
RIVER RECOVERY PLAN

Section 6 — Northam

Water and Rivers Commission
Avon River Management Authority

WATER AND RIVERS COMMISSION
RIVER RECOVERY PLAN SERIES
REPORT NO RRP 2
MAY 1999



Acknowledgments

The Avon River Management Authority gratefully acknowledges the input of a number of people in the development of this River Recovery Plan. The plan is richer for their input.

The members of the Steering Group deserve special thanks for the time and energy dedicated to the development of the plan. The Steering Group was comprised of Dennis Beresford, Eric Chamberlain, Eric Fox, Barbara McAllister, Doug Morgan, Bev Polain and John Wilding.

Reference Details

The recommended reference for this publication is: Water and Rivers Commission and Avon River Management Authority 1999, *River Recovery Plan, Section 6 — Northam*, Water and Rivers Commission, River Recovery Plan Series No RRP 2.

ISBN 0-7309-7319-0

ISSN 1441-5208

*Printed on recycled stock
May, 1999*



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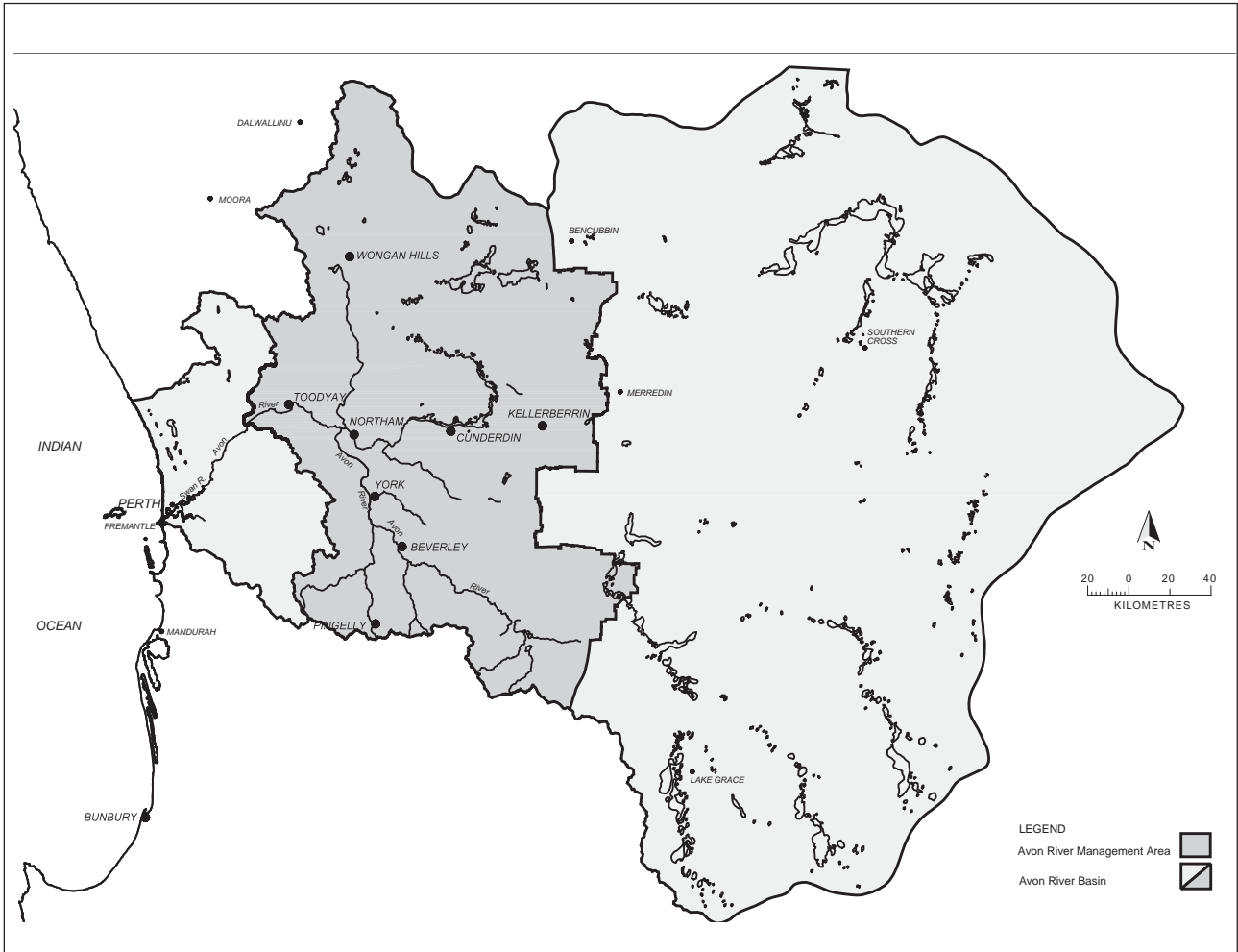


Vision for the Avon River

The Avon River Management Authority has a vision for the Avon River for the year 2020. It is summarised as follows:

- The Avon River and its tributaries have significantly improved as naturally functioning ecosystems according to measurable indicators.
- Sustainable agricultural systems are now firmly in place in 50% of the Avon River basin.
- All point sources of pollution of the Avon River have been identified and either eliminated or their impact minimised.
- Town Planning Schemes and Rural Strategies are in place and being implemented, which ensure top priority to maintaining the quality and the recovery of the Avon River ecosystem.
- Recreation use of the river is managed so as to provide fun, as well as appreciation of the river, with minimal environmental impact.
- The river wildlife has also recovered according to measurable indicators, and feral animals have been largely eliminated from the riverine bushland.
- Rural and urban communities have learned to respect the river, and to share responsibility for its recovery and conservation.
- Integrated, purposeful management of the river and the catchment are accepted as the responsibility of government agencies and community groups, and these parties share a common vision and goals, and enjoy working together to achieve them.





Map 1. The Avon River system



Introduction

The setting

The Avon is a large river, with a river basin of some 120 000 km², extending from beyond Southern Cross in the east to the Darling Range in the west. The river rises in a flat, geologically old landscape, and its valley becomes more rugged and narrower downstream. The Avon is contiguous with the Swan River which it joins at Walyunga. Map 1 shows the Management Area of the Avon River Management Authority. The Avon River and its catchment are shown on Map 2.

The river section

The Avon River Management Authority has initiated detailed management planning for the main trunk of the Avon River from Brookton town site to Walyunga. For the purposes of management planning, this part of the river has been divided into 18 sections. This River Recovery Plan covers River Section 6, which lies between Spencers Brook Bridge and Northam Town Weir.

The need for management

An indication of the impact of human activity on the Avon River and the need for management is provided by Harris (1996):

...the hydrological balance [of the Avon River], established over a very long time, has been disturbed by two activities: clearance of woodland for agriculture, and clearance of the river bed to abate flood heights. These two activities mobilised, respectively, the salt long established deep in the soil, and the coarse river-bed sediments. The consequences of the new imbalance and the introduction of chemicals to fertilise the leached soils are manifest, not only locally in the degrading habitats and depletion of river life, but also downstream in the Swan Estuary.

Other human activities which have degraded the river, at a local level, include dumping of rubbish; escape of garden plants to the river, some of which have formed extensive infestations; introduction of non-native animals; clearance of vegetation immediately adjacent to the river; and disturbance of vegetation and sediments by vehicles. These activities have had varying degrees of impact on the ecological and amenity values of the river.

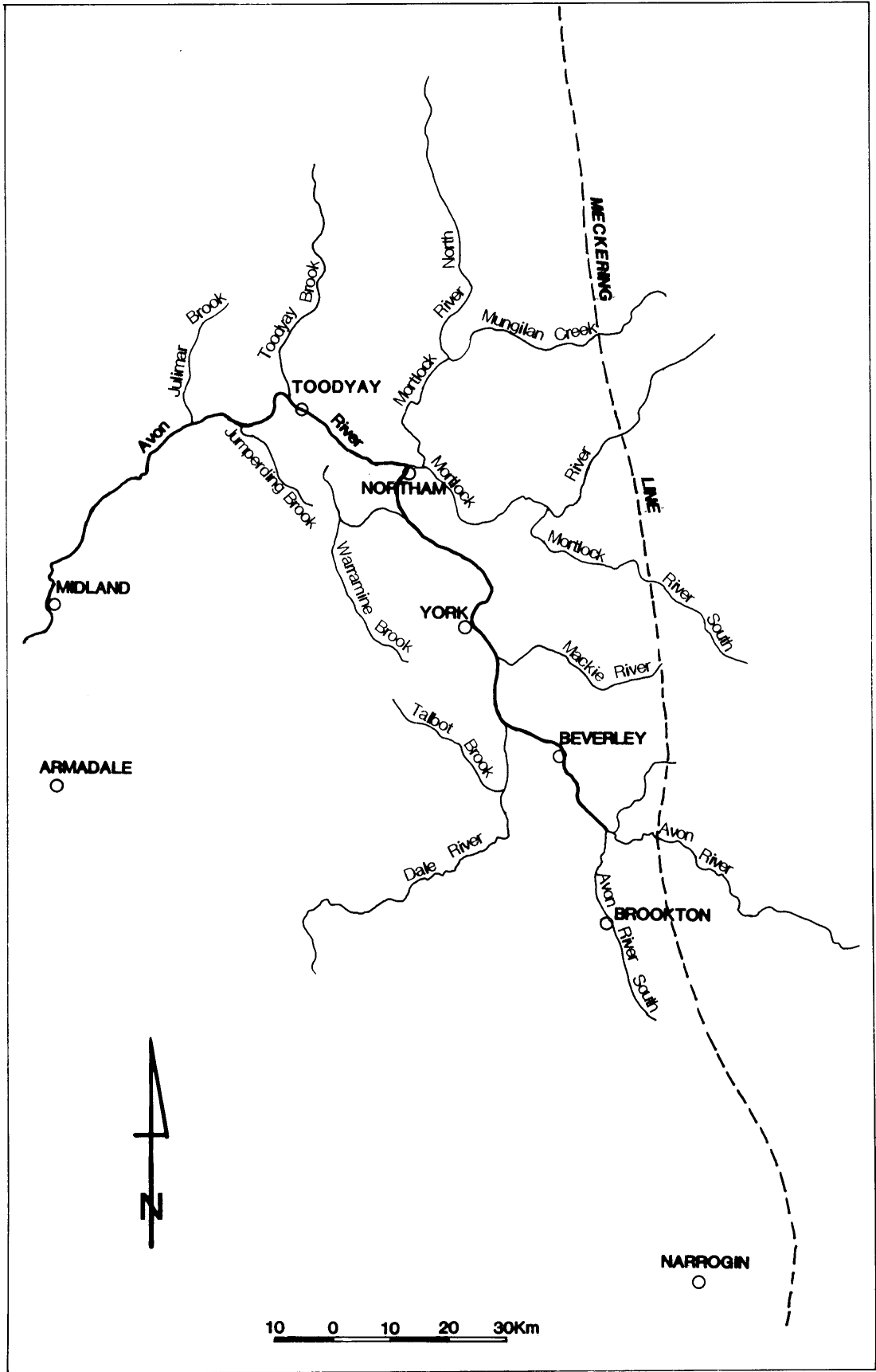
The river requires considerable, sustained management effort to arrest and reverse the damage caused over many decades of mis-use. At a local level there is much that can be done to improve the ecological condition and amenity value of the river. This recovery plan will focus on those strategies which can be achieved at a local level.

