AVON RIVER MANAGEMENT AUTHORITY

GWAMBYGINE POOL MANAGEMENT PLAN

WATER AND RIVERS COMMISSION REPORT
WRM 27
2001
WATER RESOURCE MANAGEMENT SERIES

Water and Rivers Commission

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GWAMBYGINE POOL MANAGEMENT PLAN

Prepared by

Viv Read & Associates

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Acknowledgments

Preparation of the Gwambygine Pool Management Plan has benefited by significant contributions from people committed to a healthy and sustainably managed river environment.

The River Conservation Society has a well established interest in Gwambygine Pool. Members readily provided their information, which included biological survey results, for use in planning. Dr Cicely Howell provided substantial information from her direct knowledge of the pool and has critically reviewed the text. Tony Clack arranged a survey of the pool by boat and provided good background information and keen insights into management requirements. Joy Fleay provided interesting recollections and Alan Savage provided useful comment on the biological survey.

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Gwambygine Pool, March 2001
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Preface

The Gwambygine Pool Management Plan is an important contribution to integrated river and catchment management in the Avon River Basin. The pool is significant as one of the original 26 deep water pools along the Avon River that retains most of it's ecological integrity although this is in many ways threatened.

The pool and its management are of significant and continuing interest to the local York community through the York River Conservation Society. The Avon River Management Authority (ARMA) encourages and respects the efforts of local communities for river management. This management plan is intended to direct these interests and the required supporting resources towards priority management needs. The expected outcome is retention of a natural aquatic and riparian ecosystem to benefit future generations.

The process undertaken in the development of this plan has ensured that the competing and sometimes conflicting uses or management issues have been systematically evaluated using available information and the advice of people with relevant experience. The plan is compatible with the local management guidelines of ARMA and the broader waterways management policies of the Water and Rivers Commission, and has considered the principles of the Western Australian Heritage Council.

The Gwambygine Management Plan has been prepared for ARMA under direction from the Water and Rivers Commission. It is also intended for use by those with an active interest in the pool or river environment, including the York River Conservation Society. The plan is also expected to be of interest and useful to adjacent landholders, the Shire of York, Nyoongahs of the Avon region, members of the scientific community and the public of Western Australia.

This plan has been reviewed and approved by the Water and Rivers Commission, endorsed by ARMA, recognised by the York Shire Council and accepted by the River Conservation Society.

1 Introduction

1.1 Purpose of the management plan

Gwambygine Pool is one of the original 26 major river pools on the main channel of the Avon River, a major river system in the south-west of Western Australia. It is now one of the longest and deepest river pools. The overall health of the pool and its fringing vegetation appear to be good at present although serious threats are well recognised.

Channel manipulation as part of the River Training Scheme (1956–72) was intended to reduce flooding. However, it resulted in severe erosion of riverbanks and bed structure. Ensuing sedimentation has significantly affected half of the river pools such that six pools are now completely filled. Gwambygine is similarly threatened by sediment infill.

Salinity, which is a well recognised threat to land, also has major impact on rivers. In the Avon River, stream flow salinity is increasing and saline groundwater beneath the river is rising which may be affecting fresh water seepage to the pool. The eventual full impact of salinity on the aquatic biota of the pool is not certain.

Excess nutrients in the pool can cause eutrophic conditions which could threaten ecological functions of the pool.

A Management Plan for Gwambygine Pool is required to establish priorities for appropriate management action in response to these threats so as to meet community expectations of a healthy aquatic ecosystem in the pool. It is also required to best manage a range of other issues, including weeds, fire and recreational use. These actions need to be undertaken in a way that is compatible with other river management processes and with adjacent land use.

Goals of the Gwambygine Pool Management Plan are:

- To have the pool, its aquatic ecosystem and environs well described and understood
- To have a Vision for the pool and environs consistent with other river management and accepted by the local and wider community
- To have the threats and opportunities of the pool and environs well understood
- To have a preferred set of management options to achieve the Vision
- To have priorities for management action
- To have local and broader community and government arrangements for implementation of the plan

The plan is for a 10 year period with a review after the first 5 years.

1.2 Avon River and catchment management

The Avon River provides natural drainage for a river basin with an area of 120 000 km^2. Three catchments make up the Avon River Basin. The eastern Yilgarn and Lockhart catchments in the east provide variable stream flow that discharges into the Yenyenning Lakes south-east of Beverley via the Salt River. These lakes discharge to the main channel of the Avon River on average four years out of ten.

The Dale River enters the Avon River 12 km upstream of Gwambygine Pool. The relatively fresh stream flow from this river is important particularly during the warmer months when there is low or no flow in the Avon River.

The wetter Avon catchment is located mostly to the west of the Meckering Line that signifies an area of rejuvenated drainage due to landscape uplift during formation of the Darling Scarp. The stream flow regime has resulted in river pools along the length of the main channel within this catchment.

The catchment of the Avon River has altered significantly since European settlement. Most land in the catchment has been cleared of natural vegetation for agricultural use. There is now greater stream flow that carries increased loads of sediment and nutrients. Salinity is significantly affecting both land and water. Concern about flooding of towns and agricultural land along the river led to implementation of the River Training Scheme (RTS) between 1956 and 1972. Bulldozers deepened the channel and removed the islands to increase stream flow velocity. Sediment mobilised by these actions is filling the river pools.

The deteriorating condition of the river and catchment resulted in community action through local government initiative in 1984. This led to the formation of the Avon River Management Authority (ARMA) through provisions under the *Waterways Conservation Act (1975)* with support from the State Government in 1993.

The mission of ARMA is "to restore and manage the natural functions of the Avon River system for the long-term benefit of the community". Detailed information is contained within the 'Avon River Management Programme' (WRC, 1999).

ARMA is responsible for implementation of the Gwambygine Pool Management Plan but will take actions though partnership arrangements with adjacent landowners and others interested in pool management.

Further concern about managing natural resources in the river basin lead to the formation of the Swan-Avon Integrated Catchment Management (ICM) Program in 1994. Under this, a partnership group (the Avon Working Group) with members from community, government and industry was formed to provide local leadership to landcare groups in natural resource management. The role of the AWG is outlined in the Avon River Basin Natural Resource Management Plan (access at www.avonicm.org.au).

The River Conservation Society Inc. (RCS) formed in 1990 due to local community concern about the Avon River near York. This group has taken an active interest in the river including Gwambygine Pool.

1.3 The planning process

The process for developing the Gwambygine Pool Management Plan builds on the substantial information base about the pool and river management that is already available. The plan adopts a broad management context that also considers:

- River management
- Catchment management
- Biogeographical context
- Cultural and heritage value
- Local and wider community expectations

Plan preparation was based on stages of:

1 Information review

2 Consultation RCS members, the community and agency personnel to identify and develop key issues

3 Development of an acceptable Vision for the pool and associated environment

4 Assessment of key environmental criteria

5 Proposal of management options that address key issues

6 Presentation of an acceptable plan with actions, responsibilities and priorities for implementation.

The review process will ensure that the draft plan is technically robust, consistent with ARMA policy and regional plans and generally accepted by the local and wider community.

2 Description

2.1 Location and environs of Gwambygine Pool

Location

Gwambygine Pool is located on the Avon River 13 km south of York and is accessed from the Great Southern Highway south of Gwambygine Road East crossing. Its specific geographic location is Latitude 32° South and Longitude 116° 48" East.

The Gwambygine Pool Management Plan specifically considers the area extending southwards from the Gwambygine Road East crossing upstream to the confluence of Marr's Creek (Avon Location 501) shown on Map 1. This is a total distance of 2.4 km (500 m from the crossing to the pool, 1100 m pool length and 900 m upstream). Laterally, the area considered is approximately 0.5 km either side of the river. The surrounding landscape is referred to in the Plan to provide a local biogeographical context.

Tributaries

Direct contributions to the pool from adjacent catchments are only minor. Black Jack Creek directly to the west of the pool has a catchment area of approximately 4 km^2. Flow from Black Jack Creek contributes about 1% of the total pool volume and about 0.002% of average annual flow through the pool. A smaller tributary is to the east. Marr's Creek south west of the pool is also small. It is likely that the total discharge of this creek is contained within a domestic dam.

A significant tributary (21 km^2) west of the river discharging near Gilgering and one east of the river (5.5 km^2) discharging near Oakover have potential to influence the pool. Nockamany Creek (which flows under Wittenoom Bridge) is a significant tributary (35 km^2) but discharges downstream of the pool. Following an initial flush, stream flow from these tributaries should be relatively fresh during winter. They have potential to discharge considerable nutrients into the river as a result of intense summer storms.

The confluence of the Dale River is 12 km upstream from Gwambygine Pool. The Dale River has a lower salt load and greater period of flow than the Avon River and hence has a significant impact on the Pool. It is also significant due to the potential for sediment transport from the Dale to the Avon. The Dale River does have deep pools (e.g. Deep Pool) considered locally to have a healthy aquatic ecosystem (C. Howell, *pers. comm.)*. These may be ecologically significant for fauna recolonising other river pools downstream.

Broun's Farm gauging station is located 2.16 km downstream from the Dale River confluence. Stream flow records commenced in November, 1975.

