AVON
CATCHMENT COUNCIL

AVON NATURAL RESOURCE MANAGEMENT STRATEGY

2005

Avon Catchment Council
PO Box 311
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INTEGRATED
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MANAGEMENT

THE AVON NRM STRATEGY

THE REGIONAL NATURAL RESOURCE MANAGEMENT STRATEGY FOR THE AVON RIVER BASIN

AVON
CATCHMENT COUNCIL

May 2005

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Come gather 'round people
Wherever you roam
And admit that the waters
Around you have grown
And accept it that soon
You'll be drenched to the bone.
If your time to you
Is worth savin'
Then you better start swimmin'
Or you'll sink like a stone
For the times they are a-changin'

Bob Dylan

Foreword

The Avon Catchment Council has developed the Regional Natural Resource Management Strategy for the Avon River Basin by extensive revision of the original strategic plan. The Avon NRM Strategy will assist decisions and actions in natural resource management towards our 'preferred future' over the next fifty years. It will see change in the manner in which the Avon River Basin's natural resources are managed, considering environmental, social and economic factors.

The drive for change has come from many quarters, but initially from our traditional fund provider, the Australian Government. On reviewing the Natural Heritage Trust Programme, the government accepted the conclusion that significant positive impacts on the environment were difficult to achieve through fragmented funding and small-scale projects. It recognised that building the capacity of communities to manage natural resources is important, and acknowledged success in this area. The revised NHT2 program and the National Action Plan for Salinity and Water Quality are responding to the need for a more focused and strategic approach to investment in natural resource management.

A requirement for change was also recognised by much of our community, who have put in tremendous effort during the decade of landcare, only to see, quite often, salinity, erosion, loss of biodiversity and acidification continuing to increase. This has at times caused considerable frustration to those most affected.

As a result of these changes, our new strategy identifies assets of high value, the threats affecting them and a clear pathway to the protection of these valued assets. The Australian and State Governments, along with the community through the Avon Catchment Council, have worked in partnership to draw up a strategy that reflects these changes and also clearly outlines a way forward for all stakeholders in the Avon, to protect assets dear to them. One of the challenges facing the Avon Catchment Council is to ensure that this strategy is meaningful to everyone at the scale that interests them most, whether it is the local 'back paddock' scale, or the state and national scale or something in between.

This challenge will be met through delivering regional programs at the local level. Champion individuals and catchment groups will provide ongoing leadership for successful works that protect our land, water, biodiversity conservation and infrastructure assets as well as adding to the lifestyle of people who live and work in the region.

The Avon NRM Strategy challenges us all to work together to be effective. Areas previously thought to be 'too difficult' or controversial must now be tackled if we are truly to make the changes we all strive for. Successful implementation of this Strategy requires that industries dependent upon natural resources are both sustainable and profitable. The Strategy does not stand alone but fits with Australian and State Government policies and strategies as well as those at the regional and local levels.

The Avon Catchment Council has undertaken the difficult task of developing a revised strategy for natural resource management for the Avon River Basin within a relatively short period of time. It has been achieved through the cooperation and assistance of our partners and our community, particularly assisted by our local landcare/rivercare/bushcare coordinator network. The Avon Catchment Council pulled together a management team consisting of policy, technical and community people from government, private industry and community. Each has had an important part to play, and without each and everyone working closely together we would never have managed to complete the task.

Now that we have this Strategy to lead us into the next fifty years, it is up to each of us to play our part in implementing it. It has been written so that everyone will find relevance to his or her situation. However it will still need us all to be involved in putting this complex jigsaw together over the next fifty years, if we truly want to ensure the Avon River Basin is thriving environmentally, economically and socially in 2054.

Barbara Morrell
Former CHAIR
AVON CATCHMENT COUNCIL

(Endorsed by Wayne Clarke
Current CHAIR
AVON CATCHMENT COUNCIL)

Welcome to Country

Our land Australia, how lucky we are to have the privilege of living in such a beautiful country and having it to call home.

We the Ballardong people are proud to acknowledge our traditional ownership of these lands and our ancestors' for they have cared and nurtured this land for thousands of years and have been the sole caretakers who implemented their cultural values and ways of living with nature side by side.

Let us work together to achieve one common goal 'The Healing of Mother Earth', for time has come to give back to her what we took from her very soul.

On behalf of the Aboriginal people

Acknowledgements

The Avon NRM Strategy has been prepared by the Avon Catchment Council with support from many individuals, agencies and organisations. It was prepared following public consultative processes with contributions from many individuals, families, groups and organisations.

Development of this Strategy would not have been possible without the input of many people. The Avon Catchment Council acknowledges those who have contributed to this Strategy either by direct input or by their involvement in earlier planning and workshop processes. The Avon Catchment Council wishes to extend its appreciation to all these people.

The ACC especially wishes to thank:

- Avon Community Landcare Coordinators;
- Department of Environment Staff;
- Department of Agriculture Western Australia Staff;
- Department of Conservation and Land Management Staff;
- Forest Products Commission;
- Wheatbelt Development Commission Staff;
- CSIRO Staff;
- Salinity Investment Framework Steering Committee;
- Attendees of the Regional Prioritisation Workshop;
- Attendees of the Focus Group Meetings;
- Avon Local Government Authorities;
- CLC Management Committees;
- Land Conservation District Committees;
- The Aboriginal Community;
- Greening Australia, World Wide Fund for Nature, WA Channel Steering Group, Avon Waterways Committee;
- The following communities: Bencubbin, Brookton, Bruce Rock, Calinigiri, Corrigin, Cunderdin, Kellerberrin, Koorda, Merredin, Mukinbudin, Newdegate, Nungarin, Pingelly, Quairading, Southern Cross, Tammin, Toodyay, Trayning, Westonia, Wickepin;
- Viv Read, Bruce Hamilton, Peter Curry, Ted Rowley, Ross Colliver, Rod Safstrom, Andrew Huffer and Carla Swift;
- URS Australia, Economic Consulting Services (ECS);
- Attendees of the numerous community meetings held throughout the region; and
- ACC members and staff, past and present, especially the former ACC Chair, Barbara Morrell.

The 2005 members of the Avon Catchment Council (left to right) – back row: Russell Crook, Martin Revell (proxy for Ross Sheridan), Cec McConnell, Wayne Clarke (Chair), Colin Nicholl, Brian Whittington and Colin Stacy (Treasurer); seated: Aminya Ennis (proxy for Bruce Bone), Merrilyn Temby (Deputy Chair), Patricia Dames and Ben Mouritz.

(Absent: Bruce Bone, Fred Bremner, Andrew Prior, Ross Sheridan and Larry Trinder)

The NRM Strategy is supported by the Australian and WA Governments through the Natural Heritage Trust and National Action Plan for salinity and water quality.