The management planning process

The process of preparing management strategies for this river section was undertaken within the Northam community. A local river group was established following an initial public meeting aimed at raising management issues for the river section. The group walked sections of the river on a number of occasions to share understanding of the history of river use and issues facing the river. A number of meetings were held during which issues were discussed and management strategies were developed. The process has done as much as was practicable to involve the local group. In addition, the local authority has been kept informed of the progress of the management planning process.

For certain strategies developed by the group, there is a risk that management efforts could be made redundant under particular flood events. However, the local river planning group was keen to take local action to improve the condition of the river, with the knowledge of the risks involved.





Map 2. The Avon River and its major tributaries



Planning context

River function and management

Jim Master's 'Principles of River Management' (Masters, 1996) provide an excellent outline of the factors affecting river function. The principles are defined, in summary, as follows.

Understand the nature of the river being protected

The natural functioning of a river or stream depends on a balance of interrelated factors in nature. All of these factors must be considered before contemplating any works for management of a river. This requires an understanding of the evolution and natural history of a river by observations and research.

Maintain the river's energy balance

The energy balance of a river, as determined by nature, should never be tampered with. The energy balance of a river relates to its natural rate of discharge. The energy balance was the dominant factor in forming the river channel and floodplain, and existed long before human interference with the River Basin.

Base management on long-term observations

Use the river history that is readily available from people who have observed the river carefully for many years.

Protect natural resources

Landcare must be directed in equal measure throughout the river catchment, including both streams and land, to ensure a functioning natural environment upon which human economic survival depends.

Respect the forces of nature

Look at the river as a universal example which shows the forces of nature working together. A river is many interrelated forces of nature working together. This pre-existing natural balance of time and energy must be retained for effective river management. Time and energy working through the speed of wind and water are the factors in river, land and catchment management. Change this and everything will be changed.

Management responsibilities

The Avon River Management Authority (ARMA) has the responsibility and authority under the Waterways Conservation Act to manage the Avon River. In fulfilling that role, the Authority works closely with and receives technical support from its parent body the Water and Rivers Commission. The Authority also collaborates with the community and other state and local government agencies having an interest in management of the river. The Waterways Conservation Act sets out for ARMA a broad range of river management functions and duties. Much of ARMA's management role relates to coordination and collaboration to achieve "sustainable management" of the river. As such ARMA is very much a broker for good management of the river. ARMA relies on the involvement and support of others to fulfill the massive task of managing the Avon.

Local government authorities have a particular interest in and responsibility for management of the Avon, as the river is contained within their municipal boundaries. With the exception of the Swan River, waterways management is a relatively recent phenomenon in Western Australia. The extent to which the river is understood as a functioning ecological system is steadily growing within the community, including local authorities. Hand in hand with that greater understanding is a greater appreciation of what is required to improve the condition of the river, and, thereby, its value as a natural system and its recreational amenity.

The interest, involvement and support of the community in river protection and recovery is of vital importance for the long-term health of the river. Groups and individuals can make a difference in river management including taking direct action to protect and improve the river; motivating others to do the same; lobbying for adequate funding for river management works; and spreading understanding and appreciation of the river throughout the community. Discovering the river as something more than a drainage system is the first step. The community can play a major role in spreading that message.



Scope, objectives and timing

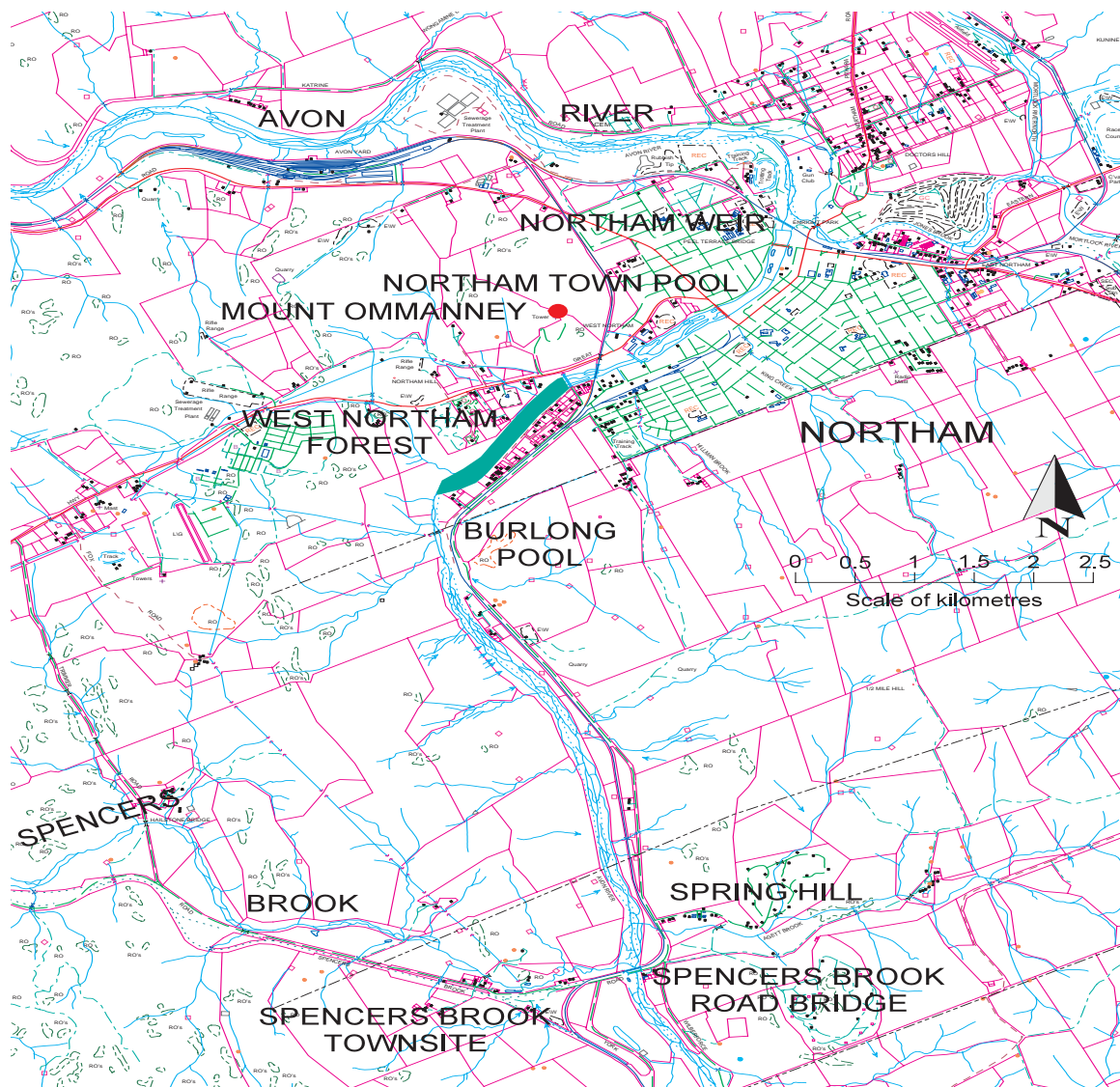
The River Recovery Plan focuses on the main trunk of the river. It does not address in any detail management of the tributaries or management of the river catchment. Furthermore, the actions in the Plan focus on what is considered to be achievable at a local level.

The objectives of the Plan for this river section are:

- to encourage greater understanding of the river as a functioning ecological system;
- to protect and substantially improve the ecological condition of the river;
- to improve the recreational amenity of the river; and
- to minimise ecological impacts of land use and development on the river.

Management Plans for the 18 sections will, in total, provide a comprehensive, systematic approach to management of the Avon, focusing on the scale at which management is most easily and suitably achieved: the local community scale. It is intended that the Plans for the sections will link to and be consistent with the Management Programme being prepared for the river as a whole.

The time frame for the Plan is five years. It is expected that, within this time frame, most of the actions would be implemented or, for major or on-going actions, well on the way to being implemented.



Map 3. Section 6, Avon River.



The Northam River Section (Section 6)

River Section Six includes Northam, the largest town in the Avon Valley (population 8000) and extends upstream to the Spencer's Brook bridge (approximately 10 km). ARMA is establishing this river section as a major trial and demonstration site for river stabilisation techniques. The section includes a variety of river forms: pools, sediment filled pools, braided river channel, trained river channel, and the confluence of a major tributary (which is severely eroded).

Northam was settled in the 1830s. The river was a valuable resource, initially as a drinking water source, then later for stock water. Burlong Pool, 4 km upstream from Northam, was an important feature. This was used as the town swimming pool for many years until it filled with sediment in the 1960s. Water from Burlong Pool was used in steam trains supplying the Goldfields.

Floods are an important feature of the Avon River. Major floods have occurred in 1872 (highest flood level recorded), 1917, 1926, 1934, 1945, 1946 and 1955. The 1955 flood, the most recent to cause significant infrastructure damage, was greater than a 1:25 year average recurrence interval flood. This flood precipitated the river training scheme, which involved the removal of vegetation and debris from the river to increase the channel capacity. Over 187 km of the Avon River (from below Toodyay to Brookton) was trained between 1958 and 1970. The braided area upstream of Northam (one of the few areas left un-trained) was left to reduce the sediment infill to Northam Town Pool.

Some of the major features of this river section are:

1. Northam Town Pool - With the potential to be Northam's greatest asset or greatest liability, several important issues face the pool: amenity values, the threat of sediment infill, pool eutrophication, excessive seagrass and Sago Pond Weed (Coleogeton and Lamprothamnium) growth and algae blooms.
2. West Northam Forest - Important issues include: aesthetic values; conservation value (the braided river community could be declared a threatened community by CALM during 1998); the forest's ability to retard sediment movement into Northam

Town Pool and attenuate floods. The forest is a major area of bridal creeper infestation.

3. Burlong Pool and Burlong Park - These and the surrounding area were important recreational facilities before the pool filled with sediment and have deteriorated. Restoring recreational opportunities for the area and maintaining sand traps to reduce sediment movement into Northam Town Pool are the major considerations for this area.
4. Spencers Brook confluence - Spencers Brook drains a considerable area to the west of the Avon River. The confluence was altered by the river training scheme, and now suffers major erosion. The creek is incising and an active head cut has progressed over 100m up Spencers Brook. A riffle is being trialled to control these two erosion problems.

The Channel Survey performed by Ecoscape and Jim Davies and Associates in 1996 characterised the Avon River. While the river training scheme caused massive destabilisation of the river, it remains a functioning ecological system and continues to move toward a new equilibrium. In addition to the impacts of the river training scheme, the river faces a number of pressures and ecological impacts as a result of human settlement. Overall, the river section faces many problems, which in turn, raise many issues which need to be resolved. The condition of the river section is summarised, with respect to a number of variables, in Appendix 1, with condition "ratings" provided in Appendix 2. A number of conclusions can be drawn from this summary:

- the entire river section, apart from the area known as the "West Northam Forest" (immediately upstream from Northam Town Pool) has been "trained". Nearly 50% of the river channel has a condition rating of D, and nearly 75% a rating C2 or worse. This indicates that the trained river channel is degraded along much of its length, eroded to a hard clay and with unstable banks and bed surface;
- the condition of 50% of the foreshore vegetation is category B3 (degraded and weed dominated) with almost all the rest in category C1 or C2 (erosion prone, exposed soil and weeds only);



- overstorey regeneration is dominated by three species: *Eucalyptus rudis*, *Melaleuca raphiophylla* and *Casuarina obesa* but regeneration is low with 84% of sites showing no regeneration of any native overstorey species;
- other significant disturbances include that caused by stock and feral animals in the river; and
- just over half of the river is fenced on both sides and a further 38% is fenced on one side only.