Landscape

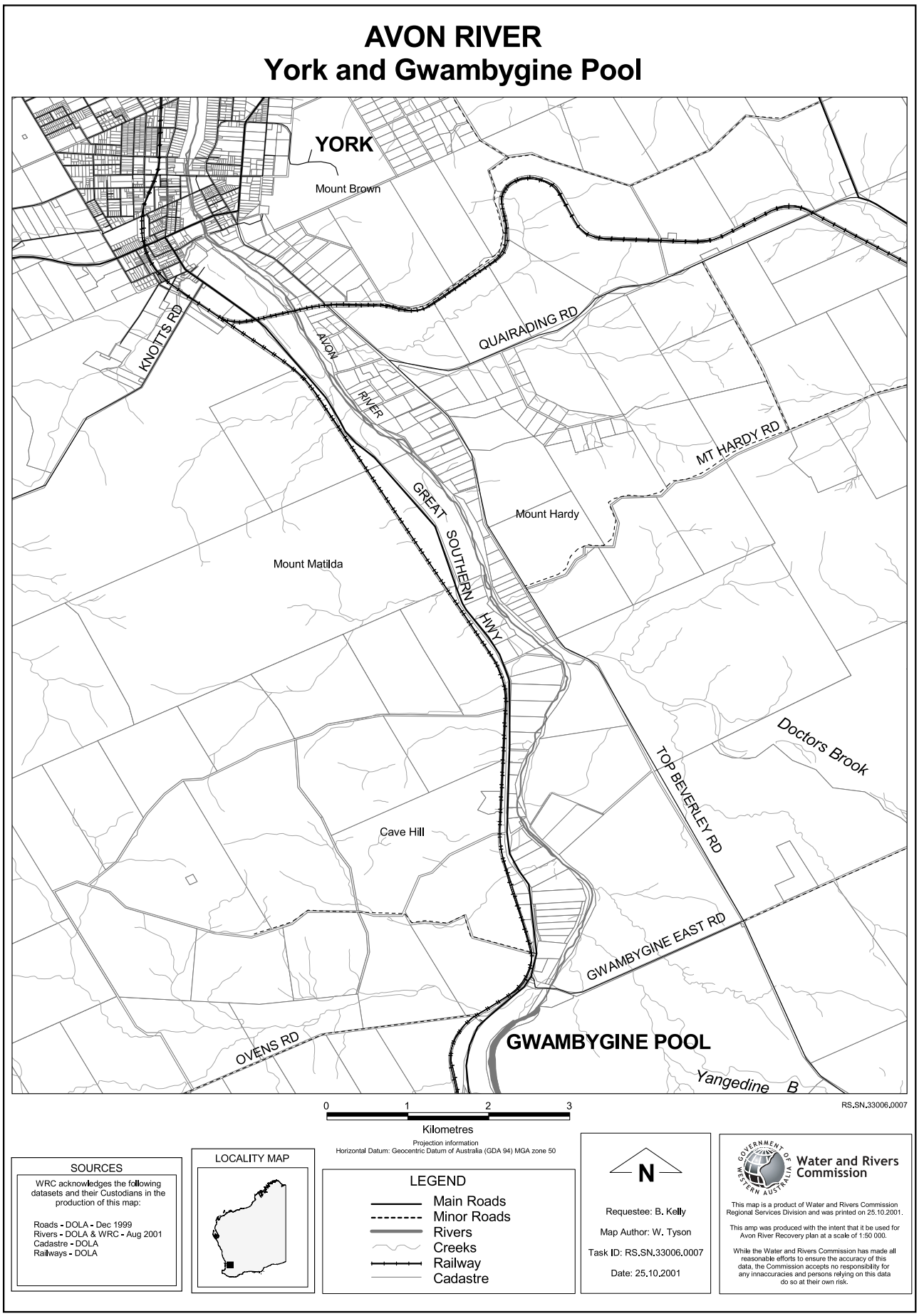
The land adjacent to the pool is described as the Avon Landscape unit (Lantzke and Fulton, 1992) characterised by alluvial terraces and floodplain. The alluvial and colluvial sediments are heterogeneously distributed. Sandy textured soils in sheets or seams have high hydraulic transmissivity. These may transmit fresh groundwater towards the river or into pools. Local observations suggest that such subterranean seepages do enter Gwambygine Pool.

Most agricultural land falls within the landscape characterised by steep, irregular hills with rocky red and brownish grey loamy soils (the York unit). Conspicuous steep rocky hills occur, the most significant to the pool being on Avon Location 40. Fresh water seepage to the pool from this area may occur.

Neighbouring properties

Only two private landholdings are adjacent to the pool. Avon Location 35 (Venerys) to the west and Avon Location 36 (Boyle) to the east. Both properties have their river-side boundaries defined by the high water mark. A small downstream property on the east side is Avon Location 0 (Scott). Upstream of the pool, private landholdings are Avon Location 40 (Fleay) on the east and Avon Location 501 (Marr) on the west.

Reserve 8125, located adjacent to the upstream end of the pool on the west side, is not vested. The responsible agency is the Water Corporation.



Map 1: Avon River, York and Gwambygine Pool

Photo 1: Members of the River Conservation Society examine aquatic fauna collected from Gwambygine Pool. Left-right: Cicely Howell, Shane Moad, Helen Pearce. *Photo courtesy Tony Clack RCS.*

'Gwambygine Park' is located on a Reserve (vested with the Shire of York) The Park has developed visitor facilities (environmental signage, walkways, BBQ's and toilets) located adjacent to the Avon River downstream from the Gwambygine Road East crossing and is one of three "Avon Ascent" sites established for environmental education.

2.2 Pools of the Avon River

Gwambygine Pool is one of 26 major river pools formed naturally in the channel of the Avon River. All river pools occur west of the Meckering Line, a geographic demarcation of the eastern extent of tectonic uplift that formed the Darling Scarp. Uplifting of the landscape rejuvenated river processes causing deep pools to form.

Why the pools were formed where they are is not well understood. Some pools appear to have formed where the Avon River channel width narrows. Others may be due to a sediment delta below the confluence of a tributary, or by being located on a bend where stream flow accelerates. There could also be geological control over the formation of Avon River pools. Gwambygine Pool may have formed due to narrowing channel characteristics (the pool width is approximately half that of the former braided river channel width upstream). There is no significant tributary to form an upstream delta, nor is the pool located on a bend. The section of river containing Gwambygine Pool is approximately north-south and suggests there are no geological controls, however the co-occurrence of steep rocky hills east and west of the river upstream of the pool suggests possible geological constriction, and may also affect local groundwater dynamics.

Pool spacing along the river is greater than is normal for meandering river channels (JDA, 1997). The distance from Gwambygine Pool upstream to Fleays Pool is 4 km and the distance downstream to Cold Harbour Pool is 7.9 km.

Avon River pools are generally also symmetrical pools and the braided channel cross-sections are asymmetrical. This is opposite to expectations for a meandering river (JDA, 1997).

A detailed description of the Avon River pools is provided in "Avon River Pool Survey" (Jim Davies and Associates, 1997). Volume 5 of the Avon River Survey undertaken by ARMA.

Photo 2: Spoil banks remaining from the River Training Scheme. *Photo courtesy Viv Read.*

2.3 Physical and biological information

Two surveys have provided significant information relevant to the management of Gwambygine Pool. The first is a survey of all major pools along the Avon River in 1996 as a part of the Avon River Survey (JDA, 1997). This survey provided a systematic assessment of the physical and chemical parameters of each pool.

The second is a biological survey undertaken over a 20 month period (1995–97) by the River Conservation Society (RCS, 1999). The intention of this survey was to identify the biological diversity of the pool and to provide benchmark measures of the aquatic ecosystem for future reference. Biological and chemical information was recorded monthly from 5 sites. A review of the chemical and some phytoplankton information recognises the survey as important for providing baseline data but noted that the information was not suitable for significant trend analysis. The signal score for aquatic biota ranged from 4 in winter to 6 in summer. (Top score = 9)

Pool morphology

Gwambygine Pool is 1109 metres long (without sediment infill) and 38 metres wide. The maximum depth measured in November 1996 was 3.75 m (JDA, 1997) but the water level then was 25 cm below the discharge channel invert so the maximum depth is 4 m. The depth of the pool decreases to a depth of 2.25 m at a distance 550 m from the outlet (Figure 2.1). The average depth is 2.43 m based on 18 measures at 50 m intervals along the length of the pool (JDA, 1997).

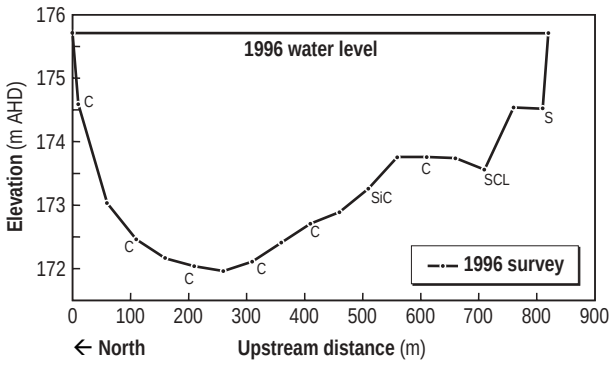


Figure 2.1: Gwambygine Pool Bed Elevation (from JDA, 1997)

Photo 3: Narrow channel at the southern end of the pool. *Photo courtesy Viv Read.*

Originally, 11 of the 26 Avon River pools had a length greater than 1 km. Under current conditions, there are only 6 pools longer than Gwambygine Pool (assuming it's full length of 1109 metres).

There are only 4 pools of greater depth in some parts (Lloyds, Millards, Glen Avon and Wilberforce) although not all of these retain pool length during summer. Gwambygine Pool is the deepest pool upstream from York.

Sediments

Prior to the River Training Scheme, the heavily braided channel of the Avon River carried very little coarse bed-load sediment (Bill Till, *pers. comm.*). Low stream flow periods had higher stream velocity in the channel and lower velocity in the pools. The opposite occurred for high flow events (JDA, 1997). The Avon was then a relatively low energy river system.

Disturbance of the river bed upstream of Northam by the RTS during the 1965–1969 period caused channelisation that significantly increased stream flow velocity. Because the channel bed was ripped to encourage scouring, the exposed river banks began to erode. Bank erosion is greatest during high flow when more of the banks are in contact with stream flow. The river has adequate power to transport coarse sediments into the pools but inadequate power to excavate the sediments from the pools.

Sediment transport generally is greatest when the channel is flowing at "bankfull" capacity. Flood flows are generally of lower velocity (Bill Till, *pers. comm.)*, however floods have an extensive period of "bankfull" capacity as the flood attenuates. It is during this period that massive sediment mobilisation can occur.

While widening of the over-all channel has not occurred due to the RTS (JDA, 1997), the actions of bulldozers pushing debris laterally have formed linear embankments. These perform as levees causing higher stream flow velocity and blocking access of floodwaters to adjacent floodways. These unintended levees occur upstream from Gwambygine Pool.

Stream flow entry to Gwambygine Pool is through a narrow channel that causes increased stream velocity and hence increased bed load transport capacity. The narrow channel

is due in part to the naturally occurring river morphology (related to geological constriction by adjacent granite outcrops) and in part due to the artificial levees. The original main channel is against the east bank but is cut off by the levee on that bank. Levees on the western side also restrict flow access to a floodway that would discharge to the pool through Reserve 8125.

The total volume of the pool is 186 000 m^3 (without sediments). This is approximately 6% of the total volume of all 26 major pools on the Avon River. In 1996 (prior to excavation), the volume of sediments in the pool was 50 000 m^3, which is 27% of the total volume of Gwambygine Pool (and 2.9% of all sediment in the river pools). The remaining volume of Gwambygine Pool is 136 000 m^3 (approximately 8.7% of total pool remnant volume).

The two pools downstream from Gwambygine Pool (Mt Hardy and Cold Harbour) are completely filled with sediment probably derived from the Mackie River. Upstream of Gwambygine, Oakover Pool filled with sediment within 2 years of the River Training Scheme. Yangedine Pool has also effectively filled with sediment in the last decade.

Sediment in Gwambygine Pool is finest at the outlet end and becomes increasingly coarse towards the inflow point. This uneven distribution is due to coarse sediment being less readily transportable than fine sediment. The inlet delta is well sorted coarse sand. The fine sediments have accumulated by settling from pool water probably sourced from catchment runoff. Up to 300 metres of the pool has been filled by coarse sediments. Annual coarse sediment inflow ranges from 110 m^3 to 1900 m^3 from surveys over 4 years (P. Kata, *pers. comm.*).

