | No data | Private | unknown | 72 | unknown | No | possibly self-scouring | Residential | Low |
| Blands * | 710 | ~2.00 | 15 | 10 000 | Medium coarse sand with 20% silt/clay at ends of pool. 90% silt/clay towards the centre of pool | None | good | 75 | dredge | Yes | No data | Residential | High |
| Railway | 170 | > 2.00 | 40 | 4 000 | Coarse sand | Private | good | 80 | f/e loader | Yes | sand slug upstream | Farm / Residential | High |
| Cold Harbour | Filled | Filled | 100 | No data | Coarse sand | Private | unknown | 77 | f/e loader | No | uncon-solidated sediment | Farm / Residential | ~ |
| Mt Hardy | Filled | Filled | 100 | No data | Coarse sand | Private | unknown | 79 | f/e loader | No | uncon-solidated sediment | Farm / Residential | ~ |
| Gwambygine * | 800 | 3.75 | 30 | 10 000 | Silt/clay throughout the pool. Upstream has sand slug with medium/coarse sand | Public | good | 87 | dredge | Yes | No data | Farm / Crown Res U/S | |
| Oakover | 740 | 0.65 | 90 | 40 000 | Higher content of silt/clay at downstream end. Upstream has medium/coarse sand with 2% silt/clay | Private | good | 95 | f/e loader | No | No data | Farm | |

*Source: Davies et al. 1997; Advance Choice Economics and Viv Read & Associates, 2007.*

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*
*Adjacent landuse: 'Res' is short for reserve*

| River pool | Length (m) | Depth (m) | % Full sediment | Estimated sand volume ($m^3$) | Pool sediments | Availability of land | Road access | Distance to Perth (km) | Method of extraction | Previous sediment removal | Channel condition | Adjacent land use | Risk of infill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yangedine | 500 | 0.70 | 90 | 60 000 | Generally coarse sand with low silt/clay content | Private | good | 99 | f/e loader | No | uncon-solidated sediment | Farm | |
| Seaton | 1000 | 2.65 | 50 | 55 000 | Silt/clay at downstream end. Upstream has higher medium sand content with > 40% silt/clay | Private | poor | 104 | f/e loader | No | No data | Farm | |
| Speldhurst | 220 | 1.38 | 90 | 55 000 | Generally coarse sand with 20–30% silt/clay. Downstream is silt/clay | Private | unknown | 106 | f/e loader | No | uncon-solidated sediment | Residential | |
| Beverley Town * | 310 | 3.58 | 70 | 50 000 | Mixture 55–70% medium sand in some sections, 85–95% silt/clay in others | Public | good | 110 | dredge f/e loader | Yes | No data | Residential | High |
| Eyres | No data | No data | No data | No data | No data | Public/ Private | good | 110 | unknown | No | No data | Crown Reserve | |
| Kokeby | No data | No data | No data | No data | No data | Private | good | 134 | unknown | No | No data | Farm / strip of Crown Res | |
| Jurakine | No data | No data | No data | No data | No data | Private | poor | 142 | unknown | No | No data | Farm / strip of Crown Res | |
| Green | No data | No data | No data | No data | No data | Private | poor | 147 | unknown | No | No data | Farm | |
| One-Mile | No data | No data | No data | No data | Coarse sand | Private | poor | 153 | f/e loader | No | uncon-solidated sediment | Farm | |

*Source: Davies et al. 1997; Advance Choice Economics and Viv Read & Associates, 2007.*