Key issues format

In order to provide a logical and systematic approach to presenting the issues, they have been brought together under five main groupings:

1. **River discovery and appreciation.**
2. **River repair.**
3. **Natural events.**
4. **River pollution.**
5. **Strategic planning.**

The groupings reflect the key issues for the river section. The main focus of the River Recovery Plan is two-fold:

- to encourage a better understanding and appreciation of the natural qualities of the river; and
- to repair the ecological condition of the river.

The need to capture community interest and involvement is vital if we are to substantially improve the condition of the river. A new attitude to the river and substantial involvement in protecting and improving the condition of the river by the entire community is needed. Without understanding and support from the community, major recovery in the condition of the river is unlikely.

The format for the Key issues section of the Plan includes:

- a strategic objective for each key issue and for each individual issue listed under the key issue;
- principles for management related to the issue (where appropriate);
- specific actions to be undertaken for each issue; and
- priority and timing for completion of each action.

Priorities for the actions relate to their relative importance for management of the river section. Timing for the actions relates to the time frame within which the action should be completed.

Priorities are rated as

- high
- medium
- low

Timing is rated as:

- short (1 year)
- medium (3 years)
- long (5 years)
- on-going

Key issue 1: River discovery and appreciation

Strategic Objective

To encourage and facilitate local community understanding, appreciation and enjoyment of the natural qualities of the river.

It is likely that for a long time the river has been regarded, by most in the community, as not much more than that big “channel” through the town which carries water downstream. The river, as many people in the community are now aware, is much more than that. It is an ecological system with special natural character and features. It supports aquatic wildlife in-stream, and terrestrial wildlife on-shore. It is a dual wildlife corridor, in-stream and on-shore. It is a major element of the rural and urban landscape. It changes character through the seasons and from year to year, depending on rainfall in its catchment. It has spiritual importance to many. Of course there is interplay between all these attributes. We should now see the river as a special place worthy of understanding, management and protection.





Avon Ascent information pillar, Northam. [Photograph courtesy of C Ryan]



Northam Town Pool. [Photograph courtesy of C Wright]

Issue 1: The river as a dominant part of town character

Strategic objective

To highlight at every opportunity the importance and value of the Avon River to the overall character of the town.

The Avon River, by its physical location and size, dominates the town of Northam. The river is a dominant element of the landscape and cultural character of the town. It is the main “corridor” in the town and divides the town into two main areas. The main focus of the river in Northam is the Town Pool. However, the river upstream from the Pool in particular is an area of great natural beauty, although somewhat degraded. Much of the river passing through Northam is hidden at the “back” of the town. There is an opportunity for the community and visitors to Northam to understand and appreciate more of the Avon River than is possible at the present.

Strategic Action

1. Encourage inclusion in promotional material for the town and surrounding area of Northam information about the river: history of use (including anecdotes); its size; its natural character and features; restoration efforts etc.

Priority: Medium Timing: Medium

Issue 2: Pools

Strategic Objective

To re-create pools, where appropriate, along the river in order that they may once again contribute to the natural form and character of the river and be used for recreation.

Many pools once existed in the Avon River. Prior to the river training scheme the river was dominated by heavily braided channel reaches separated by pools. While river siltation is a natural process, filling of the pools with sediment has been caused by substantially greater sediment quantity and mobility in the river, mostly as a result of the river training scheme. Clearing of the native vegetation of the catchment may also be a significant factor. Most former pools in this river section have been filled with sediment.

Currently, a strategy is in place to trap and remove sediment from Burlong Pool. The strategy allows for a contractor to remove a fixed amount of sediment each year from two sand traps, in the vicinity of the upstream and downstream ends of the former Burlong Pool. The main intention of this strategy is to restrict sediment flow into Northam Town Pool. At the Town Pool itself, a strategy is in place which has the following objectives:

- to increase water depth in the pool during summer;
- to improve water quality within the pool;
- to improve waterbird habitat around the pool; and
- to improve the overall aesthetics of the pool.



Pools fulfill important ecological functions in the river including over-summer refuge for aquatic animals, breeding sites for water fowl and sites for river recreation. As well, they provide a significant and attractive landscape element within the river system as extensive, open water bodies.

Strategic Actions

2. *Monitor sediment accumulation in Northam Town Pool (NTP) and take further action to minimise sediment input as necessary (plus other points raised in the NTP management plan).*

Priority: High **Timing: Ongoing**

3. *Continue the program of sediment trapping and removal at Burlong Pool as long as is required to maintain the amenity value of the site as a water-based recreation area.*

Priority: High **Timing: Ongoing**

4. *Estimate sediment fluxes at Burlong Pool (BP) (plus other points raised in the BP management plan).*

Priority: High **Timing: Ongoing**

5. *Investigate the possibility of recreating other pools in the section, especially “Leechies” Pool, which was located between Burlong Pool and Carters Pool.*

Priority: Medium **Timing: Long**

6. *Continue surveying the profile of the river between Northam Town Pool and the Northam Town boundary.*

Priority: Medium **Timing: Ongoing**

Issue 3: Feature sites

Strategic Objective

To enhance community and visitor understanding and enjoyment of the river at particular sites along the river.

This river section contains an area of untrained river, known as the “West Northam Forest”. It provides an opportunity to enjoy an untrained, relatively natural part of the river, with its braided channels and vegetation cover across the full width of the floodway. The “forest” can also provide some insight into the likely form of other parts of the river following stabilization of the bed sediments and creation of new islands and channels.



West Northam Forest from Avon Bridge. [Photograph courtesy of V Read]

Strategic Actions

7. *Initiate a detailed survey of the landform and vegetation of the “West Northam Forest”.*

Priority: High **Timing: Short**

8. *Initiate detailed survey and mapping of the natural features of the Burlong Pool “site” as a basis for landscape design to enhance its recreational value. Note that any development of the Burlong Pool area should take into account the ethnographic Aboriginal site located at Burlong Pool. Additional consultation may be required to ensure the ethnographic value of the site is not compromised.*

Priority: Medium **Timing: Medium**

9. *Prepare a schematic landscape design for a Burlong Pool recreation area, which takes advantage of the existing landscape elements and its strategic location between the river and railway line.*

Priority: Medium **Timing: Medium**

Issue 4: Walks trails

Strategic Objective

To encourage greater understanding and enjoyment of the river by providing strategically located walk trails.

Tourists and local people see this section of the river as they cross the bridges and from the parkland on either side of Northam Town Pool. Little opportunity has been provided in the past for people to learn about the river. Walk trails provide an excellent way for people to get close to the river and to appreciate and learn about its ecology. A number of locations have been selected for establishment of walk trails based on their proximity



to formal river access points, to the town centre and in anticipation of future access needs along the river.

Strategic Actions

10. Design and construct a walk trail from Northam Town Pool (western side) upstream to the “pipe bridge” and return. Extension of this walkway across the river at Pool Street footbridge and back to Northam Pool should be investigated.

Priority: High **Timing: Short**

11. In the longer term, extend the walk trail to Burlong Pool on the western side of the river.

The precise location, design and construction of the walk trails should be undertaken in such a way that the trail lies unobtrusively in the river landscape; causes minimal environmental disturbance; and requires minimal maintenance.

Priority: High **Timing: Long**

Issue 5: Interpretation and demonstration

Strategic Objective

To encourage greater understanding of the river as a functioning ecological system by providing interpretative material about the river and demonstration sites along the river, where appropriate.

The river is a dynamic and complex ecological system. Even with knowledge and understanding of its functions it will take considerable effort and time to rehabilitate. The close proximity of the river to the town of Northam provides an excellent opportunity for the community and visitors to observe and learn about the river and rehabilitation efforts. The Avon River Management Authority has resolved that the area between Spencers Brook and Northam Town Pool be established as a demonstration area for river management works.

Strategic Actions

12. Establish a permanent display presence at the new Northam Visitor Centre which explains; Avon River character and history; important river features; efforts to rehabilitate the river; and demonstration rehabilitation sites along the river.

Priority: High **Timing: Short**

13. Construct a strategically located viewing platform adjacent to the West Northam Forest which includes an interpretative display of the braided river channel system.

Priority: Medium **Timing: Medium**

14. Construct strategically-located, low key interpretative signs along the West Northam Forest walk trail.

Priority: Medium **Timing: Medium**

15. Collect and collate all relevant information about the river section.

Priority: Medium **Timing: Ongoing**

Issue 6: History and heritage

Strategic Objective

To increase the availability of historical information related to this section of the Avon River.

The river undoubtedly has been of great importance to Aboriginal and European people. For example, an Aboriginal ethnographic site is located in this river section, at Burlong Pool. The utilitarian and spiritual values of the river for those who have had an association with it provide rich material for exploring the history and heritage of the river. Much of this information is not written down but is retained in the memories of older people in the local community and elsewhere. While the process of acquiring this valuable information is likely to be ongoing, the opportunity of acquiring information from the older members of the community should not be lost.

Strategic Actions

16. Prepare an inventory of sites of historical and cultural heritage importance including location and description.

Priority: High **Timing: Long**

17. Undertake recording of oral history and knowledge about the river including: importance of the river to local culture; river use; life on the river; origins of names of river features etc.

Priority: High **Timing: Ongoing**

18. Make available for public information the inventory and oral record, and inform the community of their availability.

Priority: High **Timing: Ongoing**





Poole Street Bridge. [Photograph courtesy of C Ryan]

Issue 7: Recreation use

Strategic Objective

To encourage appropriate river recreational activities at strategically located and suitably managed sites.

The river provides an attractive setting for recreational activity. However, some recreational activities have the potential to damage the river environment, threatening its ecological integrity and slowing its rehabilitation. Impacts can be direct through damage to fringing vegetation with consequent destabilisation of the banks and bed of the river. Indirect damage occurs through introduction of weed seed to the river environment. In addition, particular sites are likely to be more appropriate for recreational use because of their strategic location, landform stability, size, ease of maintenance etc. Recreational sites should be selected using such criteria.

Principles

1. *Recreational activities associated with the river should be selected on the basis that they would have minimal impact on the river environment and are compatible with a river setting.*
2. *Recreational activities within the river which can result in unacceptable environmental impacts on the river, such as motor bike riding and other vehicle driving, and horse riding, should be discouraged. Alternative, more appropriate sites should be designated away from the river.*
3. *New recreation sites on the river should be selected on the basis of recreational demand as well as the site's strategic location, landform stability, size, ease of maintenance.*

Strategic Actions

19. *Determine and designate alternative sites for horse riding and motor bike riding. Use of these alternative sites should be encouraged. Selection of sites should be undertaken in consultation with the community and the Town and Shire of Northam.*

Priority: High Timing: Short

20. *Establish formal recreation nodes at appropriate locations.*

Priority: Medium Timing: Ongoing

21. *Monitor river recreational use and make adjustments to the designated recreation nodes as river use alters.*

Priority: Medium Timing: Ongoing

Issue 8: Access

Strategic Objective

To provide access to the river foreshore which meets management and recreational needs, with minimal impact on the river environment.

Access is defined as general access to the river edge (not into the river) and includes vehicle and pedestrian access. "Formal" access to the river in this section is limited to Northam Town Pool. "Informal" vehicle access to the river occurs in other locations for fire suppression, bridge maintenance, recreational use and from roads which run along the edge of the river. Access to the river to date has not caused significant damage to the river environment except at Burlong Pool where many vehicle tracks criss-cross the river foreshore and adjacent woodland.

Access to the river, especially vehicle access, has the potential to cause significant damage. Hence, it makes good river management sense to determine appropriate locations for vehicle access, to manage access at those sites, and to close inappropriate access. In this way adequate access to the river may be provided while the impacts of access can be minimised through specific site management. Vehicle access at specific nodes is likely to cause less damage to the river environment than continuous vehicle access, for example, from an adjacent access road.