It is uncertain how much more unconsolidated sediment remains in the channel immediately upstream of the pool. The extent to which these unconsolidated bed sediments may be stabilised by revegetation (particularly by salt water couch) and the vulnerability of that vegetation to grazing, salinity or fire, is also unclear.

Nutrients

Gwambygine Pool has over 5000 kg total phosphorus attached to pool sediments (JDA, 1997). The fine texture and the chemical composition of these sediments suggests that the phosphorus load will remain attached rather than being released to the pool water. The area of interface between these sediments and pool water will not change significantly as more fine sediments are deposited in the pool so although the total phosphorus load in these sediments will increase, their contribution to dissolved phosphorus in pool water causing eutrophication will not increase. While these sediments remain undisturbed, they should not significantly contribute nutrients to the pool water. However, nutrients may be released if oxygen levels drop during or after prolific levels of algae growth. Potential for algal blooms is high in this case.

The dissolved phosphorus load in the pool water was approximately 4 kg when measured in November, 1996 (JDA, 1997). While this is only 0.08% of the total phosphorus load in the sediments, it is sufficient to cause hyper-eutrophic conditions. Total phosphorus concentrations exceeded the acceptable limits of 0.010-0.10 mg/L for healthy rivers and streams (ANZECC,1992). The concentrations in Gwambygine Pool ranged from 0.44 mg/L to about 0.665 mg/L during low flow conditions (RCS, 1999 and JDA, 1997). The potential for algal blooms and eutrophication is high.

Salinity

Salinity was measured in the pool each month at 5 locations over a 21 month period (January 1996 to September 1997) during the RCS survey. The range over this period is from the lowest level of 3750 mg/L at the southern end of the pool during May 1996 through to the highest level of approximately 25 400 mg/L also at the southern end in March, 1997. From local observations, the normal range is from 9620 mg/L to 16 500mg/L in summer although this can increase to 39 000mg/L within a 24 hour period and take 8–10 weeks to return to the normal range (C. Howell, *pers. comm.*).

From the survey results, there seems to be little difference between sites other than at the southern end (Site E) when measured at the same time. This suggests efficient mixing of pool water probably due mostly to wind although some pool stratification has been observed (C. Howell *pers. comm.*). The results also show both fresh and saline inflow from the southern end.

The decreasing salinity at the southern end of the pool for the period from January 1996 until stream flow commenced (in June) indicates fresh seepage into the pool. This may be due to an adjacent lens of deep sand south-west of the pool that extends onto Avon Location 501 (Marr). This sand lens probably overlays shallow clay and is adjacent to granite outcrop. Considering also the steep

gradient to the river, it is possibly significant in contributing to fresh water seepage. It is also possible that fresh seepage is derived from scree material at the base of the granite outcrop on Avon Location 40 (Fleay) east of the river. Neither of these sources is confirmed.

While other fresh seepage could occur to other parts of the pool, the water quality information so far obtained shows no evidence of this. Saline seepage from a rising regional groundwater aquifer is possible but again is unconfirmed.

The substantial increase in salinity (from 5000 mg/L to almost 22 000 mg/L) from February to March, 1997 at the southern end of the pool and the high level of salinity common throughout the pool in the following month is possibly linked to water released from Yenyenning Lakes through the control gate at Qualandary Crossing, 62 km upstream from Gwambygine Pool (see also Appendix One). High salinity inflow to Gwambygine Pool was measured on 29 March 1997. However, heavy rainfall that occurred on that day may also have caused a first flush of saline water into the pool.

Gwambygine Pool is less saline than other pools upstream from the Dale River confluence with the Avon River. This also suggests the importance of the fresher flows from the Dale River in the absence of saline water releases for Qualandary Crossing particularly towards summer prior to river flow ceasing.

Streamflows

'Broun's Farm' gauging station shows that the river flows on average 286 days of a year (78% of the time). The period of no-flow ranges from 30 to 111 days. The cease to flow date is usually during December. The average flow rate is 3.24 m^3/s and the average annual flow volume is 61 million m^3 (note: this is about 450 times the remnant volume of Gwambygine Pool! ie a flow rate that could fill the pool every 1.2 days throughout the year).

Flood flows

Flood flows appear to have discharged east from the pool 300 m from the northern end to a floodway parallel to the river. Debris suggests that the January 2000 flood overtopped the pool bank at this location by approximately 50 cm. The probability of recurrence of a flood of this magnitude is 1 in 20 years for a summer event, or 1 in 8 years considering all flood events (Muirden, 2000).

Fringing and floodplain vegetation

Natural vegetation extends both sides of the pool as a very narrow fringe restricted to the pool banks. The eastern bank

Photo 4: Degenerate *Eucalyptus rudis* on the east bank. *Photo courtesy Viv Read.*

Photo 5. An established stand of Bamboo on the west bank of the pool. *Photo courtesy Viv Read.*

has three dominant species (Flooded Gum, *Eucalyptus rudis*, Sheoak, *Casuarina obesa* and Paperbark, *Melaleuca raphiophylla*) with no understorey species other than annual weeds. The Flooded Gums are not regenerating and in places are senescent or dead. The cause may be a rising regional groundwater table increasing salinity in the root zone. Flooded Gums are more susceptible to salinity than Sheoak. Some waterbirds and other fauna require these trees for roosting and nesting. The vegetation on this bank was classified (after Pen and Scott, 1995) as C1 (understorey with weeds only, no erosion) during the Avon River Survey in 1996. The RCS has listed understorey species that do occur in the fringing vegetation during botanical surveys. These include extensive halophyte flats below the exit of the pool, and behind the levees.

Western fringing vegetation is similar but with the addition of York Gums (*E. loxophleba*). There is also one patch of bamboo on the west bank near "Gwambygine Homestead". Vegetation on the west bank was classified as B3–C1 (degraded, understorey mainly weeds) during the Avon River Survey.

Salt water couch has become established on eroding banks near the south end and at the north end. Sedges (*Bolboschoenus caldwellii* and *Cyperus gynnocaulos*) occur at the north and south end suggesting fresh seepage.

An aquatic plant in the pool is *Ruppia polycarpa.* This plant is introduced to the pool but is a valuable food resource for sustaining, aquatic biota, tortoises. and waterbirds (White Faced Heron, Spoonbill).

The floodplain on the eastern and western side of the river downstream from the pool is well vegetated. The dominant overstorey vegetation is *Casuarina obesa* with frankenia and halophytes as the dominant understorey. The floodplain adjacent to the pool both on Avon Location 35 (Venerys) and Avon Location 36 (Boyle) is used for agriculture.

Natural vegetation over-storey is in good condition on the 3.8ha water reserve (Reserve 8125). Actions are underway to rehabilitate some areas disturbed by spoil deposition during pool sediment excavation (B. Oversby *pers. comm.)*. The riparian vegetation in the reserve was classified as B1 (degraded, some weeds, understorey mainly native plants).

The RCS survey report contains a flora list for the pool (RCS,1999), including introduced species and weeds. The list is appended to this plan.

Macrofauna

Macrofaunal use of the pool is relatively high. The Western Grey kangaroo from adjacent hills water at the pool. Native water rats live along the banks, brush-tailed possums and bats will reside in tree hollows. In a vastly altered landscape, the pool is important to the survival of these remnant mammal populations. Trees with hollows are important.

A total of 63 species of birds have been recorded using the pool of which 22 species are waterbirds. This contrasts with just 12 species in a woodland 1km from the pool (RCS, 1999). Gwambygine provides an important summer and drought refuge for birds. Trees with strong and accessible branches for large bodied birds to rest and roost are important.

Cobbler were once caught in the pool but are now absent (J Fleay, *pers. comm.*). Five species of fish are now in the pool of which one is introduced (*Gambusia affinis*). Gilgies are common in the pool. Fish probably breed in the fresher southern end of the pool (T. Clack, *pers. comm*.).

The Oblong Tortoise is common and breeding at the pool. Survey results showed that they are reproducing well, in that all females were carrying eggs, but fox predation is high. Surprisingly there have been no recent observations of snakes at the pool but at least 3 species can be expected. There are five frog species identified but no systematic records of lizards to date.

A faunal list is provided in the biological survey report (RCS, 1999). The list is appended to this plan.

Macroinvertebrates

Over 50 species of macroinvertebrates are identified from 9 classification Orders by the RCS biological survey. While some species may be in high abundance, the diversity of this pool is less than other freshwater river pools in WA (A. Savage *pers. comm.*). Some of these species are essential food for the macrofauna.

The species occurrence information shown in the report suggests susceptibility by some to the onset of high salinity in April 1997 compared with the same period of the previous year which was less saline. Little is understood about the resilience of the river pool suite of invertebrate species following environmental perturbations such as a rapid or sustained increase in salinity, eutrophication or increased water temperature, however, many species of macroinvertebrates are sensitive to even mild fluctuations in water quality.

Phytoplankton

Samples were taken monthly at Sites B, C and E during the RCS biological survey (RCS, 1999 Appendix 3) and assessed by Wasele Hosja, Water and Rivers Commission.

The concentration of total phosphorus in pool water is high. As water temperature increases, the potential for phytoplankton blooms is also high. These conditions are greatest in autumn when there has been a long period without stream flow through the pool, ie residence times. The potential will also be high where there is fresh inflow from a high intensity summer storm that carries high nutrient concentrations load (soil, agricultural fertiliser or stock manure) that discharges in to the pool but is not flushed from the pool.

While the recorded levels of diatoms and of dinoflagellates was high during the RCS survey period, these are not considered to be a significant risk to the aquatic ecosystem or to human or animal health. Diatoms have potential as environmental health indicators (Jacob John *pers. comm.*.).

Photo 6: People enjoyed swimming off the jetty at Gwambygine. *Photo courtesy Tony Clack.*

Photo 7: Sheep dip and yards no longer in use. *Photo courtesy Viv Read.*

The existence of cyanobacteria (the Blue-green algae) suggests a greater risk. *Anabaenopsis* and *Oscillatoria* were recorded and have potential to become toxic. *Nodularia* and *Microcystis* were not recorded but are expected to exist, possibly as cysts in sediments. Both of these are potentially toxic. Some cyanobacteria are limited by high salinity. *Nodularia* is less common with salinity greater than 25 000 mg/L. However, it seems that the pool may not often exceed this salinity level (W. Hosja, *pers. comm.)*.

Conditions that lead to a phytoplankton bloom may then result in eutrophication. Under these conditions, the phytoplankton will fix oxygen during the day and produce high levels of NH_3 during the night. The resultant high Biological Oxygen Demand (BOD) may lead to anoxic conditions and potential for fish deaths.