Contents

APPENDICES

Figures

Maps

Tables

Summary of the Strategy

The **Avon Natural Resource Management (NRM) Strategy** provides a strategic context for investment in the natural resources and infrastructure of the Avon River Basin. It responds to concern that previous support for local initiatives and small-scale local projects was not delivering regional-scale change for NRM. The Avon NRM Strategy recognises the importance of people working and living with landscapes of the region and is directed towards enhancing their opportunities for the future and their capacity to manage natural resources.

The Avon River Basin is one of over 60 regions in Australia that are currently preparing regional NRM strategies. It is one part of a bold initiative for the nation. Arrangements between the Australian Government and the States and Territories governments include investment of public funds based on the strategic regional strategies following their accreditation by State and Australian Government Ministers. Significant funding is available for investment in Western Australia through the **National Action Plan for Salinity and Water Quality** (NAP) and the extension to the **Natural Heritage Trust** (NHT2) investment initiatives.

The intentions of the Avon NRM Strategy are ambitious. It sets targets for the condition of natural resources that are acceptable at national, state, regional and local scales. It provides a blueprint for partnership arrangements between communities and government, between government agencies and with many others. It also provides a framework for integrated management at a landscape scale. These bold challenges have not been effectively addressed within the region in the past.

The Avon NRM Strategy has been prepared with leadership from the **Avon Catchment Council** (ACC) and with extensive consultation through community processes and with partner organisations. Development of the regional strategy is considered to be an ongoing process. This 'living document' is focused on regional outcomes 50 years into the future based on targets set for 20 years and provides direction for management action over the next five years.

A 'preferred future' for the Avon River Basin

The Avon Catchment Council envisages that the future will be:

> *to enjoy a socially, environmentally and economically sustainable rural lifestyle within a healthy and beautiful landscape, including land, water, biodiversity and built infrastructure, which is characterised by innovation, co-operation, the use of local wisdom and skills, strong social engagement and democratic processes, and a willingness to share our rural culture with others both inside and outside the region in a manner that contributes to global sustainability and celebrates our 'sense of place' within our unique landscape.*

This vision for the future is to be further developed based on analysis of driving influences in social, economic and environmental change within the region. This will provide a robust framework to achieve the 'preferred future' for the Avon River Basin by adaptively managing with the changes that occur.

The region

The Avon River Basin is an ancient landscape with natural drainage through low-gradient tributaries and salt lakes to the Avon River, which flows as the Swan River from the lower slopes of the Darling Scarp into the Swan-Canning Estuary in Perth.

The region is 11.8 million ha of which 62.7% has been released for agriculture and associated land uses. Extensive clearing of natural vegetation for agriculture and current land practices have caused broad degradation problems in areas used for agriculture. However, the Wheatbelt continues to maintain profitable farm enterprises and the agriculture sector in this region makes the substantial contribution of 34% ($1 467m) of the State's gross value of agricultural production, particularly through wheat exports. The remainder of the region is Crown Land with a relatively small area of pastoral use. Mining is significant in the eastern part of the region.

Most surface and groundwater is unsuitable for domestic or farm use due to high salinity, however saline groundwater resources are used by the mining industry. There are only very small areas of irrigated agriculture.

Freshwater wetlands are uncommon but their biodiversity values are significant. Salt lakes occupy 2.24% of the region and are not well understood.

Natural vegetation in this region is recognised internationally for high biodiversity value particularly for its species richness and high level of endemism (occurring only within the region). Special values include granite outcrops and woodland ecosystems.

The region has a generally declining and ageing rural population. Most of the 42 600 people in the region live in the few larger towns. Some smaller towns are no longer

socially viable. The Avon Arc (the local government areas west in the catchment that are centred on the Avon River) has future prospects of increasing population and personal income. The socio-economic prospects predicted for the Wheatbelt are less optimistic.

The communities and industries of the region are dependent upon public infrastructure, particularly for transport. Infrastructure within the region is threatened by rising water tables causing salinity and by inadequate maintenance and replacement.

The core values of working and living in the region are recognised. These include strong association with the landscape, rivers and wetlands. Aboriginal culture and association with country is also well established. Communities in the Avon River Basin have a proud history of group action to tackle land degradation through the Decade of Landcare.

Actions for regional assets and threats

An inventory of regional priority natural resource and infrastructure assets is being developed. Individual assets of national, state or local significance considered relevant at the regional scale are listed according to Asset Classes. Long-term (20 years) targets (T20) are established for the condition of these assets based largely on assessment of threatening processes. Management Actions Targets (MATs) and key actions have been identified for 'matters for targets' relevant to regional NRM management. The key actions of the Strategy are summarised below.

Avon River and floodplains

The channel, riparian zone and floodplain of the Avon River are to be managed in a way that allows rehabilitation of the disturbed river bed so as to slow sedimentation processes affecting river pools and impacting on the Swan-Canning Estuary in Perth. Over 95% of the river channel is to be fenced by 2009. Sediment management, including some excavation to protect at least 12 priority river pools, is proposed. Bridal creeper is to be substantially reduced and other weeds are to be eradicated from the river environment.

Salinity risk to the fringing vegetation and floodplain is to be identified and managed. Increased flood potential is mapped and included in local government planning.

Major and minor tributaries

Some sections of the major and smaller waterways within the region have retained substantial remnants of riparian ecosystems. Foreshore surveys will identify priority areas for management. Over 200 km will be fenced by 2009.

Creek restoration and sediment control will be undertaken for waterways.

Salt lakes and wetlands

Biodiversity Conservation Plans are to be prepared for the priority aquatic ecosystems with emphasis on listed wetlands of national significance. River pool water quality is to be maintained based on criteria assessment in the Glen Avon, Gwambygine and Wilberforce pools.

The hydrological and ecological functions of salt lakes and wetlands within the region are to be better understood. Assessment is to be made of potential changes to these due to rising water tables or discharge from engineering options for salinity control, including the potential for acid groundwater discharge.

Stream water quality

Nutrient loss and transport is to be reduced through regeneration of healthy fringing vegetation and revegetation, or other management of high risk nutrient source areas.

Regional groundwater

Salinity due to regional groundwater rise will be contained or reduced where possible based on regional-scale risk assessment and planning for change in agricultural systems, revegetation and engineering options. A large-scale demonstration of engineering options is to be planned and, if feasible, implemented. More that 10 000 ha of tree crops are to be established for salinity control by 2009.

Soil condition

Soil acidity is to be substantially reduced and alternative farming options to reduce the cause of acidification assessed. Soil structure will be improved through longer term adoption of new technology and better practice. A substantial reduction in soil erosion and waterlogging over the next 10 years is proposed through integrated water management actions. It is also expected that over 80% of landholders will be adopting best practice management to reduce wind erosion risk within five years.