Principles

4. *Public vehicle access to the river should only be at formal recreation nodes.*
5. *Vehicle access to the river at other than formal recreation nodes should be discouraged.*

Strategic Actions

22. *Maintain public vehicle access at formal recreation sites.*

Priority: Medium **Timing: Ongoing**

23. *Close inappropriate vehicle access to the river foreshore and the river reserve.*

Priority: High **Timing: Short**

Key Issue 2: River repair

Strategic Objective

To repair the ecological damage associated with river training, catchment vegetation clearance and other damaging activities.

While previously it was noted that the special character of the river should be understood and appreciated, we also must understand that the river is not in good condition. The river training scheme and excessive clearance of vegetation in the catchment has had a deleterious effect on the river environment through direct loss of foreshore and river channel vegetation causing erosion of banks and beds and sedimentation of pools. These effects have, in turn, degraded the ecological and landscape quality of the river. There is much work to be done to improve the condition of the river and to restore its natural character.

The overall intent of river repair is to restore, as much as possible, the characteristic system of alternate braided river channels and river pools. This implies that rehabilitation effort is required within the river itself and within the fringing foreshore land (and in the tributaries and catchment areas of the river).

Issue 9: Foreshore revegetation

Strategic Objective

To revegetate areas of the river foreshore based on their need and suitability for revegetation.

The direct loss of foreshore vegetation was mentioned above. There has not been substantial loss of native

overstorey vegetation from the foreshores of this river section and some regeneration of native trees is occurring along the river. However, most areas have very little understorey vegetation remaining. It has mostly been replaced by annual weeds. Also, there are some denuded foreshore areas along the river.

Fortunately, much of the foreshore overstorey remains intact or is regenerating. Therefore, foreshore revegetation efforts are best focused on understorey vegetation including sedges and rushes immediately adjacent the river channels. Foreshore revegetation should be closely linked to actions for in-stream stabilisation, stock access and weed management.

Strategic Action

24. *Prepare detailed, site-specific planting/seeding schedules for designated revegetation sites, linked to foreshore fencing, in-stream sediment stabilisation and site-specific weed eradication, where appropriate.*

Priority: High **Timing: Short**

Issue 10: In-stream stabilisation

Strategic Objective

To restrict sediment movement by stabilising river bed sediments, where appropriate.

The quantity and mobility of sediment within the river is a major management issue. In addition, the loss of the braided channel system within the river, as a result of the river training scheme, has had a major negative effect on the ecological integrity of the river and on its landscape character. Stabilisation of river bed sediments and creation of new islands and channels would help to redress these problems. However, the forces of river flow have the potential to make redundant efforts to stabilise sediments and restore channels. Nevertheless, this should not be a deterrent to local stabilisation efforts.

What is ultimately needed, for the river section and the river as a whole, is a balance between a new system of braided channels and pools, and a channel system capable of moving water downstream at an acceptable rate under flood conditions. More work is required to define an optimum balance between sediment trapping and stabilisation and flow efficiency and effectiveness.





Excavating sediment traps, Burlong Pool. [Photograph courtesy of C Ryan]

Strategic Action

25. Prepare and implement site-specific sediment stabilisation works focusing at designated sediment stabilisation sites. In general, those sites include:

- old islands (stabilising islands)
- new islands (sediment deposition islands)
- sediment slugs
- scour areas (river margins).

Priority: High **Timing: Short**

Issue 11: Sediment management

Strategic Objective

To substantially limit sediment movement along the river.

As mentioned earlier in this report, the quantity and mobility of sediment in the river has increased significantly since major vegetation clearance in the catchment and the river training scheme. Sedimentation of pools is one of the river's major problems. While sediment management is a river-wide management problem it can be addressed at the local river section scale through a variety of means such as riffles and pool extraction. Nevertheless, there is an inherent risk that the forces of river flow will make redundant any efforts to manage river sediments. However, this should not be a deterrent to local sediment management efforts.

Strategic Actions

26. Undertake a survey of the river section to identify appropriate locations for construction of river riffles.

Priority: High **Timing: Medium**

27. Prepare a sediment management strategy in association with any pool re-creation strategy.

Priority: High **Timing: Long**

Issue 12: Stock access

Strategic Objective

To restrict stock access to the river.

Animal stock cause varying degrees of damage to the river environment. Impacts include erosion of the river bed and banks, importation of weed seeds and direct loss of native vegetation. Essentially, continuous, unrestricted stock access to the river is incompatible with sound management of the river. However, there may be some scope for controlled stock access as part of a specific foreshore vegetation management strategy.

Principle

6. Stock access to the river, which can result in unacceptable environmental impacts on the river, should be discouraged. However, there may be specific circumstances where management requirements require selective and controlled grazing in particular areas.

Strategic Action

28. Advise relevant landowners along the river section the reasons for the move to restrict stock access to the river.

Priority: High **Timing: Short**

29. Undertake fencing of river foreshore with specific fencing goals.

Priority: High **Timing: Short**





Bridal Creeper smothering native vegetation. [Photograph courtesy of K Meyer]

Issue 13: Weeds

Strategic Objective

To eradicate weeds from the river section and replace with native vegetation.

As opportunistic plants, weeds pose difficult ecological problems for river management. Weeds occupy many areas of the river environment previously occupied by native plants. Some of the impacts of weeds in the river include: failure of weeds to provide the same type and diversity of habitat for native fauna; high fire risk of some weeds species; lower capacity, than native species, to stabilise embankments while having greater ability to superficially bind sediment plumes within the river; failure to meld into the natural landscape character of the river.

In general, weeds are difficult to remove entirely. In addition, the distribution of most weed species is not localised and management for many weed species must be addressed at a larger scale than the river section. Also, in certain circumstances, some weeds fulfill useful functions including stabilising sediments within the river where this is desirable. Hence, immediate removal may not be desirable. Once removed, weeds need to be replaced with native species to retard reinvasion of weeds. The reinstatement of native species is the ultimate goal.

Appendix 4 provides weed control information for the major weed found in this section of the river.

Principles

7. *Weeds are not a natural component of the river and should be removed from the river wherever possible.*
8. *Weed management strategies for the river section should be closely linked to strategies for weed management within the entire river.*

Strategic Actions

30. *Prepare site-specific weed eradication schedules, closely linked to the site-specific revegetation schedules.*

See Appendix 4 for guidance on weed management.

Priority: High **Timing: Ongoing**

31. *Incorporate in the rubbish education programme the requirement to discourage the disposal of garden plant and pond plant material in the river.*

Priority: High **Timing: Medium**

Issue 14: Rubbish disposal

Strategic Objective

To foster the notion of the river as a “rubbish-free zone”.

The disposal of rubbish within the river (usually on the margin of the river) is symptomatic of lack of regard for the river in general. Rather the river is considered as simply a convenient place to dispose of unwanted items such as machinery and garden prunings etc. Educational effort is required to improve attitudes to the river. However, in the first instance, specific accumulations of rubbish should be removed from the river; this is not likely to be a major exercise.

Principle

9. *Disposal of rubbish within the river should be discouraged. Educational efforts should be undertaken to assist in eliminating rubbish disposal within the river.*

Strategic Actions

32. *Remove rubbish from sites where it has accumulated.*

Priority: High **Timing: Short**

33. *Undertake a community education programme with the theme of the river as a “rubbish free zone”.*

Priority: High **Timing: Medium**



Key Issue 3: Natural events

Strategic Objective

To plan for natural events in a manner which protects life and property and which minimises impacts on the river environment.

The river ecosystem has evolved within a regime of natural events which include floods and fire. The native plant species growing within and adjacent to the river have developed adaptations to cope with and take advantage of these natural events. Natural events also can cause significant damage to human infrastructure, so much so that considerable efforts are taken to limit the risk and the extent of damage associated with natural events. Efforts include construction of levee banks, specific requirements for structures built in the flood plain and prescribed burning to reduce litter etc.

Issue 15: Floods

Strategic Objective

To increase community understanding of the impacts of flooding and the need for action to minimise the risk of flooding and the damage associated with flooding.

Major floods causing infrastructure damage have not occurred in the Avon River for many decades, possibly because of the lack of extremely high rainfall since about the early 1950s. The extent of flooding under such intense rainfall events is not accurately known as the effect of the river training scheme on flood mitigation is difficult to determine. Also, it is uncertain what effects the return of the river to its natural form (such as braided channels and river pools) will have on flooding. It should be noted that efforts to redress the ecological problems facing the river, such as restoring fringing vegetation, may result in greater flooding in certain areas.

Principles

- 10. Any new structures placed or built in the river (1:100 year) floodplain should not have an adverse effect on flooding.*
- 11. Preparation of Structure Plans, Town Planning Scheme Amendments and other statutory planning documents relating to the river should include reference to and a map showing flood prone land.*



Stormwater drain, Northam. [Photograph courtesy of C Ryan]

Strategic Actions

- 34. Determine and implement best management strategies for use and management of land in the 1:100 year floodplain.*

Priority: High **Timing: Medium**

- 35. Encourage and facilitate development of a flood response plans in order to minimise the damage caused by floods.*

Priority: High **Timing: Medium**

Issue 16: Fire

Strategic Objective

To minimise damage to property and to the river ecosystem associated with fire occurrence.

As mentioned previously, the Avon River has evolved in close association with fire. In many circumstances, specific plants depend on fire for their survival over time. In turn, animals which depend on those plants for habitat or food also depend on fire for their long term survival. For nature conservation purposes, fire management requires that plants are able to reach reproductive capacity between fires and that an adequate range of habitats is provided. There is potential for conflict between the ecological needs of the river and the need to protect property. A balance can and needs to be struck between these demands. Fire is an unpredictable management tool, therefore, its use should be controlled.



Principles

12. *The location of fixed firebreaks should be determined within the context of a fire management plan. The plan should include justification for the arrangement and location of fixed firebreaks and the strategic and operational explanation for cutting additional breaks during fire suppression.*
13. *The number of “fixed” firebreaks and additional firebreaks cut during fire suppression operations along the river should be limited to those that are essential for fire suppression.*
14. *Consideration should be given in fire prevention to reducing fringing forest litter through non-burning techniques such as short-term, site specific grazing.*

Strategic Action

36. *Provide information relevant to the fire management planning for the river, including environmental protection principles which address the number, location and form of firebreaks and their maintenance; access to the river during fire suppression; prescribed burning practices etc.*

Priority: Medium Timing: Ongoing

Key Issue 4: River pollution

Strategic Objective

To ensure all sources of river pollution are identified and pollutant inputs to the river from those sources are minimised.

Many substances which enter the river could be described as pollutants, particularly when they enter the river in excessive amounts. Their effects are wide ranging in scale and timing including immediate and catastrophic, for example, in the case of toxic chemical spills into the river. This would result in death of fish and other aquatic animals and plants depending on the specific type of chemical and the amount spilt. Most pollution is insidious, with effects not manifested in the river ecosystem for some time or translocated downstream many kilometres (eg eutrophication of the estuary and resultant algae blooms). Pollutants entering the river have many sources including those which are direct at discharge points e.g. industrial and stormwater discharges and indirect from the wider catchment e.g. nutrients and organic material from agricultural land.

Issue 17: Stormwater

Strategic Objective

To apply best practice to stormwater management for all new development and as much as possible to the existing stormwater management system.

Generally, stormwater enters the river at specific stormwater outlets on the margins of the river. These discharge points are usually the open ends of drainage pipes. Currently, there is no restriction on the types of material and substances which enter the river through stormwater outlets.