Amoebic meningitis can occur in water conditions where salinity is less than 15 000–18 000 mg/L and the temperature is greater that 28°C. The water temperature was measured at 24-26°C during the RCS survey during the November 1995 to February 1996 period during which the salinity level was relatively low (6 000–9 000 mg/L) suggesting that the conditions for *Amoebic meningitis* could occur. This is a significant risk to people.

2.4 Historic and cultural values

Aboriginal people used the Avon River for food, water and recreation. Concentrations of artefacts have not been found as elsewhere (e.g. at Walyunga on the Darling Scarp) which suggests that their use of river pools was transitory (S. Hallam, *pers. comm.*). There is archaeological evidence of aboriginal land use remaining at Cave Hill located near Gwambygine Pool and in Reserve 8125 (C Howell *pers. comm.*).

The Wittenoom family built "Gwambygine Homestead" of adobe construction prior to 1837 on the west bank adjacent to the pool. It has remained occupied until the 1990s. It remains privately owned on 36.8ha of land adjacent to Gwambygine Pool.

Ruins of former homesteads also exist east of the river.

The Gwambygine School site is located nearby in Gwambygine Park. It was a typical one-teacher school of the Western Australian bush.

Gwambygine Pool was a significant focus for family and community social events. Many learnt to swim there. The water was sufficiently fresh and clean for swimming all summer. Some people carted water (even by hand in barrels) for domestic use (J. Fleay *pers. comm.*.).

River pools were traditionally used by farming families for domestic and stock water as well as for pleasure. Sheep were washed prior to shearing in river pools. Remnants of yards for washing are at Fleays Pool. There is the well of a sheep dip and a centrifugal pump on the east bank at the southern end of Gwambygine Pool and also sheep dip remnants at the northern end. Arsenic based chemicals were undoubtedly used. A farm rubbish tip with a range of chemical containers and other innocuous items is a few metres from the pool filling a small gully although seepage from this has been restricted.

2.5 Past pool management

Concern about deteriorating health of Gwambygine Pool since the River Training Scheme has lead to management actions by some adjacent landholders, local community (particularly the River Conservation Society) and government.

Adjacent landholders

Recognition of changing conditions has lead to the eastern banks being fenced and the western property being de-stocked. Upstream of the pool the river is also well fenced so that no livestock now have access to the river.

Photo 8. Coarse sediment in the pool. *Photo courtesy Peter Kata.*

Photo 9. Excavation of sediments from the pool. *Photo courtesy Peter Kata.*

Community

The York River Conservation Society is an active community-based group focussed on river management. The group formed in 1990 and has undertaken surveys, fencing and river rehabilitation projects.

Gwambygine Pool has been of specific interest to the RCS. Projects initiated for the pool include:

- Arranging fencing , revegetation and relocation of stock water supply
- Biological survey 1995-97 ("Biological Survey of Gwambygine" report)
- Vegetation condition assessment
- Water Quality Monitoring
- Microbiology study
- Study of the Oblong Tortoise (with Dr Gerald Kuchling, Univ. WA)
- Surveys of birds, water rats, insects and phytoplankton.

The Avon River Management Authority initiated surveys of the river and its pools. ARMA's Management Programme provides a strategic framework for management of the pool with respect for other riverine values.

Government

The Water and Rivers Commission funded and supervised removal of coarse sediment from the pool as requested by RCS and supported by ARMA. In May 1996, 8300 m^3 were excavated from Gwambygine and transported to the adjacent reserve. The sediments were disposed of locally under commercial contract.

In May 1999, a further 4060 m^3 of coarse sediments were removed. Surveys of the pool sediments are taken to measure the rate of sediment infill.

Local government planning strategies now reduce the potential for inappropriate development near the river within the Shire of York.

3 'Vision, Goals and Objectives' for Gwambygine Pool

3.1 Vision

The local community, including ARMA, agree that the future vision for the pool should be:

> *"Gwambygine Pool remains as a significant naturally productive deep water pool on the Avon River with healthy natural fringing vegetation and a stable aquatic ecosystem. The pool and adjacent landscape are integrated with other river and land management to provide significant biogeographical and heritage linkage.*
>
> *The historic and cultural values of the pools and adjacent areas are respected and protected. Future residents and visitors to the area enjoy these values as a part of the pool environment. It is a preferred place for contemplation and reflection. Recreation or other activities do not detract from these values.*
>
> *The pool is recognised as a place of scientific study. Understanding of the ecological functions leads to better river and pool management elsewhere."*

A relevant quote from the RCS Biological Survey report conveys community interest in the future of the pool:

> *"…link a time frame measured in millions of years for biodiversity, to a time frame measured in thousands of years for the aboriginal communities who have left their mark on the pool, and to a time frame measured in one hundred years and a few decades for European settlers whose pioneer homesteads still stand on the banks of the pool…."*

3.2 Management objectives for Gwambygine Pool

Four Management Objectives have been identified to guide actions towards achievement of the Vision:

1. To maintain a healthy and sustainable aquatic ecosystem in the pool supported by a well-structured and functioning fringing vegetation ecosystem.

Description

Gwambygine Pool has retained sufficient ecological integrity to be maintained as a healthy aquatic ecosystem into the future but is threatened in many ways. Management action is required.

Threats

- Coarse sediment infilling the pool reducing pool length.
- Fine sediment adding to the nutrient load in the pool and reducing pool depth.
- Increasing salinity of stream flow (annual and episodic increases).
- Fringing vegetation is degraded. There is little natural under-storey due in part to previous livestock grazing, increasing groundwater salinity and invasion by weeds.
- Changing fringing vegetation is reducing habitat opportunities for native fauna.
- Wild fire that could damage riparian vegetation or escape to/or from adjacent farmland.
- Weeds and feral animals (aquatic and terrestrial) that retard ecosystem functions and may affect adjacent farmland.

Opportunities

- To develop and demonstrate Best Practice for river pool management

Milestones

- Practical indicators of ecosystem health for the pool are identified and accepted for management.
- Baseline measures of the accepted indicators of ecosystem health are established.

2. To establish baseline scientific information and understanding for the pool and environs that enables change in river ecology to be detected and to guide management actions.

Explanation

The biological survey undertaken by the RCS provides an initial inventory of macro and micro flora and fauna associated with the pool. Little is understood about Avon River pool ecology.

Threats

- Use of the pool that detracts from the scientific integrity of ecological studies
- Inadequate or diminishing resources and interest from research institutions, government and community
- Difficulty of developing adequate understanding of river ecology to enable effective management responses.

Opportunities

- To document the full suite of species that comprise the communities of one river pool
- To understand changes in time within the aquatic ecosystem of the pool
- To understand ecosystem resilience or resistance to perturbations or changed conditions
- To identify relevant and practical indicators of ecosystem health
- To develop baseline information and monitor changing conditions and for management decisions (such as saline water release from Yenyenning Lakes)
- To establish Gwambygine Pool as a recognised indicator of environmental health for the Avon River.
- To provide an understanding of river pool ecology that assists with management of other river pools
- To generate interest in riverine ecology in the Avon.

Milestones

- Baseline measures of the accepted indicators of ecosystem health are established.
- Practical indicators of ecosystem health for the pool are identified and accepted for management.

3. To define appropriate scientific and recreational activity at Gwambygine Pool and its immediate environs to guide management planning.

Description

Gwambygine Pool has always been used for local community enjoyment prior to and after European settlement. The recreational opportunity has diminished due to poor water quality in summer. Many still seek opportunities to have access to the river. Facilities at Gwambygine Park and in the town of York provide alternative opportunities. The combination of good road access and reserve land adjacent to a relatively healthy pool provides good opportunities. There are good visitor facilities downstream at Gwambygine Park.

Threats

- Active or environmentally insensitive recreational use may diminish other recreational opportunities, damage the ecosystem (including breeding water birds) or interfere with scientific studies.

Opportunities

- The pool and environs have potential to provide good opportunity for passive, contemplative or enquiring recreational pursuits.

Milestones

- The preferred purpose of the pool is understood and respected (no report of inappropriate use)
- Facilities exist to encourage knowledge, appropriate activity and understanding of river pool ecology.

4. To have recognised bio-geographic, cultural and heritage linkage with the pool.

Description

The Avon landscape is vastly altered from its natural state. Small islands of remnant vegetation are outliers now to the narrow corridor of the Avon River. Linkage between these is important to provide summer and drought refuge for fauna and to allow re-colonisation of patches following disturbance (such as by fire).

Artefacts of European and Aboriginal settlement are found close to Gwambygine Pool. Appreciation of these values into the future can be enhanced by linkage with the river pools.

Threats

- Remnant vegetation on farms and along the river decreasing in ecological value
- Cultural and historic artefacts are lost or destroyed
- Knowledge and memories are not recorded
- Previous cultures and practices are not respected

Opportunities

- To increase bio-geographic linkage by in-fill revegetation
- To identify and preserve cultural and historic places and knowledge as a part of the pool and it's environs
- To integrate ecological and heritage value management planning.

Milestones

- A regional bio-geographic plan is prepared and accepted
- Cultural and historic values are recognised formally and are enhanced locally.

4 Management strategies

Seven Key Issues have been identified from current knowledge about Gwambygine Pool and from consideration of the threats to achieve the Vision for the pool.

They are:

- Sediment Control
- Salinity
- Nutrient enrichment
- Fringing vegetation decline
- Loss of faunal habitat and ecosystem function
- Weeds, feral animals and fire
- Recreation and other use options.

Six Management Strategies have been developed to address these Key Issues.

The Management Strategies refer to Management Zones for the pool and environs. The zones are:

2) the pool, including steep banks (P)
3) fringing vegetation of the pool (FVP)
4) floodplain adjacent to the pool (FpP)
5) floodways (billabongs) (FW)
6) upstream riparian ecosystem (URE)
7) downstream riparian ecosystem (DRE)
8) Reserve 8125 (R)
9) adjacent tributary catchments (ATC)

4.1 Sediment management strategy

Management of both coarse and fine sediment infill to Gwambygine Pool is required.

Coarse sediment management

Coarse sediment has been excavated from the pool on two occasions. While this does reclaim pool capacity, it is a relatively expensive management option with little long-term benefit. Surveys indicate that the annual sediment deposition rate is between 500 and 1900 m^3. At \$5 m^3, the annual maintenance cost would be \$2 500 – 9 500 plus monitoring costs. In practical terms, this would require an expenditure of up to \$100 000 (NPV) every 10 years to maintain pool capacity. Approximately 20% of these costs could be retrieved by sale of sediments.

This approach to coarse sediment management requires an on-going cost. The period over which sediment will continue to be delivered to the pool is uncertain. The bedload in the channel is largely unconsolidated. The banks of the channel in the river sections upstream of the pool are relatively stable however there is potential for additional sediment to be delivered from the channel and tributaries further upstream.