Dryland salinity

Local flow aquifer systems at risk of causing salinity are to be identified and managed. By 2009, it is expected that over 50 000 ha of deep-rooted perennials and 10 000 ha of tree crops will be established and 100 000 ha of salt-affected land will be revegetated for production or conservation benefit. Engineering options are to be

applied where appropriate and productive use made of fresh or saline water discharge where feasible.

Plant and animal pests and diseases

Coordinated community action to substantially reduce pest plants or animals and diseases that affect production or the environment is to be arranged through Local Area planning processes.

Native vegetation

Native vegetation on farms, in reserves and in the Crown/Pastoral zone is to be maintained or, where possible, increased. Over 2 000 ha of remnant vegetation will be fenced annually in priority areas over the next 10 years. Covenants for at least 500 ha are to be arranged each year. Conservation reserves are to be managed with cooperative action by state agencies, local government and local communities.

Natural diversity landscapes

Priority landscapes with physical and biodiversity values of regional significance are to be identified. Programs of integrated management action are to be implemented, including landscape-scale bush regeneration, revegetation, weed and pest control linked with profitable farm practices.

Threatened species and communities

Although threatening processes are increasing, the intent is to have no further loss of species of ecological communities from the region. This will require specific actions to increase the habitat of some species, including Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*). Over 20 other threatened species or communities are to be secured annually through management actions.

Regional water and energy supply

Drought-proofing through integrated surface water management linked with reduction in waterlogging and potential salinity is to be facilitated for most rural properties through farm water planning and technical design. Survey and evaluation of additional productive groundwater resources is proposed. Opportunities for desalination will be assessed, and it is expected that at least one desalination trial will be established in the region within 5 years.

Opportunities for renewable energy generation within the region are to be assessed, particularly in relation to bio-energy sources. It is expected that 10 MW could be generated within 5 years.

Regional infrastructure, roads and towns

Roads are at considerable risk to rising water tables. Ten demonstration sites where salinity risk is reduced by preventative action linked with other integrated management will be established. Technical support will be arranged to assist with coordinated surface water management and culvert/floodway design.

Implementation of recovery plans for 10 priority rural towns at risk to rising water tables in the region is to be progressed. Two towns are to have 'Integrated Water Management Systems' demonstrations established by 2006.

Community capacity for NRM

The capacity to achieve regional outcomes for NRM is to be further built based on established local skills, information and knowledge. Local area assets are being collated and Local Area Plans being developed for at least 30 Shires within the region.

Teams of people with technical skills and community knowledge will be focussed on delivery of actions according to the short and long-term targets.

Social, heritage and cultural values

Aboriginal and post-settlement heritage cultural values are being identified and documented. Opportunities to protect these values will be developed as part of Local Area Plans for NRM.

Implementing the Strategy

The Avon Catchment Council has adopted an innovative approach to implementing the Avon NRM Strategy, based on the requirement for targeted investment in regional-scale projects to deliver multiple-benefit NRM outcomes for resource condition change. The key principles developed for the Implementation Framework include:

- Integration of management actions to address a range of priority assets;
- Engagement and support for community, based on partnership arrangements;
- Projects undertaken at a landscape scale with management actions that address regional resource condition targets;
- Assessment of social, economic and environmental benefits and impacts of proposed actions.

Significant differences are recognised for locations within the Avon River Basin. To assist with delivery within the regional model, the Avon Catchment Council has identified three 'zones' for implementation. They are:

The Avon Arc – 5.9% of the region. The population in this zone is relatively high and will continue to increase. Management actions differ to those required for the other zones.

The Wheatbelt – 64.3% of the region. The population density in this zone is sparse and will continue to decrease. Implementation of management actions is required on an extensive scale.

Crown/Pastoral – 29.8% of the region. Very few people live in this zone. Mining and pastoral uses affect a relatively small part of this area. The conservation values of this zone are high.

Natural resource and infrastructure assets will be identified within each zone. Through computer-based spatial analysis, local areas where high priority assets are clustered will be determined. **Local Area Plans** (LAPs) will be prepared in partnership with local government, associated communities and other Avon Catchment Council partners.

Regional Delivery Programs (RDPs) are a key mechanism of the Implementation Framework. These provide for integration of actions at a landscape scale to address the 20-year resource condition targets for the region. The proposed RDPs and related Sub-programs are:

RDP 1.
Integrated Water Management

The Integrated Water Management (IWM) RDP brings together management for all aspects of the water cycle, including water use and management of rivers and streams. It has strong links to biodiversity conservation and land use, particularly for agriculture. The proposed Regional Delivery Sub-programs are:

- Catchment Water Management Sub-program
- Valley Floor Management Sub-program
- River and Tributaries Restoration Sub-program

RDP 2.
Sustainable Industry Development

The Sustainable Industry Development (SID) RDP brings together all aspects of industry development to support effective and efficient natural resource management, including dealing with salinity and rising water tables, and promoting new sustainable and profitable industries. It also includes the management of the adverse impacts on existing infrastructure and considers additional industry requirements for sustainable industry development. The proposed Regional Delivery Sub-programs are:

- *Sustainable Agricultural Industry Development Sub-program*
- *Tree Crops Sub-program*
- *Infrastructure Sub-program*
- *Industry Water Use Sub-program*

RDP 3.
Natural Diversity Program

The Natural Diversity (ND) RDP considers all aspects of conserving and enhancing natural biodiversity within the Avon River region at a range of scales across landscapes. It includes responses to the threatening processes, integrating with land use, linking to relevant aspects of water management and involving the community and landowners. The proposed Regional Delivery Sub-programs are:

- Native Vegetation Conservation Sub-program
- Natural Diversity Sub-program
- Threatened Species and Ecological Communities Sub-program
- Salt Lakes and Wetlands Sub-program
- Regional Biodiversity Sub-program

RDP 4.
Capacity Building Program

The regional **Capacity Building** (CB) RDP covers all aspects of capacity building to support the effective and efficient delivery of NRM in the Avon region. It includes capacity building, training and support to local communities, landowners and land managers. Involvement by Local Government is a significant opportunity for regional NRM as these organisations are highly experienced with governance, administration and project management, and have regulatory powers. The proposed Regional Delivery Sub-programs are:

- Capacity for RDP Implementation Sub-program
- Community Capacity Sub-program
- Local Government Partnership Sub-program
- Aboriginal Community Involvement Sub-program
- Institutional Planning and Policy Support Sub-program

The Avon NRM Strategy emphasises the importance of capacity building through RDP 4. This will be structured under the recognised 'landcare', 'bushcare' and 'rivercare' themes and also for the special interests of local government and Aboriginal values. There will be balance between providing the services required through the RDPs and building community capacity. A team-based approach is proposed with coordination through the Avon Catchment Council.