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*
*Adjacent landuse: 'Res' is short for reserve*

| River pool | Length (m) | Depth (m) | % Full sediment | Estimated sand volume ($m^3$) | Pool sediments | Availability of land | Road access | Distance to Perth (km) | Method of extraction | Previous sediment removal | Channel condition | Adjacent land use | Risk of infill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boyagarra * | ~600 | ~3.00 | No data | ~10 000 | Medium coarse sand upstream with a high percentage of silt/ clay downstream | Private | poor | 155 | f/e loader | Yes | braided channel upstream | Farm / Crown Reserve | |
| Dwardadine | ~250 | ~2.00 | No data | No data | No data | Private | good | 183 | unknown | No | unaffected RTS | Farm / Res? | |
| Quandadine | No data | ~1–2 | > 30 | No data | No data | Public/ Private | good | 188 | unknown | No | unaffected RTS | Farm / Crown Reserve | |
| Dwarlacking | ~300 | > 2.00 | No data | No data | No data | Public | good | 195 | unknown | No | unaffected RTS | Crown Reserve | Low |
| Jangerin | No data | No data | No data | No data | No data | Public/ Private | poor | 200 | unknown | No | unaffected RTS | LHS Crown Res / Farm | |
| Mandiakon** | No data | shallow | No data | No data | Sand/clay | Private | good | 138 | unknown | No | unaffected RTS sand slug | Farm | |
| Mile** | No data | No data | No data | No data | Sand/clay | Private | good | 132 | unknown | No | unaffected RTS | Farm | |
| Waterhatch** | No data | No data | No data | No data | Sand/clay | Private | good | 124 | unknown | No | unaffected RTS | Farm | |

*Source: Davies et al. 1997; Advance Choice Economics and Viv Read & Associates, 2007.*

*Notes: Pools marked with (*) have management plans*
*Pools marked with (**) are on the Dale River*
*Adjacent landuse: 'Res' is short for reserve*

# Glossary

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| Algal bloom | The rapid, excessive growth of algae, generally caused by high nutrient levels and favourable conditions. |
| Anabranch | A secondary channel of a river which splits from the main channel and then later rejoins the main channel. |
| Anoxic | Deficiency of oxygen in the water. |
| Basin | Area of land drained by a river and tributaries (river catchment) (see *catchment*). |
| Catchment | The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater. |
| Ecosystem | A term used to describe a specific environment, e.g. lake, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources. |
| Electrical Conductivity (EC) | A measure of salinity. The higher the electrical conductivity of a stream the greater the salinity. |
| Environment | All the biological and non-biological factors that affect an organism's life. |
| Erosion | The subsequent removal of soil or rock particles from one location and their deposition in another location. |
| Eutrophication | An excessive increase in the nutrient status of a waterbody. |
| Floodplain | A flat area adjacent to a waterway that is covered by floods every year or two. |
| Floodway & bank vegetation | Vegetation which covers the floodway and bank part of the riparian zone. The vegetation which actually grows in the floodway or on the banks above the stream. |
| Foreshore | Area of land next to a waterway. |
| Groundwater | Water which occupies the pores and crevices of rock or soil. |
| Habitat | The specific region in which an organism or population of organisms live. |
| Large woody debris | A branch, tree or root system that has fallen into or is immersed (totally or partially) in a waterway. |
| Monitoring | The regular gathering and analysing of information to observe and document changes through time and space. |

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| Native species | Species that normally live and thrive in a particular ecosystem. |
| pH | Technically this is the hydrogen ion (H+) concentration in the water. It is the simplest measure of acidity/alkalinity. |
| Regeneration | Vegetation that has grown from natural sources of seed, from vegetative growth, or has been artificially planted. |
| Riffle | The high point in the bed of the stream (accumulation of coarse bed materials) where upstream of accumulations a shallow pool is formed. Downstream from the crest of the accumulation the water is often shallow and fast flowing. |
| Riparian zone | Refers to the zone directly adjoining a waterway. Any land that adjoins, directly influences, or is influenced by a body of water. |
| Salinisation | The accumulation of salts in soil and water which causes degradation of vegetation, land and water quality. |
| Sediment | Soil particles, sand and other mineral matter eroded from land and carried in surface waters. |
| Sedimentation | The accumulation of soil particles within the channel of a waterway. |
| Slug | Sediment deposit (see also *sediment* and *sedimentation*). |
| Tributary | A stream, creek or small river which flows into a larger stream, river or lake. |
| Turbidity | A measure of the suspended solids in the water. |
| Water quality | The physical, chemical and biological measures of water. |