Principle

15. *Stormwater management should be based on best practice, which minimises the amount of pollutants entering the river through the stormwater drainage network.*

Strategic Action

37. *Encourage and facilitate preparation of a municipal stormwater management programme which applies best management practice to existing and new stormwater drainage systems.*

Priority: High Timing: Short



Photograph from C Ryan collection.



Issue 18: Industrial wastewater

Strategic Objective

To minimise the input of pollutants to the river from industrial sources.

Pollutants entering the river from industrial sources can do so in a number of ways including from discharge outlets, via stormwater drainage system and via groundwater flow. Point source discharges from prescribed premises can be managed through licensing under the Environmental Protection Act. Currently there are no prescribed premises in this river section licensed to discharge wastewater to the river. Management of other pollutant sources requires other approaches including working closely with the owners/managers to improve waste management.

Strategic Actions

38. *Seek licensing of point sources of pollutant to the river, under the Environmental Protection Act, where appropriate.*

Priority: High **Timing: Ongoing**

39. *Encourage and facilitate those responsible for pollutant sources, which are not prescribed premises, to determine and implement best management practice strategies to minimise pollutant inputs to the river.*

Priority: High **Timing: Ongoing**

Issue 19: Septic wastewater

Strategic Objective

To minimise nutrient input to the river from septic wastewater systems.

For most of the developed area of Northam adjacent to the Avon disposal of septic waste is via septic tank and leach drain systems. These systems have considerable potential to leach nutrients which, over time, make their way via groundwater flow to the river.

Gradually, these systems are being replaced by reticulated sewerage, as part of the Water Corporation's in-fill sewerage programme. This conversion will result in diverting wastewater to a centralised wastewater treatment plant and will result in significant reduction in pollutants entering the river from individual septic wastewater systems.

Strategic Actions

40. *Encourage and facilitate in-fill sewerage, especially adjacent to the river.*

Priority: High **Timing: Short**

41. *Investigate the suitability of utilising alternative wastewater treatment units, where appropriate and where a sewerage system is not likely to be available for a considerable period of time.*

Priority: High **Timing: Ongoing**

Issue 20: Agricultural wastewater

Strategic Objective

To minimise loss of pollutants from agricultural land to the river.

The quantity of pollutants, especially nutrients and salt, entering the Avon from agricultural sources is excessive. Most of this input is likely to occur via tributaries rather than directly into the main trunk of the river. Hence, the focus for management to reduce those inputs is the tributaries and their catchments. While it is not within the scope of this River Recovery Plan to address pollution management for tributaries in detail, it is important that it is dealt with through an appropriate process.

In the short term, there are particular strategies which can be implemented which can go a long way towards reducing nutrient and sediment input into tributaries and into the main trunk of the river.

Strategic Actions

42. *Encourage and facilitate management planning for tributaries of the Avon River associated with this river section.*

Priority: High **Timing: Medium**

43. *Prepare schedules for fencing and re-vegetation of foreshores of tributaries to create buffers to filter out nutrients and other polluting materials (eg organic matter).*

Priority: High **Timing: Short**



Issue 21: Accidental pollution spillage

Strategic Objective

To minimise pollutant input to the Avon River from accidental spillage.

Accidental spillage of pollutants is not likely to happen often. However, they do have the potential to cause immediate and severe pollution of the river. Processes for dealing with such spillages are developed throughout the state through the Western Australian Hazardous Materials Emergency Management System (WAHMEMS) and through Local Emergency Management Action plans.

Strategic Actions

44. Collaborate with other Local Government, Fire Brigade, Bush Fire Brigade, Department of Environmental Protection, Water and Rivers Commission, Health Department and Main Roads Department to ensure that a contingency plan for hazardous chemical spills is in place to protect the Avon River.

Priority: High Timing: Ongoing

Key Issue 5: Strategic Planning

Strategic Objective

To ensure that all planning processes and provisions reflect sound management of the Avon River.

There are many river management issues which are pertinent to this broad category. They include activities which have potential to affect the river's ecology and landscape and the amenity that they afford. Much of the responsibility for planning for proposed developments which have the potential to affect the river lies jointly with Local Government and the Avon River Management Authority. Sound river management within local government planning processes and by ARMA requires a strong information base. ARMA has responsibility for promoting, supporting and commissioning research and other investigations on the river, both by professional and amateur groups. Information on the Avon River has increased substantially in recent years as a result of ARMA's efforts, increasing the effectiveness of planning and management.

Issue 22: Land use planning

Strategic Objective

To ensure statutory and non-statutory land use planning, at local, regional and state scales, reflect river protection and management principles and specific management requirements.

Land use planning can provide, at various levels, the most effective means of achieving protection and recovery of the river, for example by influencing the location and design of development and by establishing controls on the use and ownership of foreshore areas. The Town Planning Scheme is one of the major tools for addressing sound river management at a local scale. Appropriate zoning, policies and principles can be built into a Scheme which reflect sound river management needs. Other relevant statutory planning mechanisms include:

- Town Planning Scheme amendments;
- Local and Limited Rural Strategies;
- Planning new areas of residential development; and
- Planning for infrastructure development.

In some circumstances, river management at a local level can be affected by planning processes being undertaken by other agencies at the local, regional or state level. Such planning should be addressed at the local level. Following a literature search and discussion with relevant agencies, it would appear that the only significant planning processes currently underway which would affect the river are the W&RC & ARMA "Avon River Management Programme" and the Water Corporation's in-fill sewerage programme. The latter is addressed under Issue 19.

Land within the designated 1:100 year floodplain can be used as a reasonable yardstick for defining the "river". Plans of the area indicate that there is a significant area of private land within the river. It would make sense to designate all land within that floodplain, which constitutes the river, as having new local scheme reserve purpose which reflects the nature of that land and its management needs.

Principle

16. Guidelines and principles aimed at the protection and recovery of the river environment should be included or at least reflected within all relevant statutory land use planning documentation.



Strategic Action

45. Encourage within the review of the Shire and Town of Northam's Town Planning Scheme consideration of the following:

- all land within the 1:100 floodplain to have a new local scheme reserve purpose, which reflects the nature of that land and its management needs, such as: "river protection and management";
- the Principles detailed in this River Recovery Plan;
- ARMA's river management policies.

Priority: High **Timing: Ongoing**

Issue 23: Ownership of foreshore land

Strategic Objective

To ensure, wherever possible, that "alienated" river foreshore land reverts to public ownership.

Many of the early land titles along the river included all or a portion (usually half) of the river within the title. However, the Avon River is a "proclaimed river" under the Rights in Water and Irrigation Act 1914. Therefore, the bed of the river is deemed to be vested in the Crown for the purposes of the Act, if it forms the boundary or part of the boundary between parcels of land. Where no boundary exists in the river bed it would be owned by the landowner.

The status of the bed and foreshore of the river section varies markedly along the river, between private (fee simple) ownership and vesting in the Crown. Alienated foreshore land can revert to Crown "ownership" through one main mechanism: ceding to the Crown of land under Section 20A of the Town Planning Act. Land can also be bought or resumed by the Crown but this is a rare occurrence in rural areas.

Ownership of land within and along the margin of the river is best held by the Crown for a number of reasons:

- it allows unhindered, legal, public access along one of the major watercourses in Western Australia;
- management activities within the river foreshore land can more easily be controlled and coordinated if the land is held by the Crown; and
- specific (Government) funding for management of foreshore land is likely to be more easily acquired if the land is owned by the Crown.

Land within the designated 1:100 year floodplain can be used as a reasonable yardstick for defining the "river". Plans of the area indicate that there is a significant area of private land and roadways within the river. Action 45 mentioned reservation of this land under the Shire's Town Planning Scheme. It is further suggested that this "river" land ultimately be acquired by the Crown.

Principle

17. Wherever possible, foreshore land along the river should be in Crown (public) ownership.

Strategic Action

46. Take every opportunity to acquire, for public ownership, land within and adjacent to the 1:100 flood plain.

Priority: Medium **Timing: Ongoing**

Issue 24: Management of foreshore land

Strategic Objective

To ensure that suitable arrangements are in place for management of specific areas of foreshore land.

A large proportion of river foreshore land is held in private ownership. In this circumstance, management of that land must be by mutual agreement between the landowner and the Avon River Management Authority.

Principle

18. Where foreshore land is held in private ownership and where that land has specific management requirements, a management agreement with the landowner should be developed between the landowner and ARMA. Such agreements should have a common format in order to minimise the administrative burden and simplify the process for landowners.

Issue 25: Development proposals

Strategic Objective

To ensure development which may have an impact on the river, is environmentally acceptable.

Land use adjacent to the river can affect the river in various ways. Land use proposals which may affect the river need to be properly assessed. In particular, land use proposals which have the potential to degrade the



river if not properly managed should require the consent of the Local Authority, with advice from the Avon River Management Authority.

Principle

19. All forms of development which may have an impact on the river should be included within Town Planning Schemes as requiring consent of either the Town or the Shire of Northam.

Strategic Actions

47. Include within the new Town Planning Schemes, for the Town of Northam and Shire of Northam, reference to specific forms of land use, which may significantly affect the river environment, and which would require consent of the Shire/Town. Such land uses should include but not necessarily be limited to:

- *intensive agriculture, including:*
 - *horticulture;*
 - *feedlots (cattle, lamb etc);*
 - *extensive piggeries;*
- *clearing of vegetation adjacent to the river.*

Priority: High

Timing: Short

Issue 26: Service corridors

Strategic Objective

To ensure that service corridors are designed, constructed and maintained in order to have minimal impact on the river environment and landscape.

Many service corridors cross the Avon River in particular road and rail bridges and water pipes. Generally, the relevant agencies do not have specific policies regarding protection and maintenance of these structures. However, they do respond to specific needs or issues relating to the structures or the corridor under their control. For example, where vegetation adjacent to a structure may be a fire hazard, the agency may wish to remove a portion of the vegetation back to a certain line at which the fire risk would be acceptable.

All new structures crossing the Avon River (built after the creation of ARMA in 1993) require licensing under the Waterways Conservation Act.

Principle

20. Agencies proposing to construct new service structures or undertake maintenance work on existing service structures across the river should consult with the Avon River Management Authority.



West Northam Forest near the Westrail Bridge. [Photograph courtesy of C Ryan]



Making it happen

Implementation

This River Recovery Plan includes many Actions to be completed and Principles to guide management decision-making. The overall responsibility for coordinating implementation of the Recovery Plan belongs with the Avon River Management Authority (ARMA). However, implementation of the Actions will, in most cases, require the cooperation and assistance of other government agencies, organisations and individuals.

Many of the actions require implementation through statutory and administrative processes including:

- contingency planning for spillages of pollutants;
- revising Town Planning Scheme reserves and zoning; and
- acquiring land within and immediately adjacent to the river for public “ownership”.

These actions will require working with Local Government and State Government agencies and organisations such as the State Emergency Service and Bush Fire Brigades.

Many of the other actions require practical work, including:

- plan and implement revegetation of foreshores and islands;
- plan and construct walk trails;
- removal of weeds from the river, linked to revegetation of the river;
- removal of rubbish from the river;
- fencing foreshores; and
- closure of inappropriate vehicle access.

Implementation of many of these practical actions would be greatly assisted by community participation. The establishment of a “Friends of the Avon River” group is strongly suggested for this river section, as

community interest and participation will greatly increase the chances of achieving significant recovery in the condition of the river.