Development and support for information and knowledge management appropriate to the strategic needs of the

region will be coordinated through the Avon Catchment Council Information Network. This will also include cross-boundary consideration with other NRM regions.

A program for **Monitoring and Evaluation** (M&E) for resource condition and program performance is being developed in a way that is consistent with the State M&E Framework.

The next steps

The Avon NRM Strategy represents considerable organisational change for management of natural resource and infrastructure assets within the Avon River Basin. This will require a process of evolutionary change towards the new model for delivery of regional outcomes. A 12-month program of actions required during this initial period has been developed. The **Evolutionary Project** includes:

- Processes for identifying regional assets for local asset inventories;
- Preparation of Local Area Plans;
- Preparation of Business Plans for Regional Delivery Programs;
- Development of an Avon Catchment Council Organisational and Delivery Structure appropriate for implementing the regional strategy.

The Avon Catchment Council will prepare an **Investment Plan** based on the Avon NRM Strategy and will also actively negotiate **Partnership Arrangements** that are appropriate for efficient delivery of NRM outcomes through the Implementation Framework.

The Avon NRM Strategy is considered by the Avon Catchment Council as a 'living document' that will respond to ongoing consultation processes, changing priorities, new information or understanding and program evaluation processes. It is expected to 'grow' to meet the challenges that will occur with time and will retain a strategic focus on the 'preferred future' for the Avon River Basin.

1. What the Strategy is About?

The Avon NRM Strategy provides an integrated planning framework for management of natural resources over the next five years towards our 50-year vision for Avon communities and landscapes.

1.1 The purpose of the Strategy

The Strategy provides an **integrated planning framework** for management of natural resources within the Avon River Basin. The focus of the Strategy is on the land, water and biodiversity resources of the region although it is well recognised that natural resource management has strong linkage with regional economies, social well-being and regional infrastructure management.

Natural resources within the Avon River Basin have degraded since recent settlement and are further threatened by current land use practices and community lifestyle. Salinity is a conspicuous and significant threat to all natural resources and associated values but there are many others. The scale at which our natural resources are threatened is greater than can be managed individually, hence a coordinated approach is needed.

The financial resources required to address all threats and manage the Avon's natural resources in a sustainable way are far greater than those that are currently available. This means that a strategic approach for investment is essential. The Avon Natural Resource Management (NRM) Strategy provides a framework for working together within the region to ensure that the available resources are invested in actions with greatest benefit.

The Avon NRM Strategy provides direction for investment in conservation and sustainable use of natural resources within the region. It provides a framework for coordinated action over the next five years set within a 50-year timeframe for achieving our preferred future landscapes in the Avon River Basin. The Strategy considers the changes to the landscape that we can make as well as those that we can't.

The Avon River Basin is particularly significant in Western Australia as it is the major surface water catchment for the Swan River that is central to the character of Perth. The Avon River becomes the Swan River where the Swan Coastal Plain meets the Darling Scarp.

Recognising the inter-dependence between the Avon and Swan regions, the Avon NRM Strategy links with management of natural resources on the Swan Coastal Plain, particularly for health of the Swan River and estuary.

The Avon NRM Strategy also provides a mechanism for recognising and contributing towards national and global priorities for sustainable environmental management.

1.2 Background and scope of the NRM Strategy

In Western Australia, natural resource management (NRM) is defined as:

> ***…the ecologically sustainable management of the land, water, air and biodiversity resources of the State for the benefit of existing and future generations, and for the maintenance of the life support capability of the Biosphere. It does not include mineral resources, but includes coastal and marine resources up to the State three nautical mile boundary.*** (NRM Council in WA)

Since the early 1980s, communities in the Avon River Basin have tackled land degradation. Soil Conservation Districts, and later Land Conservation District Committees, were formed with limited statutory powers to coordinate local actions. The evolving **landcare** movement initiated and adopted participatory farm and catchment planning processes driven by the challenge to control salinity and the need for responsible landscape management.

During the same period, community concern about the declining condition of the Avon River and the effect it was having on the Swan Estuary was high. Local government initiated coordinated action for management of the river system. This was later supported by the State and Australian governments and developed as an effective **rivercare** program.

With increasing landscape awareness, the very low percentage of remnant native vegetation in agricultural areas became a major concern. Landcare and catchment groups sought to protect remaining patches of bush. This has support at many levels through a **bushcare** program.

The need to coordinate local land, river and bush management efforts on a regional scale was recognised. **The Swan Avon Integrated Catchment Management (ICM) Program** was developed in 1994 to encourage and coordinate local community effort in the Avon and Swan regions. It was a bold initiative to provide direction for management action and resource investment at a regional landscape scale through partnership arrangements between communities, government and industry. The Avon Catchment Council continues with this initiative.

The State Salinity Strategy (2000) was developed by the WA State Government through consultative processes to provide strategic leadership to address increasing concern about the impact of salinity. A subsequent Salinity Taskforce review led to the adoption of a broader approach through **integrated natural resource management** for Western Australia. This is adopted within a catchment context for the Avon River Basin.

NRM in the Avon region is now a well-developed **partnership approach to provide integrated management of our natural resources at a landscape scale**. It recognises that managing the landscape as a system rather than as separate parts is best. It treats the causes of threatening processes that affect natural resources rather than the symptoms. In most cases, these processes occur across property boundaries for which a cooperative approach is required.

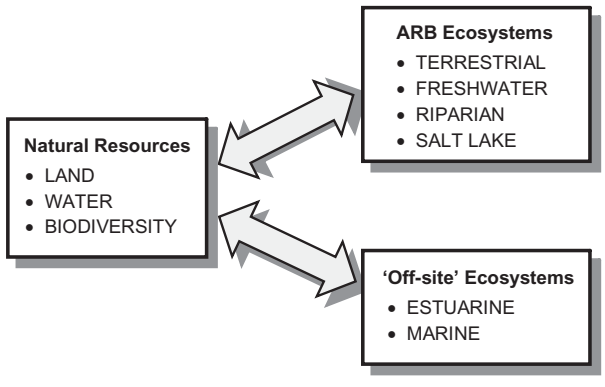


Figure 1 Natural resources related to ecosystem management in the Avon River Basin

NRM provides **a framework for protecting and conserving natural resources through ecosystem management**. Figure 1 shows the key land, water and biodiversity resources as linked to management of terrestrial (including farmland, remnant vegetation and reserves), freshwater (including rivers and wetlands), riparian (foreshores) and salt lake ecosystems in the Avon. Management is also linked to the estuarine ecosystems of the Swan and Canning rivers, and to the marine ecosystems of the Indian Ocean.

The scope of NRM in the Avon River Basin needs to include consideration of air quality and the potential impacts of climate change.