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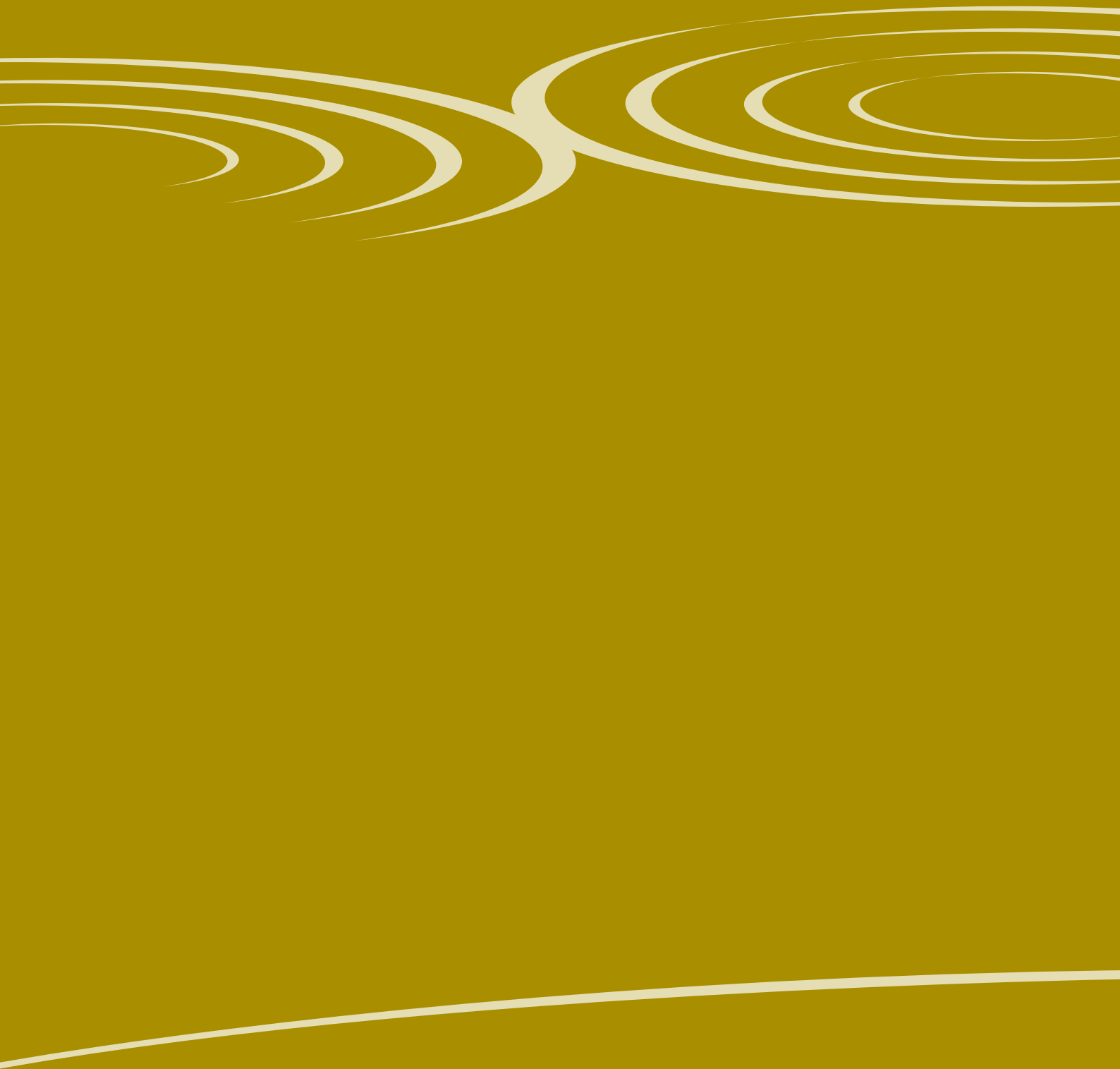

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