Review

The time horizon for the River Recovery Plan is five years. However, the success of implementation of the Actions in the Plan should be reviewed each year. It would be appropriate for the group which guided preparation of this Recovery Plan to meet on an annual basis to review implementation of the Actions and advise ARMA. The review should be consistent with the priority and timing of each Action. At the end of the five year lifetime of the Recovery Plan, a thorough review of the Plan should occur. ARMA should coordinate the annual and five-yearly review.

Research options

During preparation a number of opportunities for additional river management-based research became apparent. It is suggested that consideration be given to undertaking research in these areas. The research areas are listed below and are not ordered according to any priority.

1. Colonisation of river pools in association with recreation of pools.
2. Foreshore vegetation species regeneration, especially post-fire regeneration.
3. In-stream plant colonisation and regeneration, including with respect to soil depth, soil salinity, cross-sectional location in the river bed.
4. In-stream plant colonisation and regeneration: impact on channel development.
5. Channel development: impact on flow velocity and flood levels.
6. Fire history - species regeneration.



References

Ecoscope & Davies, J. 1996, *Avon River Survey Report*.

Harris, T. F. W. 1996, *The Avon, an Introduction*, Avon River Management Authority.

Masters, J. 1996, *The Principles of River Management*, Avon River Management Authority.

Pen, L. & Scott, M. 1995, *Stream Foreshore Assessment in Farming Areas*, Blackwood Catchment Coordinating Group.



Appendix 1

Condition of Section 6 of the Avon River

General condition

(See Appendix 2 for key to condition of channel and foreshore).

Channel:

13% of the section was in category B2.
13% of the section was in category B3.
9% of the section was in category C2.
17% of the section was in category C3.
48% of the section was in category D.

Foreshore:

3% of the section was in category B2.
50% of the section was in category B3.
38% of the section was in category C1.
9% of the section was in category C2.

Channel stability

Bank stability:

75% of the sites surveyed were stable.
25% of the sites surveyed were eroding on one bank.

Bed stability:

38% of the sites surveyed were stable.
29% of the sites surveyed were eroding.
33% of the sites surveyed were accreting.

Bed material:

5% of the sites surveyed contained rock.
20% of the sites surveyed contained gravel.
15% of the sites surveyed contained clay.
70% of the sites surveyed contained indurated clay.
65% of the sites surveyed contained sand.

Channel features:

25% of the sites surveyed contained scour channels.
15% of the sites surveyed contained sand slugs.
60% of the sites surveyed contained bars.

Vegetation

Presence of common overstorey species:

90% of the sites surveyed contained *Eucalyptus rudis*.
90% of the sites surveyed contained *Melaleuca raphiophylla*.
88% of the sites surveyed contained *Casuarina obesa*.

Death of common overstorey species:

25% of the sites surveyed contained dead eucalyptus.

Regeneration of *Eucalyptus rudis*:

84% of the sites surveyed had no regeneration.
12% of the sites surveyed had low regeneration.
4% of the sites surveyed had medium regeneration.
0% of the sites surveyed had high regeneration.

Regeneration of *Melaleuca raphiophylla*:

58% of the sites surveyed had no regeneration.
23% of the sites surveyed had low regeneration.
19% of the sites surveyed had medium regeneration.
0% of the sites surveyed had high regeneration.

Regeneration of *Casuarina obesa*:

27% of the sites surveyed had no regeneration.
40% of the sites surveyed had low regeneration.
27% of the sites surveyed had medium regeneration.
6% of the sites surveyed had high regeneration.

Problem weeds:

Nil.

Disturbance

General:

10% of the sites surveyed contained dumped rubbish.
30% of the sites surveyed were disturbed by feral animals.
10% of the sites surveyed contained service corridors.
45% of the sites surveyed had stock in the river.
15% of the sites surveyed had been burned.

Fencing status:

52% of the sites surveyed were fenced on both sides.
32% of the sites surveyed were fenced on one side.
16% of the sites surveyed were not fenced.



Appendix 2

Key for general river condition

Channel condition

Channel Type	Rating	Description
Untrained	A	Stable banks and bed surface.
	B1	No bank erosion; small areas of unconsolidated bed sediments.
	B2	Bank erosion; unconsolidated bed sediments; minor sand slugs.
	B3	Large sand sediment deposits cover the majority of the river channel with high bed mobilisation rates. Overstorey remains intact but root systems are exposed with undercutting of some bank features. Regeneration potential at this cross-section type is lower.
Trained	C	Some surface stabilisation of sediments and areas of accretion. Stabilising vegetation may be in the form of regenerating overstorey species, groundcovers, or weed grass species. Typically the main channel in these areas will have bed features such as alluvial bars or bed dunes.
	C1	No areas of significant erosion. Accretion is occurring across much of the main channel width. The accreting bedforms may be bed dunes forming stable bars, or erosion bar features on the channel margins or within the centre of the main channel now stabilised and accreting. As well as grasses and ground covers C1 type rivers sections have significant regeneration of overstorey species within the main channel.
	C2	Numerous bedforms ie. bed dunes or accreting bars, low rates of ongoing erosion. Only limited regeneration of overstorey species in the main channel but large areas stabilised by ground covers or grasses.
	C3	Cross section displays both areas of stabilised accretion and areas of erosion. Only isolated bar features and less than 50% of bed is stabilised (grasses/groundcover) accreting bed dunes. Only isolated regeneration of overstorey species. May be scour channels and preferential erosion across bed.
	D	As defined in Pen and Scott (1995) the river channel under this category is described as little more than a ditch. The bed surface provides little prospect of vegetation establishment.
	D1	These sections may either have a bed surface that is heavily eroded and indurated or may be areas of unconsolidated and erodable surface sand deposits. Areas of extreme bed salinity preventing any prospect of vegetation re-establishment may also be given this classification.
	D2 and D3	Classifications as in Pen and Scott (1995) are not warranted on the Avon as the presence of weed species in the channel particularly couch has a beneficial effect of increasing sediment stability and promoting accretion).

Foreshore condition

Rating	Description
A	Pristine (ie. only minor disturbances to vegetation).
B1	Degraded; weed infested.
B2	Degraded, heavily weed infested.
B3	Degraded, weed dominated.
C1	Erosion prone; understorey weeds only; exposed soil.
C2	Eroding; understorey weeds only; surface erosion.



Appendix 3

River rehabilitation information

While no reference books are available specifically on river rehabilitation and revegetation, there are many excellent books on bush regeneration which would be useful guide for rehabilitation works along the river. The following process should be considered an initial guide to planning rehabilitation.

Rehabilitation of the foreshore and river bed should include determining:

1. **Causes** of the site degradation and vegetation loss at the specific site.
2. **Objectives** for rehabilitation of the site.
3. **Options** for rehabilitation.

Revegetation:

- direct seeding (preferably using seed collected locally);
- planting (preferably with plants grown from seed of local provenance or sedges/rushes transplanted from areas of dense growth elsewhere on the river);
- brush matting (placing of seed bearing branches especially of woody seeded plants such as *Eucalyptus*, *Melaleuca*, and *Casuarina*); and
- topsoiling (placing of top soil in denuded areas, gathered from similar, though weed free areas).

Site works:

- construction of small sediment trapping structures downstream from which are planted sedges and rushes.

4. **Plan** for site rehabilitation including
 - proposed site delineation;
 - method (from options and other considerations such always re-establishing overstorey to limit weed growth through shading and revegetating downslope, especially of sedges/rushes, toward the river);
 - site preparation requirements (weed control, soil preparation);
 - excluding stock grazing and controlling feral

animals especially rabbits;

- availability of plants and materials;
- other resources including funding; and implementing and monitoring rehabilitation of the site.

Ensure adequate lead time is allowed to plan and implement the site rehabilitation plan.

Recommended literature on bush management, native vegetation rehabilitation and wildlife protection:

Bradley, K. 1991, *Bringing Back the Bush. The Bradley Method of Bush Regeneration*, Ure Smith Press, NSW.

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The main problem weed occurring in this river section



Appendix 4

Weed management information

is bridal creeper. Information and the suggested removal/control methods for this weed species are listed below:

Bridal creeper (*Myrsiphyllum asparagoides*)

Bridal creeper is a bulbous plant which smothers small plants by climbing or trailing over the ground. Its seed is carried by birds although vegetative spread of bridal creeper has also been noted through the disturbance and physical spread of tubers by machinery along cultivated fire breaks.

The control methods detailed in Ben Carr & Associates (in the Proceedings of the Bridal Creeper Symposium - see reference at the end of this Appendix) include:

- Do nothing
This is not a control method but may be the best approach until effective, long term controls are available.
- Bush regeneration
This approach involves a long term commitment to address the bridal creeper problem by removing disturbance factors where possible and judicious “hand weeding” (creeper “mats” and small plants especially); using the Bradley Method of regeneration (see reference in Appendix 2) The Bradley Method involves three key elements:
 - always work from areas with good condition bushland to areas with poor bushland;
 - create minimal disturbance when working in bushland; and
 - only work at the rate on natural regeneration and to not over-clear.
- Chemical control
This is one of the most effective control methods for bridal creeper. The recommended method involves spraying non-selective herbicide such as Glyphosate 360 at a rate of 1 in 100 water when starting to grow

(May-June). Repeat applications are necessary.

- Burning
Burning does kill bridal creeper and intense fires kill the underground tubers. However, fires can also stimulate growth if tubers are not killed and post-fire ash beds are suitable for seedling growth from seed dispersed from adjacent unburnt areas. This not a recommended strategy but if a wildfire did occur in the area bridal creeper control should then be given a high priority in those areas. Bridal creeper regrowth should be sprayed after fire when it is actively growing.

Suggested control strategy

- Accurately map distribution of bridal creeper along and adjacent to the river;
- Commence control; priority should be given to areas which have the best quality bushland and least bridal creeper infestation - from these areas control can spread into most seriously infested areas;
- Manually spray, using the recommended herbicide and rate, in late autumn early winter (May-June) techniques to minimise the impact on native plants should be used e.g. pulling the creeper down from native plants and blanketing plants; and
- Hand weed, using minimal disturbance techniques to weed out bridal creeper seedlings along a front between good bushland and bridal creeper infested areas should be undertaken. Note, however, that it is vital to not over weed in order to avoid re-invasion of bridal creeper.

A very useful publication on Bridal Creeper is the *Proceedings of a symposium* [on Bridal Creeper] held at the Department of Conservation and Land Management, W.A. in October 1995 (available from CALM).



Appendix 5

Condition of Section 6

Avon River Channel Survey:
Volume 2

Prepared by Jonelle Black
for the
Avon River Management Authority



PREFACE

The Avon River Channel Survey has been conducted in two parts. First, information about the condition of 191 kilometres of the Avon River (from the Avon Valley Nature Reserve to the Brookton Townsite) was collected by Ecoscape Pty Ltd and Jim Davies & Associates Pty Ltd. Secondly, the data collected in the field were entered into a computer system and analysed.

The results from this analysis are presented in two volumes. Volume 1 contains a single report that summarises all the data. It is designed to provide information quickly on areas of specific interest. Volume 2 contains a series of detailed reports, one for each section of the Avon River that was surveyed. These reports will provide a comprehensive base from which to develop management plans for the Avon River.

The following report concentrates on Section 6. It provides information on channel stability, vegetation condition and disturbances to the river foreshore. It also grades the sites within Section 6, allowing rehabilitation programmes to be directed towards sites in poor condition and conservation programmes to be orientated towards sites in good condition.



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1.0 GENERAL INFORMATION

For ease of management, the Avon River was divided into 18 sections spanning approximately 191 kilometres. Table 1 lists those features which form the downstream and upstream boundaries of each section. In addition, the major confluences and pools in each section are given in Table 2.