The Avon NRM Strategy is intended to provide direction for practical actions that lead to resource condition change. It recognises that threats to natural resources also affect local economies (especially farm businesses), social values and public infrastructure. Proposed actions for NRM consider social, economic as well as environmental impacts or benefits (the 'triple bottom line' for auditing purposes or accounting for investment in the region).

There is further recognition of the need for viable industries to support stable rural communities living within healthy landscapes of the future. Development of sustainable and profitable industries is a major mechanism to achieve NRM outcomes in the Avon River Basin. The Avon NRM Strategy identifies the required partnership arrangements with relevant organisations for this to occur.

NRM requires both private and public investment of innovation, time, knowledge and financial resources. The Avon NRM Strategy identifies and develops opportunities for this to occur.

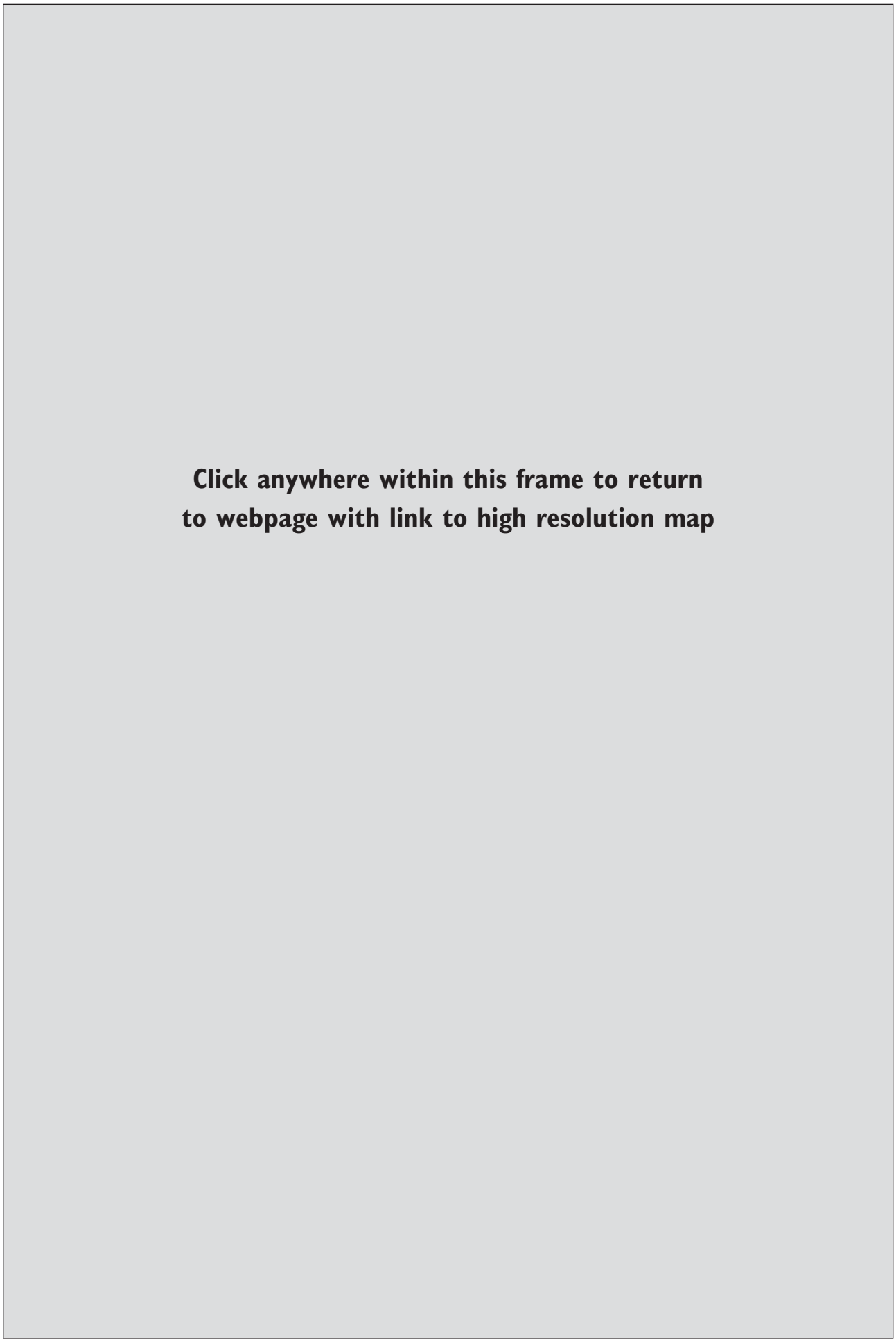
1.3 Boundaries of the Avon River Basin

The Avon River Basin is an 11.8 million hectare surface water catchment that discharges to the Swan-Canning Estuary in Perth

The Avon River Basin is almost twice the size of Tasmania. The extent of the basin is approximately 430 km both north-south and east-west. Of the total area (11.8 million hectares), 71% (8.4 million hectares) is land currently used mostly for agriculture or conservation. The remaining 29% (3.4 million hectares) is vacant Crown Land or pastoral lease with some mineral extraction.

The boundary of the Avon River Basin defines one of six natural resource management regions in Western Australia. The Avon River Basin shares boundaries with all other regions.

The Avon River Basin is defined by surface and groundwater characteristics. Map 1 shows its location extending east



Map 1 Location of the Avon River Basin

of Perth and includes the catchment areas for the Avon-Mortlock, Yilgarn and Lockhart river systems.

Most of the Yilgarn and Lockhart systems drain internally to salt lake systems but in exceptionally wet years will connect and drain through the Avon and Swan rivers to the Swan-Canning Estuary in Perth and eventually to the Indian Ocean at Fremantle.

The Brockman River, Ellen Brook, Upper Helena River and Wooroloo Brook also drain to the Swan River from rural areas, however they are not included as part of the Avon River Basin. They are considered as adjacent catchments because of the requirement for partnership arrangements for investment under the National Action Plan for Salinity and Water Quality. Cooperative management arrangements for these catchments are defined in a Memorandum of Understanding between the Avon Catchment Council and the Swan Catchment Council.

1.4 Who is involved?

The Avon NRM Strategy involves all who live in communities within the Avon River Basin and many other stakeholders (communities and stakeholders of the Avon region are described in the Community Engagement Protocol for the Strategy). The Community Engagement Protocol is a supporting document. The Avon Catchment Council provides leadership and coordination for NRM within the region through consultation, liaison and development of partnership arrangements with community and other key stakeholder groups.

Avon Catchment Council

Managing natural resources in the Avon is the interest of many individuals and organisations representing a range of values from local to national and international. The key role of the Avon Catchment Council is to coordinate these interests for NRM within the region. This role is recognised and supported through Bilateral Agreements between the Commonwealth of Australia and the State of Western Australia to deliver the Extension to the Natural Heritage Trust (NHT2) and the National Action Plan for Salinity and Water Quality (NAP) investment initiatives. NRM in all regions of WA is led by catchment councils ratified according to a Memorandum of Understanding (MOU) with the State Government as witnessed by the State NRM Council.