There is a need to establish criteria for initiating further excavation of sediment from the pool. This will be based on cost effectiveness and risk to the pool ecosystem. Recent photography and surveys show that coarse sediments have again deposited up to 240 m into the pool. Part of this length has large scour holes. It is suggested that sediment be allowed to accumulate up to 300 m, approximately 27% of the pool volume, into the pool before further excavation is arranged. This could occur over a period of 5–10 years. More frequent excavation is probably not cost-effective.

Action 4.1.1: Arrange monitoring to identify 300 m of sediment infill to the pool.

Action 4.1.2: Assess the potential for impact on the pool ecosystem when volume is reduced by 27%.

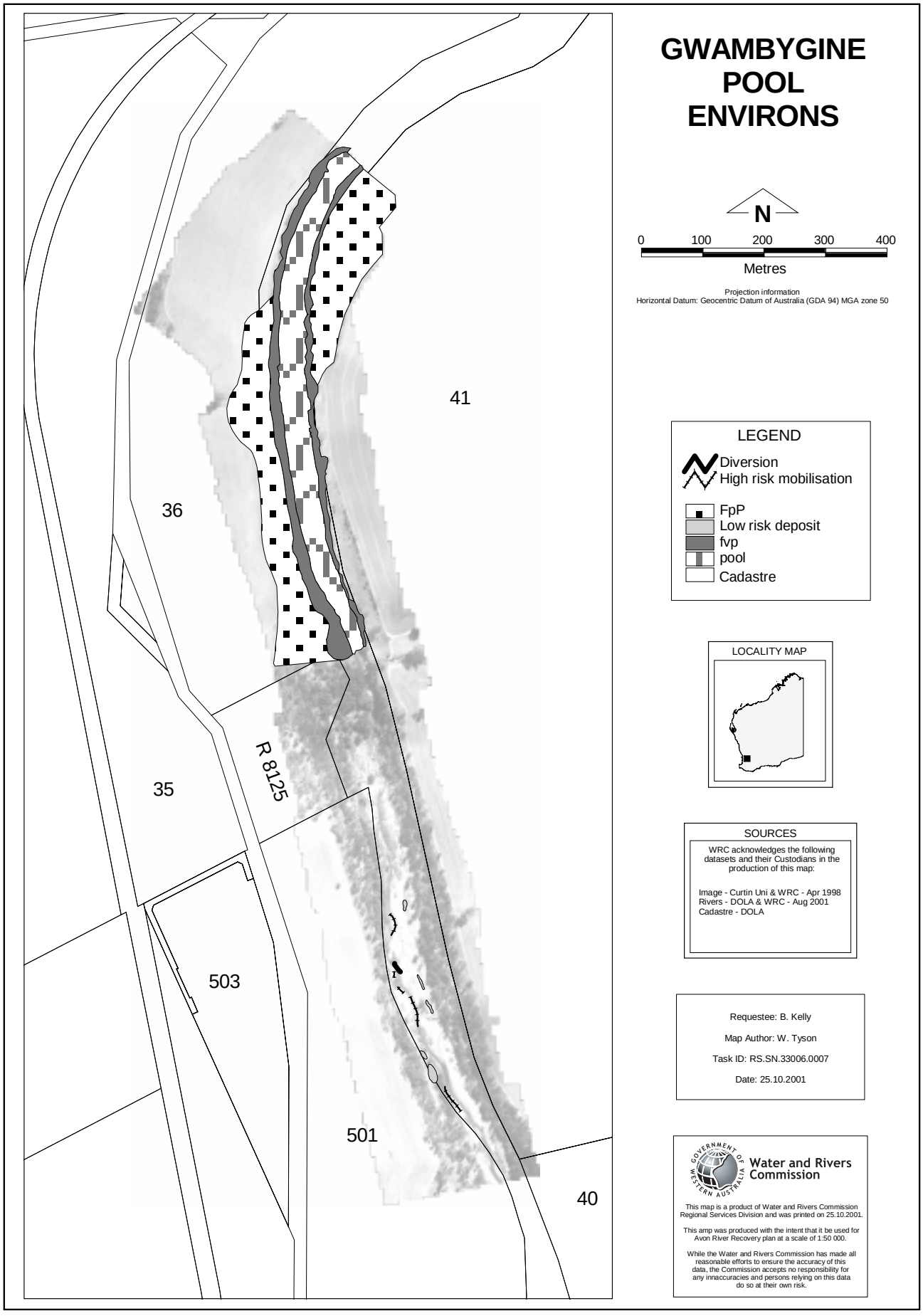
Reduction of sediment transport

Stabilising existing sediments and reducing channel sediment transport provides alternative management options. The principles for management are to:

- reduce streamflow velocity,
- reduce the amount of sediments available for transport,
- reduce the interface between stream flow and unconsolidated sediments, and
- encourage natural sediment island formation and accretion.

A range of options are compared in Table 4.1.

Action 4.1.3: Initiate a set of ecological studies to identify the requirements and limitations for re-colonisation of unconsolidated sediments and to identify additional plants for river sediment stabilisation (Note — suit student project).



Map 2: Gwambygine Pool Environs

Photo 10. Unconsolidated sediment upstream of the pool. *Photo courtesy Viv Read.*

Action 4.1.4: Ensure that upstream river fencing remains effective and that all stock access to the river environment is restricted to controlled fire risk reduction only. Horses and cattle should be excluded.

Action 4.1.5: Identify all recently formed sediment islands between the pool and Marr's Creek. Select a range for trial stabilisation. Design a range of interception structures (e.g. star picket triangles) that encourage sediment accumulation.

Action 4.1.6: Map areas and estimate the volume of potentially mobile sediments between the pool and Marr's Creek.

Action 4.1.7: Assess the potential benefits and risks by piling unconsolidated sediment from a high risk location onto well stabilised sediment islands.

Action 4.1.8: Prepare site assessment of potential to breach the artificial levees in order to allow stream flow access to east and west floodways upstream from the pool.

Action 4.1.9: Identify locations of the stream flow/ unconsolidated sediment interface where the risk of sediment mobilisation is high. Assess potential for removal of sediment from these locations.

Black Jack Creek

The potential for Black Jack Creek to contribute sediments to the pool in stream flow or by bank erosion is comparatively small. Options for management include construction of a detention dam on Avon Location 40, installing a 'Stop' on Avon Location 40 to divert stream flow to the floodplain on that property, or to contain stream flow within the existing creek channel. The latter option is preferred.

Action 4.1.10: A small Diversion Bank should be constructed to contain stream flow in the creek channel that discharges about 100 m downstream from the vehicle access. The vehicle access area should be revegetated allowing only single lane truck access. Cars should be parked near the entry to the reserve.

Table 4.1: Options for reduction of sediment transport upstream of the pool.

Options	Comments
1. Increased natural revegetation of unconsolidated sediment.	Since exclusion of stock, salt water couch and *Frankenia* sp. colonise and stabilise some but not all sediment. Moisture status and salinity may determine the extent of colonisation. Disturbance by grazing, locusts, chemicals or fire in the river bed will destabilise the sediments.
2. Enhance sediment island formation and stabilisation with installation of artificial controls.	Some risk of initiating new island formation in the wrong place. Best to enhance stability of existing island formations. Potential for significant benefit is unknown.
3. Remove sediment from the river bed.	Excavation during summer of potentially mobile sediments. This could cause some disturbance of partially stabilised areas. Costs could be similar to excavation of sediments from the pool.
4. Pile sediment in the river bed.	Creating piles of sediment in the river bed so that most is elevated above and out of contact with average winter stream flow. Piles could be placed on existing stabilised sediments. These areas would provide best opportunity for stabilisation of the additional piles.
5. Divert minor meanders from unconsolidated sediments.	Some risk with poor design. One meander (shown on map) could become a diversion trial.
6. Increase stream flow in floodways by breaching the artificial levees.	Floodways behind levees could be made active by intermittent breaches. Some de-snagging of the eastern floodway would be required. The effect should be reduced stream flow velocity on entry to the pool.

Fine sediment management

The rate at which fine sediments are being deposited in Gwambygine Pool is not known. Suspended sediments settle during low flow through the pool. These fine sediments have high nutrient load that add to the pool nutrients while in suspension but become less available when deposited on the pool floor.

Reduction of fine sediment deposition is desirable. Changes in agricultural practices to less tillage, more accurate fertiliser application and surface water control will reduce the source of these sediments. Ensuring these practices are in place at least in the adjacent tributaries upstream of the pool will assist. However, even the best landcare will not prevent soil and nutrient loss to the river during intense rainfall events.

Prior to the River Training Scheme, discharge from tributaries to the river channel was via flood ways that would filter fine nutrients and sediment. Re-establishment of the filtering function of the floodplain should be an important objective of Avon River Recovery Planning.

Removal of fine sediments from the pool would be expensive, impractical and increase the risk of a substantial release of stored nutrients. However, some assessment is required of the rate of deposition and of the impact that increasing sediment deposition (hence reducing pool depth) is having on the aquatic ecosystem. The average pool depth is now 2.43 m. It is expected that an average pool depth of less than 1.5 m would have a significant impact on the pool ecosystem although this impact is not established. Comparison with studies of Northam Town Pool is suggested.

Action 4.1.11: Arrange stratigraphic analysis of two sediment cores to date the history of deposition and measure the potential nutrient storage.

Action 4.1.12: Continue annual monitoring of pool depth.

Action 4.1.13: Assess the potential impact on the pool ecosystem of a pool depth of 1.5 m or less.

4.2 Salinity management strategy

Salinity levels in the pool are rising due to increasingly saline inputs from surface water and ground water, including saline water released from Yenyenning Lakes.

Saline groundwater discharge to the pool

Since the RTS, the fresh perched aquifer beneath the floodplain is less frequently recharged and is in fact 'drained' due to the lower river bed level. Without the downward pressure of a perched aquifer, the saline regional groundwater table rises more rapidly. It is probably now commonly permeating upwards though the confining layer. Saline seepage is frequently observed in the river bed.

It is anticipated that the regional groundwater aquifer has an upward but also westward trend within the vicinity of the pool. Many Flooded Gums on the east bank are senescent apparently due to salinity, and there is no regeneration of these. The trees are alive and regenerating on the west bank near the pool. It is possible that the regional hydraulic gradient will suppress fresh seepage to the pool from shallower aquifers. There has been no investigation of the potential for increasing saline discharge into the Avon River.

Action 4.2.1: Arrange groundwater investigations to assess the potential for increasing saline discharge in to the pool. The investigation should focus on the east bank but also assess the immediate pool environs. Link to action recommended in River Recovery Plan for Section 11/12, Gwambygine to Edwards Crossing.

The River Conservation Society initiated revegetation of the east bank with variable success.