Table 1. Sections of the Avon River

Section	Downstream boundary	Upstream boundary	Distance (km)
1	Upper edge of Avon Valley National Park	Confluence with Jimperding Brook	11.23
2	Confluence with Jimperding Brook	Deepdale Road	8.14
3	Deepdale Road	Goomalling Bridge	9.16
4	Goomalling Bridge	Glen Avon Weir	11.30
5	Glen Avon Weir	Northam Pool Weir	17.45
6	Northam Pool Weir	Confluence with Spencer Brook	10.13
7	Confluence with Spencers Brook	Wilberforce Crossing	8.75
8	Wilberforce Crossing	Burges Siding	9.08
9	Burges Siding	Balladong Bridge	12.05
10	Balladong Bridge	Gwambygine East Road	11.40
11	Gwambygine East Road	Oakover	5.83
12	Oakover	Top of Beverley Road	12.09
13	Top of Beverley Road	Beverley Mawson Bridge	6.81
14	Beverley Mawson Bridge	Confluence with Avon River South branch	21.67
15	Confluence with Avon River South branch	Johnson Road	5.51
16	Johnson Road	Qualandry Crossing	12.17
17	Qualandry Crossing	Yenyenning Lakes	Separate assessment
18	Confluence with Avon River South branch	Brookton Townsite	18.46

Note: Section 2 is upstream of section 1, section 3 is upstream of section 2.



Table 2. Major confluences and pools for each section of the Avon River.

Section	Confluences	Pools
1	Julimar Spring (3.0), Mortigup Brook (6.5), Munnapin Brook (8.0), Malkup Brook.	Cobbler (9.0), Long (10.5 - 11.0).
2	Jimperding Brook (2.5).	Diving (2.5 - 3.0), Deepdale (8.0 - 8.5).
3	Toodyay Brook (5.0), Boyagerring Brook (8.5).	Nil
4	Seven Springs (2.5).	Lloyds (2.0), Millard (3.0 - 5.0).
5	Mistake Creek (4.0), Wongamine River (13.5), Mortlock River (17.5).	Glen Avon (0.5 - 1.5), Katrine (5.5 -6.5), Egoline (7.5 - 8.5).
6	Spencers Brook (6.10).	Northam (0.5 - 1.0), Burlong (4.3 - 5.0).
7	Heal Brook (7.0).	Wilberforce (7.5).
8	Salmon Gully (5.0).	Mackie (3.5 - 4.0), Tipperary (8.5).
9	Nil	Tipperary (0.5 - 1.0), Meares (3.5), 5 Mile (?), York 1 Mile (9.5), York Town (11.0)
10	Bland Brook (0.5), Mackie River (6.5).	Mt Hardy (2.5), Cold Harbour (4.0).
11	Nil	Gwambygine (1.0 - 1.5), Fleays (5.5).
12	Dale River (6.5).	Brouns (4.5), Robins (10.0 - 10.5).
13	Nil	Speldhurst (2.0).
14	Wannering (6.0).	Beverley (0.5), Eyres (6.5 - 7.0).
15	Turkey Cock Gully (1.5), South and Eastern Branches of the Avon River (5.0), Monjerducking Gully (6.0).	Nil.
16	Bally Bally Gully (6.0).	Nil
17	Not assessed	Not assessed
18	Mangiding Brook (8.5).	Nil

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



2.0 CHANNEL STABILITY

2.1 Bank and bed stability

Within Section 6, approximately 75% of the river embankment was stable on both sides. In comparison, only 38% of the channel bed was stable. Hence, along this stretch of the Avon River, the banks of the river were more stable than its bed surface. When taking all the sections into consideration, the number of sites with stable banks in Section 6, was higher than average. In contrast, the number of sites with a stable bed surface was lower than average (figures 1 and 2).

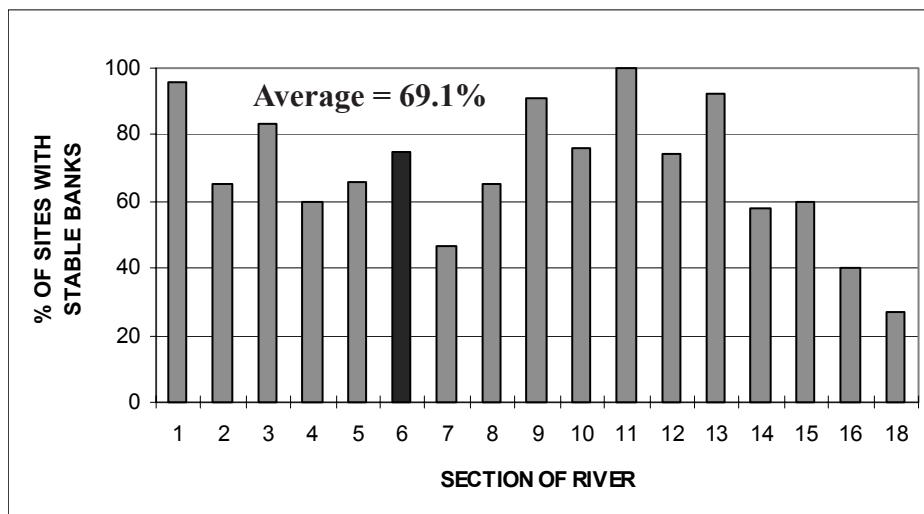


Figure 1. Bank stability along the Avon River.

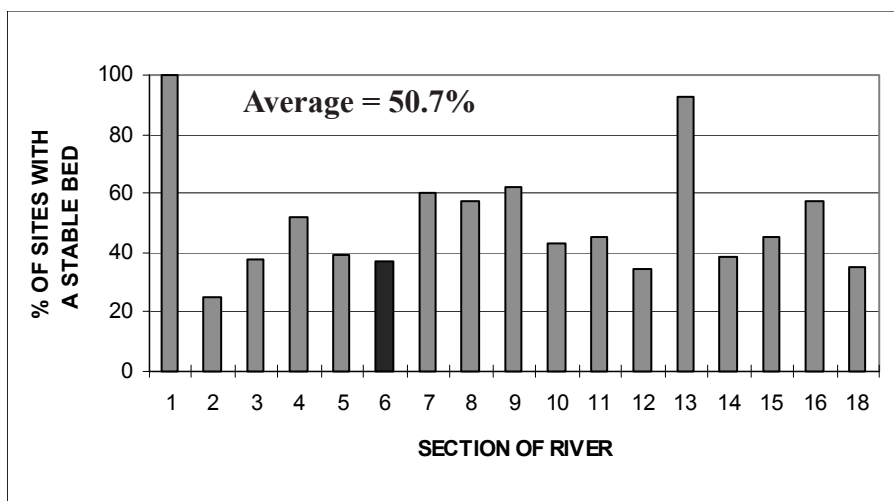


Figure 2. Bed stability along the Avon River.



2.2 Channel features

It is important to note the geomorphological features of a river channel in order to determine whether the channel is eroding, accreting or in dynamic equilibrium. In Section 6, 60% of the sites were neither eroding or accreting. Of the remaining sites, 25% contained scour channels, while 15% contained sand slugs. Compared to other sections of the Avon River, Section 6 had a moderate number of scour channels and sand slugs (figures 3 and 4).

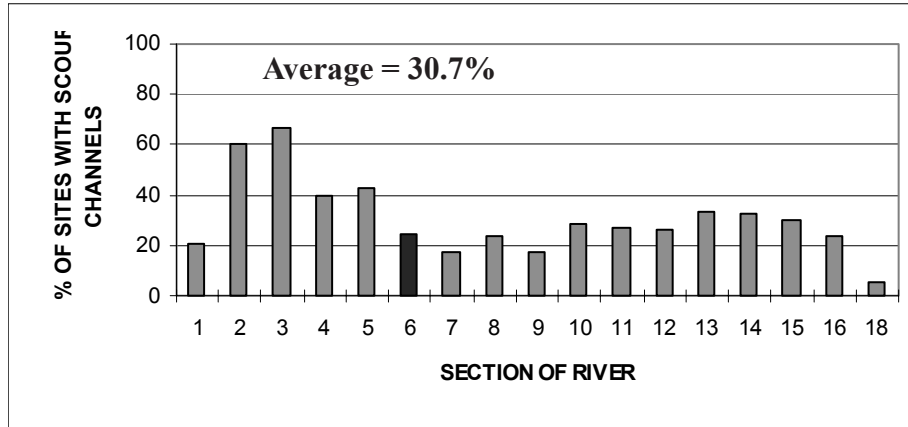


Figure 3. Scour channels along the Avon River.

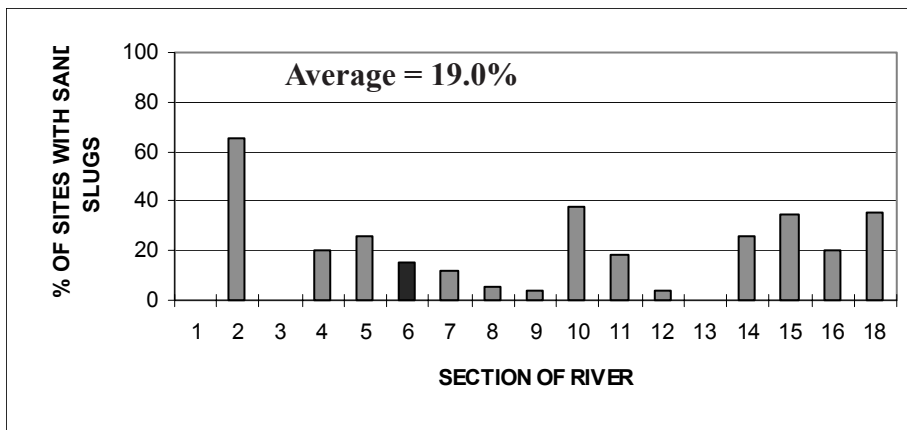


Figure 4. Sand slugs along the Avon River.



3.0 VEGETATION CONDITION

3.1 Presence, health and regeneration of common overstorey species

Of the three common overstorey species found along the Avon River, *Eucalyptus rudis* and *Melaleuca raphiophylla* were identified at nearly all the sites. In comparison, *Casuarina obesa* was identified only at 80% of the sites. In general the overstorey was healthy, however 9% of the sites contained dead or dying vegetation. Further research is necessary to determine whether the regeneration rate for each species is equivalent to that which naturally occurs (figure 5).

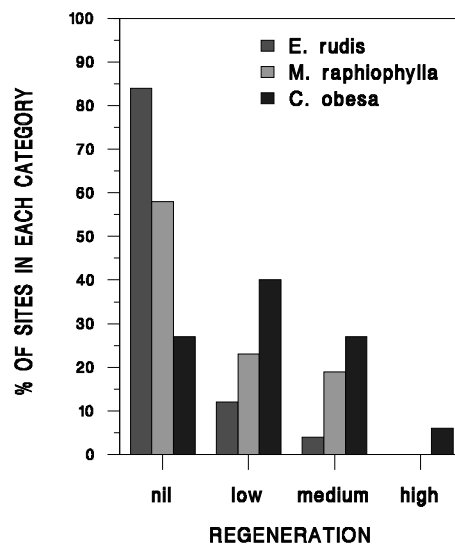


Figure 5. Regeneration of common overstorey species in Section 3.

3.2 Problem weeds

No problem weeds were identified in Section 6.



4.0 DISTURBANCE FACTORS

4.1 General disturbances

The level of human disturbance was high in Section 6. At the time of the survey, 30% of the sites were disturbed by feral animals (figure 6). Sites were also disturbed by stock (45% of the sites), burning (15% of the sites), rubbish dumping (10% of sites) and service corridors (10% of the sites).