The Avon Catchment Council provides leadership for NRM in the Avon River Basin through the roles of:

- Advocacy
- Facilitation and coordination
- Information and knowledge brokerage
- Strategic planning for NRM activities within the region
- Arranging investments for priority NRM outcomes
- Engaging communities and stakeholders in managing natural resources
- Monitoring change in resource condition through implementation of strategic actions.

The Avon Catchment Council is constituted as an Incorporated Association with nine community members (three from each of the Avon, Lockhart and Yilgarn catchments) and six members from agencies or supporting organisations, including:

- Agriculture, Department of (DAWA)
- Conservation and Land Management, Department of (CALM)
- Education and Training, Department of (DET)
- Environment, Department of (DoE)
- Planning and Infrastructure, Department for (DPI) (including Main Roads WA)
- Wheatbelt Development Commission (WDC).

The organisational structure of Avon Catchment Council is currently supported by specific-purpose Sub-committees and Working Groups.

Partnership arrangements

The Avon Catchment Council operates most effectively for natural resource management through partnership arrangements with a range of groups and organisations, including:

- Community organisations (catchment groups, Land Conservation District Committees, Aboriginal groups, environmental groups, 'Friends of ….' groups)
- Local Government and Regional Organisations of Councils
- Australian and State Government agencies
- Non-government organisations (including Greening Australia WA and World Wide Fund for Nature (Australia))
- Research and Development Corporations and research institutions (CSIRO, universities)
- Industry organisations (Saltland Pastures Association, WA No-Till Farming Association (WANTFA), Oil Mallee Association and others).

The processes for consultation and engagement of those involved in development and implementation of the Avon NRM strategy are outlined in Section 1.9.

1.5 Building on our past achievements

Over the past decade, there have been substantial NRM achievements in the Avon River Basin particularly in the development of community-based partnership arrangements and in developing a landscape approach to management that is appropriate to the Avon River Basin.

Significant NRM achievements include:

Community capacity

- Formation of 37 Land Conservation District Committees (LCDCs) and over 170 catchment groups
- Community-based Landcare, Rivercare and Bushcare coordinators throughout the region
- Coordination of NRM information through the ACC's Information Network
- The *Yilgarn Forum* – an annual meeting of LCDCs
- Strategic planning at LCDC and catchment level
- Planning and implementation of NRM projects
- Skills and knowledge (e.g. seed collecting, saltbush planting)
- Commercial tree crop initiatives including the Oil Mallee Association (270 growers), the Avon Sandalwood Network (60 members), the Master Tree Growers Network and share-farming arrangements (35 landholders) for commercial tree crops.

Land resources

- Integrated farm and catchment-based planning is accepted practice
- Regional land resource surveys completed for agricultural areas of the Avon River Basin
- Regional salinity status assessed through the Land Monitor project
- High farmer awareness of resource issues and impacts.

Water resources

- Comprehensive management surveys of the Avon River and major tributaries
- Recovery plans prepared and rivercare groups formed for all 19 sections of the Avon River
- The Avon River is almost completely fenced for livestock control
- Community interest and skills for managing waterways are high.

Biodiversity resources

- Protection of over 20 000 ha of private natural vegetation in 836 remnants by fencing funded under the State Remnant Vegetation Protection Scheme (1989-2000)
- Two existing and six potential Biodiversity Recovery Catchments
- Interim Recovery Plans and actions for 28 critically endangered flora species
- Translocations undertaken for five critically endangered flora and 10 threatened fauna species
- Recovery plans prepared for two critically endangered Threatened Ecological Communities (15 identified)
- Land for Wildlife Program has assessed 37 968 ha of remnant vegetation on 231 properties
- The reserves system enhanced by purchase of 5228 ha of private remnant vegetation (14 private properties)
- Conservation Agreements negotiated for 100 landholders with over 14 000 ha of remnant vegetation under the Woodland Watch program.
- Covenants for 20 private properties securing more than 3 500 ha of natural vegetation.

Sustainable industry development

- Rapid adoption of minimum-till and no-till cultivation practices. There is now 75% of cropping land prepared with minimum tillage in the Avon River Basin).
- Incorporation of routine liming into paddock management strategies.
- Development of broad-scale perennial options (woody and vegetative) for increased water use and industry diversification, including:
  5 600 ha of saltbush
  4 500 ha integrated oil mallee
  3 600 ha maritime pines
  2 500 ha tagasaste
  1 700 native species (under the 'search' project)
  800 ha of sandalwood.
- Management of soil erosion through contour working.

Infrastructure protection

- 21 towns in the Avon River Basin under the Rural Towns Program
- Understanding of impacts of high water tables on infrastructure
- Salinity management strategies developed for towns in the program.

1.6 Opportunities through a targets-based approach

Natural resource management in the Avon River Basin has achieved significant results from considerable effort and investment over the past decade, however it remains difficult to be assured that there will be effective resource condition change with ongoing investment in relatively fragmented and small-scale projects. The large scale of threatening processes and the uncertainty of response to some intervention actions, particularly for salinity control, has led to the requirement for a more strategic approach to investment of public funding in NRM.

The basis of the regional strategic approach is a focus on management of priority assets with assessment based on resource condition targets. This 'targets-based' approach is fundamental to national and state NRM strategies for investment under the Bilateral Agreements between the Commonwealth of Australia and the State of Western Australia for the Extension to the Natural Heritage Trust (NHT2) and the National Action Plan for Salinity and Water Quality (NAP) investment initiatives.

An assets-based approach is adopted by the Natural Resource Management Council (NRMC) in Western Australia for public investment in salinity management following recommendations made by the State Salinity Taskforce (Frost et al., 2001). The Salinity Investment Framework (SIF) has identified land, water, biodiversity, infrastructure and social assets at a state level considering their 'value' and 'threat' (Dept. Environ., 2003). A preliminary assessment of the priority of State-level assets has been undertaken (Govt. of WA, 2003b).

A similar process of asset identification has been undertaken for the Avon region as a trial of asset identification and assessment at a regional level for the SIF (URS, 2002).

The Avon Catchment Council has adopted similar principles to those used for the SIF in this Strategy. It recognised the advantages of targeted investment in the high-value assets that are identified as important at the regional scale. Regional assets are identified in this Strategy as including those that are important at a national and state-scale as well as those that are important locally. Following similar procedures to those applied for the SIF, the regional assets for priority investment are assessed according to criteria of value, level of threat and the feasibility of benefits by investment in intervention.