Further revegetation of the complete fenced area on the east bank is recommended. Reticulated watering could be sourced from the southern end of the pool or from other sources over summer. In addition, the eastern floodplain (FlP) on Avon Location 40 should be fenced and allowed to naturally regenerate. An adjacent un-grazed area shows the preferred plant community structure for the floodplain. Consideration for the floodway with flood flows occurring about one year in eight.

Action 4.2.2: Arrange revegetation of the east bank within the fenced area.

Action 4.2.3: Arrange fencing of the floodplain on the east bank and facilitate natural regeneration.

Saline water release from Yenyenning Lakes

A rapid increase in salinity of Gwambygine Pool in April 1997 may have resulted from the release of saline water from Qualandary Crossing at the Yenyenning Lakes. Discharge of this water into the pool was diluted by flow from the Dale River. Without flow from the Dale, salinity in the pool may have been much higher. The Dale River has periods of zero flow ranging from 30 to 110 days commencing from about mid-December. The effect on the pool ecosystem of the saline water release from the Lakes is not known. It is also not known what the impact would be if the discharge to the pool was of higher salinity, if it was for a longer duration or if it occurred earlier in the season. These effects should be better understood.

While the potential effect on the pool is not known, it seems reasonable to have saline water released from Qualandary Crossing only when there is either flow in the Avon River or at least flow in the Dale River. Development of a simple decision model based on flow in these rivers and river pool ecosystem limits is recommended.

Action 4.2.4: Initiate a set of ecological studies to determine the potential impact on the pool ecosystem of saline discharge considering frequency, duration, concentration of salinity and season of discharge.

Action 4.2.5: Arrange with the Yenyenning Lakes Management Committee for saline water release from the control gate to only occur during periods of adequate flow in the Avon and/or Dale rivers.

Action 4.2.6: Arrange development of a decision support model based on river flow and salinity regimes, lake water salinity and acceptable discharge levels for sustainable pool ecosystem functions.

4.3 Fringing vegetation management strategy

Natural vegetation in the riparian zone of the Avon River is confined to a narrow fringe on the banks of the main channel. Most of the floodplain has been cleared for agriculture and vegetation in the channel was removed during the River Training Scheme. Remnant riparian vegetation is threatened by increasing salinity. The plant community structure and composition is altering to one dominated by Sheoak (*Casuarina obesa*). The Flooded Gum (*Eucalyptus rudis*) is regenerating in very few places and is in decline. The Sheoak will not provide hollows or strong and accessible perches for wildlife although it does suppress weed growth. Of further concern is that preferred management by fencing to keep stock from the river results in a high fire risk to the river and to neighbours, weeds and increased harbourage for feral animals.

Photo 11: Grazed and ungrazed (background) floodplain. *Photo courtesy Viv Read.*

Photo 12: Regeneration in the floodplain. *Photo courtesy Viv Read.*

Reserve 8125 (3.8ha) is an important area of natural vegetation located adjacent to the southern end of the pool. The reserve has been subjected to several recent fires.

River fencing

Considering these issues, it is recommended that fencing for stock control in the riparian zone be continued and maintained. Any disturbance to the fragile revegetation process of unconsolidated sediments in the bed of the river is a risk.

Action 4.3.1: Continue arrangements for construction and maintenance of river fencing adjacent to and upstream from Gwambygine Pool.

Weed control

The major task is to control broad-leaf weeds and Wild Oats. Long-term un-grazed areas show that weeds will eventually be suppressed by canopy closure of natural vegetation, however, this does not remove the short term weed problem, nor will it exclude all weeds. Control can be by chemical sprays, managed grazing/slashing or judicious burning. Trial of each of these separately and in combination under varying conditions is recommended. There are sites well suited for trials in the Reserve, the fenced area on the east bank or in the fringing vegetation of Avon Location 501 (Marr).

Action 4.3.2: Initiate a set of trials for target weed control within fringing vegetation.

Revegetation and natural regeneration

While the potential impact of salinity on the riparian zone vegetation is difficult to manage, there are opportunities for in-fill revegetation and to facilitate natural regeneration. This should be consistent with other recommended actions, including those for weed control trials. Guidance for further revegetation actions should be derived from an assessment of salinity risk.

Action 4.3.3: Review the River Conservation Society Revegetation and Natural Regeneration Plan for the pool and environs to include consideration for salinity risk assessment, trials for weed control and bio-geographic linkage.

Management of Reserve 8125

This reserve is not vested. The responsible government agency is the Water Corporation. It has been used for temporary deposition of road construction material and of sediments excavated from the pool. It should now be managed primarily as a natural vegetation reserve with the important function of filtering sediments from discharge into the pool from either slope runoff or from the re-activated western floodway.

Previous management actions are consistent with this priority (B. Oversby *pers. comm.*). The Reserve should be fenced on the roadside to reduce entry by itinerant campers (and hence reduce fire risk in summer). Consideration is also required for an area without vegetation for movement of heavy machinery that may be required for future pool excavation. A suitable area is located beneath York Gums 50 m from the road entrance.

Action 4.3.4: Prepare a simple Management Guideline for Reserve 8125 acceptable to ARMA that clearly states its preferred purpose, considers access facilities and control, and outlines methods for vegetation management.

Faunal habitat enhancement

Loss of tree hollows and robust perches in the future is inevitable with current decline of the Flooded Gums. Allowing natural regeneration of these where possible, particularly in the floodplain is desirable. Retaining fallen logs in the pool is desirable. Otherwise, revegetating with tree species that will eventually form hollows is recommended. Meanwhile, faunal habitat opportunities can be supplemented with nest boxes and artificial perches.

Action 4.3.5: Undertake revegetation with tree species that will eventually form hollows.

***Action 4.*3.6:** Construct artificial perches and nest boxes to supplement faunal habitat opportunity.

4.4 Nutrient management strategy

It is difficult to manage the increasing nutrient load and increasing frequency of eutrophication in the pool. Reduced nutrient input sourced from farmland is considered by landcare groups through catchment management activities. There is opportunity to filter discharge from tributaries within the riparian zone. This is to be considered during Avon River Recovery Planning. Excavation of fine sediments from the pool (discussed in Section 4.1) is not recommended at this stage. Diversion of streamflow from Black Jack Creek (Action 4.1.10) will reduce a small source of nutrient inflow resulting from intense summer rainfall events.

Photo 13: Wild Oats in revegetation site of the east bank of the pool. *Photo courtesy Viv Read.*

Retention of tall, shady fringing vegetation is also important to keep pool water temperatures low during summer. Significant understorey and control of fire in the fringing vegetation is also important to ensure nutrient filtering of runoff adjacent to the pool.

Trials using Phoslock to render nutrients less available for phytoplankton growth in the Canning River could become relevant to river pool management.

There are intensive industries that could significantly contribute nutrients to the pool and the potential does exist for future polluting developments. However, current Local Government planning is adequate control to ensure this does not occur.

Action 4.4.1: Establish regular monitoring of physical and chemical parameters in the pool that are determinants of algal blooms.

Action 4.4.2*:* Assess Phoslock trials for application to Gwambygine Pool.

Action 4.4.3: Ensure adequate provision within the Town Planning Scheme for the Shire of York to prevent pollution of the pool and environs from future development proposals.

Action 4.4.4: Signs be erected at the pool to warn people of the risks associated with algal blooms and *Amoebic meningitis*.

4.5 Knowledge management strategy

From the continued interest of the River Conservation Society, a body of knowledge is being developed for Gwambygine Pool. Little is known about ecosystem structure and function for pools of the Avon River. The resilience or resistance of pool ecosystems to major disturbance (such as a rapid increase in salinity) or changing conditions (such as increasing water temperature or reducing water depth) is also not well known. The opportunity exists for the Gwambygine Pool ecosystem to become well known and for this knowledge to be applied for pool management elsewhere.

Although considerable information has been collated for the pool, there are information gaps. Also, although existing information provides some of the base-line data required for trend analysis or comparison with other pools or river

systems, no ongoing monitoring programme is in place to make full use of this information.

Completion of a full biological inventory for the pool is required. A range of studies of biological interest are underway, such as biological differentiation of separate populations of the Oblong Tortoise. However, the priority research requirement is for indicators of environmental health in the pool. A representative measure of pool conditions or of the abundance of an indicator species is required to monitor ecological functions in the pool. These are not currently available.

Indicators of ecological health of the Avon River pool would be of significant benefit to the Avon River Management Authority for a range of management decisions or for provision of advice. This would include decisions about release of water from Yenyenning Lakes or timing of sediment excavation, and advice about rural drains for salinity control or development proposals that may affect riverine ecosystems.

It is anticipated that further consideration of diatom populations and macroinvertebrates could suggest potential indicators of ecosystem health. Additionally, study of microinvertebrates and phytoplankton could also be relevant.

Obtaining information that is relevant requires a local Research and Development strategy for the pool. This strategy should be set within the context of the Avon River system. Information gained should be managed in a way that ensures that it is easily accessible to local landholders, community groups and river managers alike. The Avon Catchment Network in Northam was established for the primary purpose of providing access to relevant information for integrated natural resource management within the Avon River Basin. The ACN website is well structured for this purpose.

Action 4.5.1: Identify possible suites of flora and fauna species not adequately sampled by previous survey. Undertake further survey to develop a complete biological inventory for the pool.

Action 4.5.2: A local Research Strategy be developed for Gwambygine Pool considering the context of the Avon River system.

Action 4.5.3: Priority be attributed to identifying indicators of ecological health in Gwambygine Pool as benchmark indicators for river management and to assist ARMA with decisions and provision of advice.

Action 4.5.4: Information gained about the pool should be available through the Avon Catchment Network.

4.6 Biogeographical, cultural and historic values linkage strategy

Cumulative benefits accrue from a well managed combination of values. The potential exists for this to occur for Gwambygine Pool and environs.

The Avon River and its pools are a significant biogeographical corridor in an otherwise substantially altered agricultural landscape. Proposed revegetation and natural regeneration of the riparian ecosystem plus good pool management will add to these values. There is opportunity to extend this corridor linkage with the riparian zone of tributaries, reserves, road and rail corridors, rock outcrops with remnant vegetation, and bush on private land. The area surrounding Gwambygine Pool provides excellent opportunity to add complementary value by biogeographical linkage, particularly with adjacent rocky outcrops where rock wallabies once accessed the river to drink.

The rich Aboriginal and European historic and cultural information could complement these values. People living by the river, visiting occasionally or just remembering the river will have a greater appreciation of values of the place by having access to this additional information.

Considering the preferred use of Gwambygine Pool and environs for preservation of environmental values, development of ecological knowledge and provision of inter-related landscape values, it is important to ensure that inappropriate use of the pool and riparian zone is avoided. Destructive activities or disturbance during important breeding periods would detract from achieving the Vision for the pool. These issues have been considered in detail by ARMA.