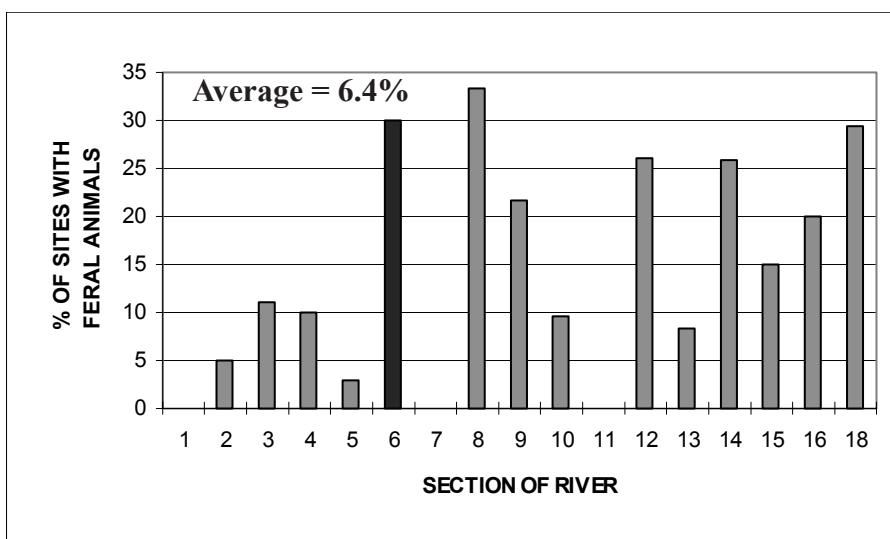


Figure 6. Rubbish dumping along the Avon River.

4.2 Fencing Status

Within Section 6, 52% of the sites were fenced on both sides of the river. Of the remaining sites, 32% were fenced on one side, while 16% were not fenced at all. Compared to other sections of the Avon River, Section 6 had a moderate amount of fencing (figure 7).



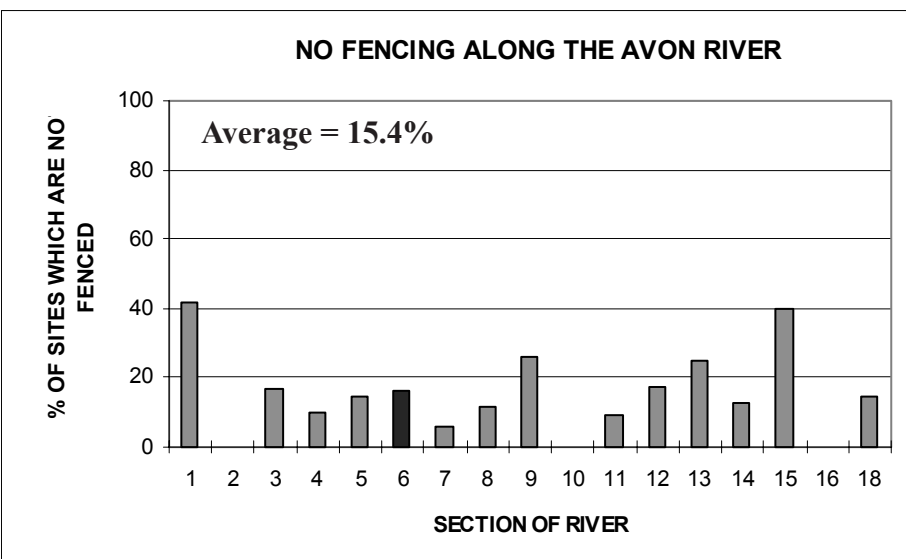
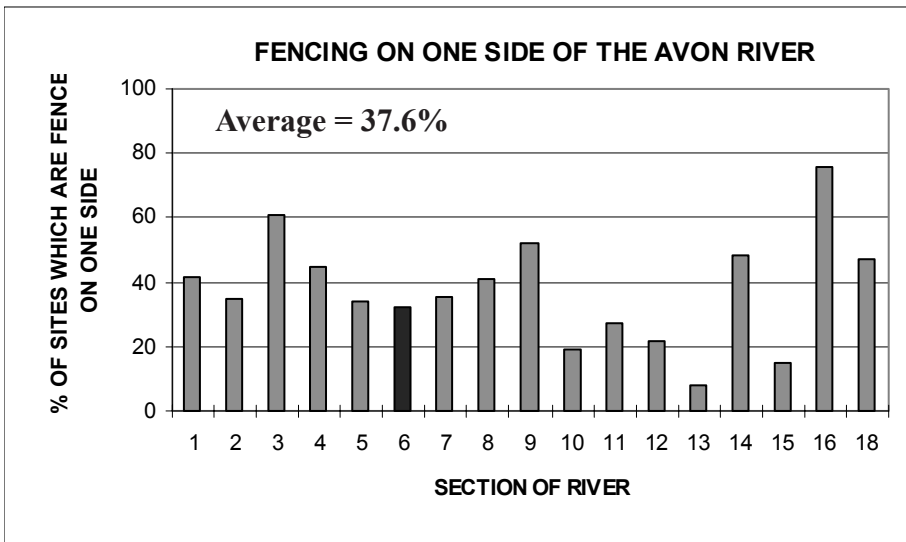
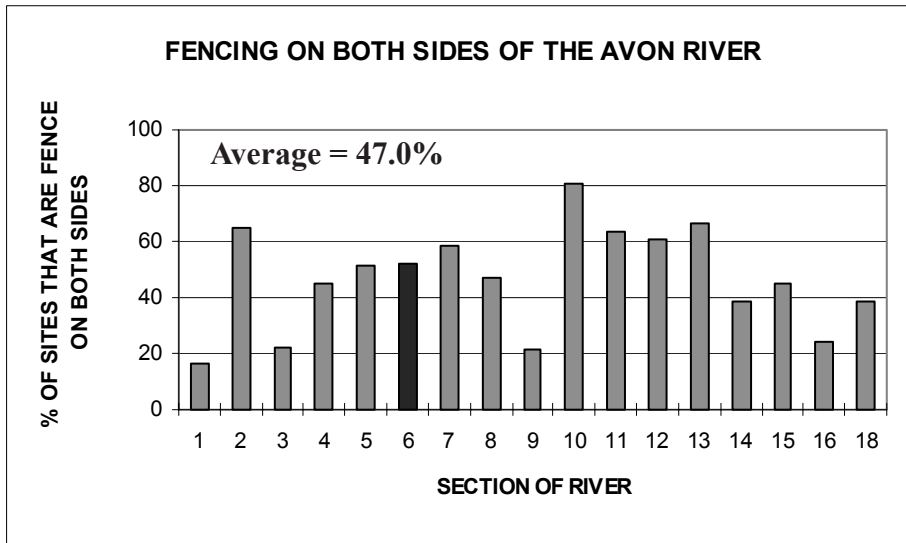


Figure 7. Fencing status along the Avon River.



5.0 GENERAL CONDITION

5.1 Channel and foreshore assessment

In Section 6, the general condition of the channel was variable, ranging from B2 to D (see appendix A). A large proportion of the channel was in category D, indicating that its banks and bed surface was unstable in many places. The general condition of the foreshore ranged between B2 and C2, but was predominantly B3 (see appendix A). This indicates that the foreshore was largely dominated by weeds.

5.2 Condition of individual sites

To determine the general condition of each site, a weighting system was developed to take into account the different variables that were measured in the survey. Those variables that indicated that the site was in a poor condition (eg. scour channels and sand slugs) were assigned a high value, such as 5. Those variables that indicated that the river was in a good condition (eg. stable bed surface and banks) were assigned a low value, such as 1. An overall weighting was obtained for each site by summing these values. Hence, a site with a *low* overall weighting would be in a better condition than a site with a *high* overall weighting (figure 8).

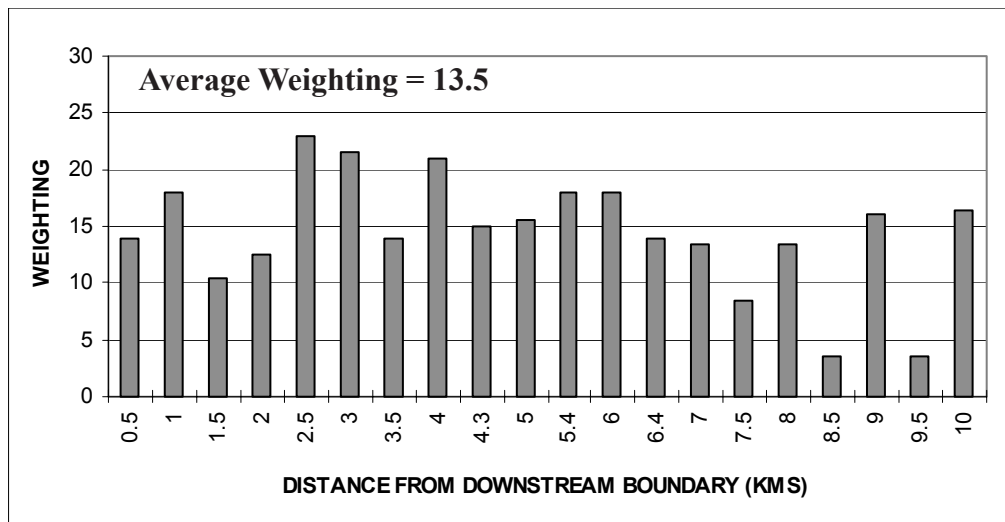


Figure 8. Condition of sites within Section 3.



6.0 CONCLUSION

The development of catchment plans for each section of the Avon River, and their subsequent implementation, will require commitment from both government departments and the local community. The Avon River Channel Survey, has clearly indicated that some sections of the Avon River are in a degraded condition. Hence, it follows that in the process of writing catchment plans for the Avon River, these sections should be given priority.

To meet this objective, the sections were ranked according to their average weighting (as calculated in 5.2). From table 3, it can be seen that Section 6 may be considered a moderate priority for a management plan.

Table 3. Ranking of sections along the Avon River.

<i>Ranking (from worst to best)</i>	<i>Sections</i>	<i>Average Weighting</i>
1	2	19.6
2	18	17.4
3	15	16.0
4	16	15.4
5	14	15.3
6	5	14.7
7	6	14.5
8	7	14.4
9	10	14.3
10	81	4.2
11	4	14.0
12	3	13.5
13	12	12.2
14	1	10.6
15	9	10.5
16	11	10.3
18	13	9.0



CHANNEL CONDITION

<i>Channel Type</i>	<i>Rating</i>	<i>Description</i>
Untrained	A	Stable banks and bed surface.
“	B1	No bank erosion; small areas of unconsolidated bed sediments.
“	B2	Bank erosion; unconsolidated bed sediments; minor sand slugs.
“	B3	Undercutting of banks; large sand slugs.
Trained	C1	No bank erosion; majority of sand deposits are consolidated.
“	C2	Bank erosion; only large sand deposits are consolidated.
“	C3	Scour channels; most sand deposits are not consolidated.
“	D	Unstable banks and bed surface.

FORESHORE CONDITION

<i>Rating</i>	<i>Description</i>
A	Pristine (ie. only minor disturbances to vegetation).
B1	Degraded; understorey is weed infested.
B2	Degraded; understorey is heavily weed infested.
B3	Degraded; understorey is weed dominated.
C1	Erosion prone; understorey only weeds, with areas of exposed soil.
C2	Eroding; understorey only weeds, with areas of surface erosion.