Adoption of a strategic approach to public investment in NRM within the Avon River Basin will result in change to the way that services for managing our natural resources are delivered. The new approach will still depend upon a high level of capacity for NRM by community, government and other partners for efficient and effective action on the ground. Considering the extent of threatening processes in the Avon region and relatively small population within the region, it is expected that an assets-based approach will require ongoing support for community initiative to achieve regional resource condition targets.

1.7 Managing the region within a state and national context

The vast but sparsely populated Avon River Basin is an important part of continental Australia

Managing our natural resources is important to individuals, local communities, regional interests, the state, the nation and globally. Undertaking NRM at the regional scale is an effective way to combine the range of interests.

Map 2 shows the location of the Avon River Basin within the Australian continent – it is one of more than 60 NRM regions nationally and one of 22 NRM regions eligible for National Action Plan (NAP) investment.

Table 1 shows the area of the Avon River Basin in a national and global context. It is 1.56% of the Australian land mass and 4.75% of the area of WA. It also shows the relatively small population, most of whom live in the west of the Avon River Basin. The region's population is only 0.22% of the Australian population and 2.2% of the people who live in WA.

The Avon River Basin is vast in area but sparsely populated. The population density of 0.36/km^2 is low but is similar to many other semi-arid continental regions. However, most of the population is located in the Avon Arc, which is close to Perth, so the population density for the Wheatbelt is considerably lower.

Table 1 A global and national context for the region

	Land Area (km^2)	**Population**
Planet Earth	134 777 000	6 000 000 000
Australia	7 682 300	19 485 000
Western Australia	2 525 500	1 940 500
Avon River Basin	120 000	42 600

The purpose of the Avon NRM Strategy is to provide direction for priority action and investment for conservation and sustainable use of natural resources. While this is planned at a regional level, it contributes to expected national outcomes for natural resource management. These expected outcomes also represent international interest in Australia.

The **National Framework for NRM Standards and Targets** provides principles and guidelines for investment through national natural resource management programs in regional NRM strategies. This is relevant to the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT).

The National Natural Resource Outcomes are listed in Appendix 1. They are focussed on the condition of natural resources in Australia but also relate to sustainable resource use systems.

Click anywhere within this frame to return to webpage with link to high resolution map

Map 2 NRM regions in Australia

The Avon Catchment Council recognises its roles and responsibility according to the NAP and NHT Bilateral Agreements, and the potential for benefit through Regional Partnership Agreements to be arranged between the region and the Australian and state governments for investment within the region.

The Avon NRM Strategy is linked to many other regional, state and national strategies for natural resource management.

1.8 Structure and development of the Strategy

The Avon NRM Strategy is structured so that the 'core values' of communities in the Avon River Basin and the 'preferred future' for our communities and landscapes drive the development of strategic actions. Figure 2 shows the four key areas of NRM as being:

- Water Resources
- Land Resources
- Biodiversity Conservation
- Infrastructure

Assets, threats, goals, targets and actions for management of the natural resources have been identified for each of these key areas. Supporting documentation contains detailed information which is summarised within the Strategy.

The Avon NRM Implementation Framework (Figure 3) shows how the Strategy is to be implemented. These processes are evolving with continuously improving knowledge and understanding of requirements for efficient and effective implementation.

Monitoring and evaluation is important to assess the effectiveness of implementing the actions of the Strategy. The condition of the natural resources and the efficiency of the projects will be evaluated against the targets. The Avon Catchment Council will adjust the Strategy and implementation program in response to monitoring and evaluation information.

The ***Investment Plan*** provides an outline of the priorities for investment in NRM within the Avon River Basin. This is important for attracting investment, particularly through the Australian/State Government funding initiatives (NHT2 and NAP).

The Avon Catchment Council has many opportunities to develop ***Partnership Arrangements*** for NRM within the Avon River Basin. These will be formalised according to the Strategy and the Investment Plan.

1.9 Consultation and engagement

Community engagement protocol

Consultation and engagement with community and other key stakeholders is a significant component of the Avon NRM Strategy. The Avon Community Engagement Protocol builds on the many processes of consultation undertaken during development of the Swan Avon ICM Program over the previous 10 years. It is based on six phases:

1. Publication of the intent to undertake the regional NRM strategy development.
2. Consultation and engagement during the planning process.
3. Public comment on draft planning documents.
4. Finalisation of planning documents considering public comments.
5. Consultation and engagement during implementation of actions.
6. Consultation during a review of the Avon NRM Strategy in 3-5years.

The Avon Community Engagement Protocol identifies the many sections of the broader Avon community, including:

- Family farm businesses
- Small landholders
- Grower organisations
- Land Conservation District Committees
- Catchment groups
- Environmental groups
- Local government authorities
- Politicians
- Aboriginal groups
- Small and medium businesses

Avon Catchment Council partners

The Protocol framework identifies the key consultation processes undertaken throughout the region for development of the Strategy. These include two series of Focus Group meetings, workshops to review the 'preferred future' scenarios, regional workshops to review targets and priorities for action, and a formal review period for the draft strategy.

Community consultation

The extent to which the community has been consulted during development of the draft regional strategy is listed below:

- 31 Focus Group meetings at locations throughout the region;