Action 4.6.1: Prepare a regional biogeographical linkage strategy that is consistent with the Natural Resource Management Plan for the Avon Working Group and is acceptable to local landholders, landcare groups, conservation and community groups, and government agencies.

Action 4.6.2: Ensure that ARMA's 'Recreation Management Guideline' is well known.

5 Management plan review

The context of the Gwambygine Pool Management Plan is set within a 10 year period. It is recommended that the plan be reviewed after 5 years to assess new monitoring information according to the proposed research strategy and to review the progress of implementing the recommended actions of the plan.

6 Strategy summary

VISION

ARMA and the local community agree that the future vision for the pool should be:

"Gwambygine Pool remains as a significant naturally productive deep water pool on the Avon River with healthy natural fringing vegetation and a stable aquatic ecosystem. The pool and adjacent landscape are integrated with other river and land management to provide significant biogeographical and heritage linkage.

The historic and cultural values of the pools and adjacent areas are respected and protected. Future residents and visitors to the area enjoy these values as a part of the pool environment. It is a preferred place for contemplation and reflection. Recreation or other activities do not detract from these values.

The pool is recognised as a place of scientific study. Understanding of the ecological functions leads to better river and pool management elsewhere."

MANAGEMENT OBJECTIVES		
Objective	**Milestones**	**Target date**
1. To maintain a healthy and productive aquatic ecosystem in the pool supported by a well-structured and functioning fringing vegetation ecosystem.	❖ Practical indicators of ecosystem health for the pool are identified and accepted for management. ❖ Baseline measures of the accepted indicators of ecosystem health are established.	Year 1 Year 1
2. To establish baseline scientific information and understanding for the pool and environs that enables change in river ecology to be detected and to guide management actions.	❖ Framework for monitoring ecosystem health for the pool Documented base line ecological information about the ❖ pool that is accepted by the scientific community	Year 1 Year 3
3. To have recreational use of the pool that increases appreciation of the natural and heritage assets and does not diminish ecosystem health.	❖ The preferred purpose of the pool is understood and respected (no report of inappropriate use) ❖ Facilities exist to encourage knowledge and understanding of river pool ecology.	Year 2 Year 4
4. To have recognised bio-geographic, cultural and heritage linkage with the pool.	❖ A regional bio-geographic plan is prepared and accepted ❖ Cultural and historic values are recognised formally and enhanced locally.	Year 5 Year 10

Recommendations for management strategies		Management zone	Priority	Recommended lead role
Action 4.1.1	Arrange monitoring to identify 300 m of sediment infill to the pool.	**P**	**H**	**WRC**
Action 4.1.2	Assess the impact of a 27% volume reduction on the pool ecosystem.	**P**	**H**	**WRC/ RCS**
Action 4.1.3	Initiate a set of ecological studies to identify the requirements and limitations for re-colonisation of unconsolidated sediments and to identify additional plants for river sediment stabilisation (Note — suit student project).	**URE**	**H**	**WRC**
Action 4.1.4	Ensure that upstream river fencing remains effective and that all stock access to the river environment is restricted to controlled fire risk reduction only.	**RVP, URE, DRE**	**H**	**LH**
Action 4.1.5	Identify all recently formed sediment islands between the pool and Marr's Creek. Select a range for trial stabilisation. Design a range of interception structures that encourage sediment accumulation.	**URE**	**H**	**WRC**
Action 4.1.6	Map areas and estimate the volume of potentially mobile sediments between the pool and Marr's Creek.	**URE**	**H**	**WRC**
Action 4.1.7	Assess the potential benefits and risks of piling unconsolidated sediment from a high risk location onto well stabilised sediment islands.	**URE**	**H**	**WRC**
Action 4.1.8	Prepare site assessment of potential to breach the artificial levees in order to allow stream flow access to east and west floodways upstream from the pool.	**URE**	**H**	**WRC**
Action 4.1.9	Identify locations of the stream flow/unconsolidated sediment interface where the risk of sediment mobilisation is high. Assess potential for removal of sediment from these locations.	**URE**	**H**	**WRC**
Action 4.1.10	A small Diversion Bank should be constructed to contain stream flow in the Black Jack creek channel that discharges about 100 m downstream from the vehicle access. The vehicle access area should be revegetated allowing only single lane truck access for sediment removal. Cars should be parked near the entry to the reserve or mid-slope.	**FVP**	**L**	**WRC**
Action 4.1.11	Arrange stratigraphic analysis of two sediment cores in order to date the history of deposition and measure the potential nutrient storage.	**P**	**M**	**WRC**
Action 4.1.12	Continue annual monitoring of pool depth.	**P**	**H**	**RCS**
Action 4.1.13	Assess the potential impact on the pool ecosystem with a depth of 1.5 m or less.	**P**	**H**	**WRC**
Action 4.2.1	Arrange groundwater investigations to assess the potential for increasing saline discharge in to the pool. The investigation should focus on the east bank but also assess the immediate pool environs.	**FpP, URE**	**H**	**WRC**
Action 4.2.2	Plan and arrange revegetation of the east bank within the fenced area.	**FVP**	**H**	**RCS/LH**
Action 4.2.3	Arrange fencing of the floodplain on the east bank and facilitate natural regeneration.	**FpP**	**M**	**LH**
Action 4.2.4	Initiate a set of ecological studies to determine the potential impact on the pool ecosystem of saline discharge considering frequency, duration, concentration of salinity and season of discharge.	**P**	**H**	**WRC**

Recommendations ontinued overleaf…

P - the pool	**R** - Reserve 8125	**H** - High	**ARMA** - Avon River Management Authority
FVP - fringing vegetation of the pool	**ATC** - adjacent tributary catchments	**M** - Medium	**RCS** - River conservation Society
FpP - floodplain adjacent to the pool		**L** - Low	**WRC** - Water and Rivers Commission
URE - upstream riparian ecosystem			**LH** - Land Holders
DRE - downstream riparian ecosystem			**SoY** - Shire of York

… Recommendations continued

Recommendations for management strategies		Management zone	Priority	Recommended lead role
Action 4.2.5	Arrange with the Yenyenning Lakes Management Committee for saline water release from the control gate to only occur during periods of adequate flow in the Avon and/or Dale rivers.		**H**	**ARMA**
Action 4.2.6	Arrange development of a decision support model based on river flow and salinity regimes, lake water salinity and acceptable discharge levels for sustainable pool ecosystem functions.		**M**	**WRC**
Action 4.3.1	Continue arrangements for construction and maintenance of river fencing adjacent to and upstream from Gwambygine Pool.	**FVP, URE**	**H**	**LH**
Action 4.3.2	Initiate a set of trials for significant weed control within fringing vegetation.	**FVP, URE**	**H**	**WRC**
Action 4.3.3	Prepare a Revegetation and Natural Regeneration Plan for the pool and environs that considers salinity risk assessment, trials for weed control and bio-geographic linkage.		**M**	**WRC**
Action 4.3.4	Prepare a simple Management Guideline for Reserve 8125 that states clearly it's preferred purpose, considers access facilities and control, and outlines methods for vegetation management.	**R**	**M**	**WRC**
Action 4.3.5	Undertake revegetation with tree species that will eventually form hollows.	**FVP**	**M**	**RCS/ WRC**
Action 4.3.6	Construct artificial perches and nest boxes to supplement faunal habitat opportunity.	**FVP**	**M**	**RCS**
Action 4.4.1	Establish regular monitoring of physical and chemical parameters in the pool that are determinants of algal blooms.	**P**	**H**	**WRC/ RCS**
Action 4.4.2	Assess Phoslock™ trials for application to Gwambygine Pool.	**P**	**M**	**WRC**
Action 4.4.3	Ensure adequate provision within the TPS for SoY to prevent pollution of the pool and environs from future development proposals.		**H**	**SoY**
Action 4.4.4	Signs be erected at the pool to warn people of the risks associated with algal blooms and amoebic meningitis.	**P, R**	**H**	**ARMA**
Action 4.5.1	Identify possible suites of flora and fauna species not adequately sampled by previous survey. Undertake further survey to develop a complete biological inventory for the pool.	**FVP**	**M**	**RCS**
Action 4.5.2	A local Research Strategy be developed for Gwambygine Pool considering the context of the Avon River system.		**M**	**RCS/ ARMA**
Action 4.5.3	Priority be attributed to identifying indicators of ecological health in Gwambygine Pool as benchmark indicators for river management and to assist ARMA with decisions and provision of advice.	**P**	**H**	**RCS/ WRC**
Action 4.5.4	Information gained about the pool should be available through the Avon Catchment Network.		**M**	**RCS**
Action 4.6.1	Prepare a regional biogeographical linkage strategy that is consistent with the Natural Resource Management Plan for the Avon Working Group and is acceptable to local landholders, landcare and conservation groups and government agencies.		**M**	**ARMA, CSIRO, CALM, Greening WA**
Action 4.6.2	Ensure ARMA's 'Recreation Management Guideline' is well known.		**M**	**ARMA/ RCS**

P - the pool	**R** - Reserve 8125	**H** - High	**ARMA** - Avon River Management Authority
FVP - fringing vegetation of the pool	**ATC** - adjacent tributary catchments	**M** - Medium	**RCS** - River conservation Society
FpP - floodplain adjacent to the pool		**L** - Low	**WRC** - Water and Rivers Commission
URE - upstream riparian ecosystem			**LH** - Land Holders
DRE - downstream riparian ecosystem			**SoY** - Shire of York

7 Reference and recommended reading

Applehaus, K.T. and Walker, D. (unpublished) *The Distribution of Biomass of the macrophytes in Northam Town Pool* Univ. WA report on 1998 survey to Water and Rivers Commission.

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River Conservation Society Inc. (1999) *A Biological Survey of Gwambygine Pool: Report on a survey of Gwambygine Pool, Avon River, York. Period: January 1996 to June 1997*.

Southwell, C. E. (1993) *A Preliminary Study of the Bedload Regime Response of the Avon River to Channelisation* Waterways Commission Report 36.

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Appendix one
Record of saline water release from the Yenyenning Lakes

Gauging records at Qualandary Crossing show flow increased significantly from 0.003 m^3/sec to 3.211 m^3/sec from 14 March to 16 March 1997. Flow stayed at about this level until 26 March from when it decreased to almost zero flow but increased again from 31 March to 2.574 m^3/sec attenuating to zero by 25 April. The salinity of this flow ranged from 58 200 mg/L to 64 200 mg/L. As there was no rainfall recorded in Beverley until 29 March (when 55 mm fell over two days) and that the flow from the crossing after the rain was of about the same salinity as before it, the flow can be assumed to be due to two gate openings at Qualandary Crossing, one on 15 March which was closed on 27 March, then opened again on the 31 March after the rain and left opened until flow ceased on 25 April.

Gauging records at Broun's Farm show a small increase in flow from 0.042 m^3/sec on 19 March to 0.072 m^3/sec on the 21 March. Salinity of stream flow for about the same period increased from 13 000 mg/L on 20 March to 32 600 mg/L on 23 March. This gauging station records flow from both the Dale and the Avon rivers. Prior to this period, flow would have been entirely from the Dale River.

Appendix two
Fauna list for Gwambygine Pool

(Courtesy of York River Conservation Society)

MACROINVERTEBRATES (Excluding Protozoa, Rotifera, Porifera and Cnidaria)

Annelida:	*Nematoda* sp.	
	Oligochaeta Tubificidae sp.	
	Hirudinea sp.	
Mollusca:	*Bivalvia Fluviolorata subtorta*	
	Bivalvia Hyriidae westralunio	
	Gastropoda Pomatiopsidae Coxiella striatula	
	Gastropoda Pomatiopsidae Coxiella glabra	
	Gastropoda Planorbidae gyraulus	
Arachnida:	*Hydrachnidae* sp.	
	Hydracarina sp.	
	Eylaidae sp.	
Crustacea:	*Cladocera*:	*Chydoridae*
		Daphniidae Daphniopsis pusilla
	Ostracoda:	*Mytilocypris*
	Copepoda:	*Sulcanus conflictus*
		Harpacticoida
		Cyclodoida
	Amphidoda:	*Austrochiltonia subtenuis*
		Ceinidae
	Decapoda:	*Palaemonetes australia*
		Cherax quinquecarinatus
Insecta:	*Colembolla*	
	Coleoptera:	*Carabidae*
		Gyrinidae
		Hydrophilidae Berosus
		Hydrophilidae non-Berosus Sp A and Sp B
		Hydrophilidae Berosus ameonus
		Hydrophilidae Hybogralius sp.
		Hydraenidea Ochthebiinae sp.
		Dytiscidae Antiporus gilberti
		Dytiscidae Nectorosoma penicilatus
		Dytiscidae Lancetas lanceolatus
		Dystiscidae Macrogyrus reichei?
		Dystiscidae Aulonogyrus strigosus
		Dystiscidae Magaporus howitti
		Dystiscidae Platynectes sp.
		Dystiscidae Paroster sp.

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	Trichoptera	*Leptoceridae oecetis sp.* *Leptoceridae Notalina spira* *Leptoceridae Triplectides australia*
	Hydroptilidae	*Hydroptilidae* sp.
	Lepidoptera	*Lepidoptera* sp.
Odonata:	*Zygoptera*:	*Coenagrionidae Xanthagrion erythroneurem* *Coenagrionidae Ishneura* sp.
	Anisoptera:	*Libellulidae Orthetrum caledonicum* *Lebellulidae Orthetrum caledonicum* *Corduliidae Hemicordulia tau.*
Diptera:		*Chironomidae Procladius paludicola* *Chironomidae* sp. *Tabanidae Tabanini* *Stratiomyidae Odontomyia*? *Ephypridae* sp. *Ceratopogonidae nilobexxia* sp *Ceratopogonidae monohelia* sp *Culicidae Anophelini* *Culicidae Culcini* *Stratiomyidae Odontomyia*?
Hemiptera:		*Corixidae Agraptorixa parvipunctata* *Corixidae micronecta* sp. *Notonectidae Anisops thienemanni*

MICROINVERTEBRATES (Awaiting identification)

FISH

Galaxias occidentalis	Western Minnow	Common
Arthenirosoma vallacii	Hardyhead	Common
Bostockia porosa	Nightfish	Occasional
Pseudogobius olorum	Swan River Goby	Occasional
Gambusia affinus	Mosquito fish	Abundant. Introduced.

REPTILES

Cheloduna oblonga	Oblong or Western Snake-necked Tortoise	Abundant

(Other reptiles await survey)

AMPHIBIANS (Identified from frog calls only—Awaiting confirmation)

Crinea pseudinsignfera	Western froglet or Bleating frog
Limnodynastes dorsalis	Pobblebonk or Banjo frog
Litoria moorei	Bell frog or Motorbike frog
Helioporus albopunctatus	Western Spotted frog
Pseudophryne guentheri	Crawling frog

MAMMALS (Awaiting survey)

Mammals observed: Brush tailed possums, Western Grey Kangaroos, Foxes, Cats, Black Rat (*Rattus rattus*), abundant.

Appendix three
River Conservation Society bird survey, Gwambygine Pool, 1997

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
WATER BIRDS												
Black Duck	xxx	x	x	x	xxx		x	x		x	x	xx
Little Pied Cormorant	x	x	x	x			x		x	x	x	x
Great Egret	x		x	xx							x	
Eurasian Coot	x	xx	xxx	x	x	x	x	x	x	x	xx	xx
Spoon Bill	x	x		x		x	x	xx	x	xx		
Little Black Cormorant	x	x	x	x	xx	x			x	x	x	x
White Faced Heron	x	x	x	x	x	x		x	x	xx	x	x
Hoary Headed Grebe								x	x			
Australasian Grebe	x	x		x			x	x	x	x	x	x
Little Grebe												
Rufous Night Heron	x	x	x	x	x		x	x	x	x	x	xx
Grey Teal	xx	xxx	x	x	x	x		x	x	xx	x/f	xx
Wood Duck	xxx	x	xx	x	x	x			x	x	xx	xx
Black Fronted Plover	x	x	x					x	x		x	x/f
Chestnut Breasted Shelduck	x	x	x			x	x	x	x	xx	x	xx
White Egret			x				x		x			
Pied Stilt	x										x	
Dusky Moorhen								x				x
Sacred Ibis					x					x		
Sacred Kingfisher						x		x				x
Black Swan											x	
Banded Stilt												x
Total Species	**12**	**12**	**12**	**11**	**9**	**8**	**7**	**12**	**13**	**12**	**14**	**16**

x = present xx = several xxx = lots /f = fledging

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Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
LAND BIRDS												
Grey Fantail	x	xxx		x	xxx	x	x	x	x	x	x	xx
Corella			x						xx			
Ring Necked Parrot	x	x	x	x	x	x	x	x	x	x	x	x
Western Warbler	x	xx	x	x	x	x	x	x	x	x	xx	x
Rufous Whistler	x	x		x	x	x	x	x	x	x	x	x
Magpie	x	xx		x		x	x		x	x	x	
Weebill			x				x	x				x
Raven	x	xx		x	x	x	x	x	x	x	x	x
Striated Pardalote	x	x		x	x				x	x		xx
Richard's Pippit							x			x	x	
Kookaburra				x	x	x	x		x	x	x	x
Red Capped Robin		x		x	x							x
Mistletoe Bird	x	x	xx	x	x	x		x				
Magpie Lark		x		x							x	
Splendid Wren	x	x	x	x	x	x	x	x	x	x	x	xx
Silvereye	xx	x		x	x	x	x	x	x	x	x	
Yellow Rumped Thornbill	xx	xx	xxx	x	x	x	x	x		x	xx	x
Black Shouldered Kite	x	x		x			x		x		x	x
Tree Martin			x				x	x	x	xxx	xx	xx
Willy Wagtail	x	xx	x			x			x	x	x	x
Kestrel/Black Falcon	x		x			x	x			x		
Crested Cockatoo		x										
Grey Shrike Thrush		x					x	x		x	x	
Brown Honeyeater	x						x		x		x	
Rainbow Bee Eater	x							x		x	xx	x/f
Black Faced Woodswallow	x											
Chestnut Rumped Thornbill							x				xx	
Mulga Parrot												
Shining Bronze Cuckoo												
Mudlark						x						
Grey Butcher Bird							x					
Laughing Turtle Dove												
Crested Pigeon						x	x		x			x
Black Faced Cuckoo Strike						x	x		x		x	
Horsfield's Bronze Cuckoo									x		x	
Fantail Cuckoo												/f
Singing Honeyeater											x	x
Galah											xxx	xx
White Winged Triller											x	
Wedgetail Eagle												x
White Fronted Chat												x/f
Barn Owl			xx	xx								
Total Species	**17**	**17**	**11**	**15**	**16**	**16**	**21**	**12**	**18**	**20**	**24**	**21**

x = present xx = several xxx = lots /f = fledging

Appendix four
Flora list for Gwambygine Pool

(Courtesy York River Conservation Society)

Acacia acuminata	Jam tree
Acacia microbotrya	Manna gum
Acacia meisnerii	Gwambygine acacia
Acacia saligna	Golden wreath wattle
Amyema linophyllum	Mistletoe
Anthemis cotula	
Anthericesceae Dichopogon capillipes	
*Arctotheca calendula**	
Asparagoides asparagoides	Bridal creeper
*Aster sublatus**	Bushy starwort
Atriplex? exilifolia (Un-named species+)	A saltbush
*Arctotheaa colendula**	
Atriplex semibaccata	Berry saltbush/Creeping saltbush
Authericaceae arthropodium capillipes	
Boerhavia schomburgkiana	
Bolboscheonus caldwellii	March club rush
*Bromus diandrus**	Sweet brome
Casuarina obesa	Swamp she-oak
*Chenopodium album**	Fat hen
Chemopoduym sp	
*Cotula coronopifolia**	Water buttons
Cyperus gymnocaulos	Spiny flat sedge
Cucumis myriocarpus	
*Dittrichia graveolens**	Stinkwort
*Emux australia**	Doublegee
Eucalyptus loxophleba	York gum
Eucalyptus rudis	Flooded gum

* Indicates introduced species.

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Frankenia pauciflora	Sea heath
*Gynandrisis setifolia**	
Hakea preissii	Needle tree
Halosarcia sp	Samphires
*Heliotropium curassivicum**	Smooth heliotrope
*Hordeum lepiorum**	Barley grass
*Juncus acutus**	Spiny rush
Juncus australia?	
Maireana sp	
Melaleuca rhaphiophylla	Saltwater paperbark
Melaleuca viminea	Mohan
Melaleuca hamulosa	
Neurachne alopecuroidea	Foxtail mulga grass
Nemcia obovata	Boat poison
*Oxalis pes-capra**	Soursob
*Oxalis purpurea**	Large flowered wood sorrel
*Olea europa**	European olive
*Osteospermum clandestinum**	Stinking roger
*Paspalum vaginatum**	Saltwater couch
Ptilotus spathulatus	
Reodium botrys	
*Romulea rosea**	Guildford grass
Ruppia polycarpa	
Rhagodia drummondii	A saltbush
*Rumex crispus**	Curled dock
Samolus repens	Creeping brookweed
Sarcocornia quinqueflora	Beaded samphire
*Solanum nigrum**	Black nightshade
*Spergularia rubra**	Sand spurry
Sporobolus virginicus	Marine couch
*Sonchus oleraceus**	
*Ursinia anthemoides**	
Vicia sativa spp *sativa**	Vetch

* Indicates introduced species.

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How can it be improved?

.....

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How can they be improved?

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