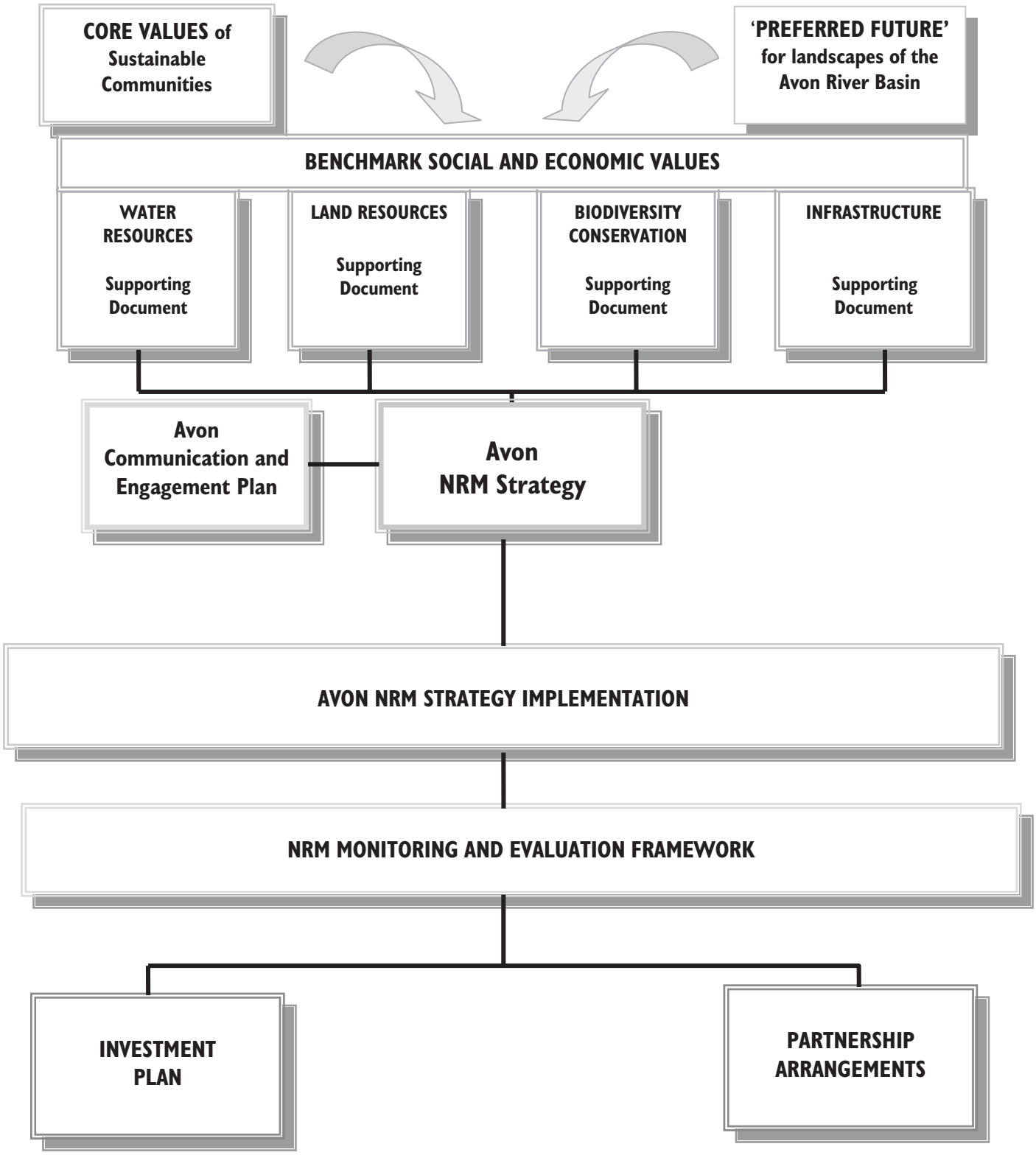
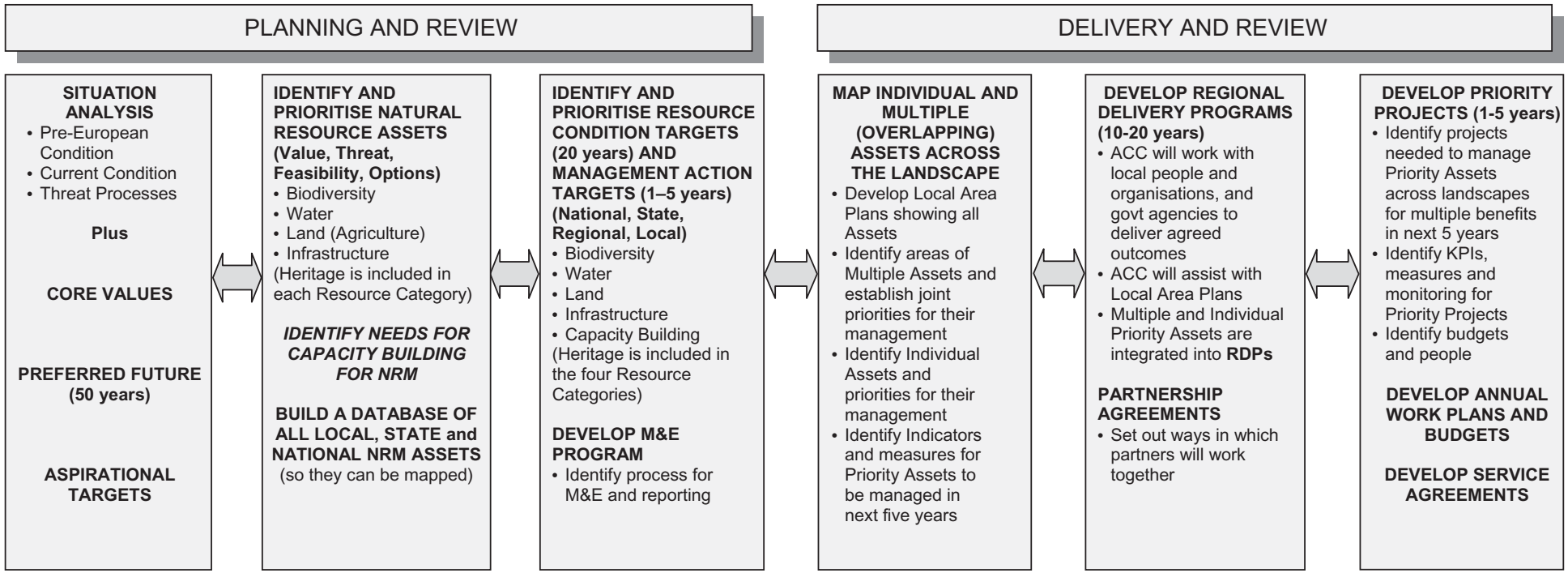


Figure 2 Structure of the Avon NRM Strategy

- Four regional workshops to identify assets for the Salinity Investment Framework followed by local meetings to link with regional and local planning;
- 15 local government and three Zone Council briefings by an ACC member and Manager;
- Briefings to the Wheatbelt Area Consultative Committee as well as small and medium business organisations within the region;
- Three workshops for Community Support Officers;
- Attendance by 55 community representatives and partners at a 2-day 'prioritisation' workshop;

Figure 3 Process for implementation of the Avon NRM Strategy



- Local consultation for water resource assets in 22 LGAs;
- Three regional consultation meetings for biodiversity assets;
- Multiple asset collation with communities within five LGAs as part of a 'pilot study' for the region;
- Community interest in regional drainage engaged through the Avon Regional Drainage Group;
- Community involvement in workshop series for developing a 'preferred future' (coordinated by CSIRO, Healthy Country project); and
- Information display and access for many community members at four popular agricultural field days.

The draft Strategy was available for public comment during a 6-week period (April-May, 2004) according to processes outlined in the Consultation and Engagement Protocol. During this period, 11 workshops were held at locations throughout the region (total attendance of 329), two of these were specifically for local government arranged through WALGA. A total of 66 written submissions were received during the consultation period. These are available in a compiled format on the ACC website <www.avonicm.org.au>. The revised Strategy responds to these comments.

Aboriginal Community consultation

Aboriginal consultation has occurred through initiation of the Aboriginal Heritage Working Group through the ACC in February 2004. It is made up of three community Elders (recently members of the WA Wheatbelt Commission of Elders), the Regional Manager of the Department of Indigenous Affairs, the Manager (and Deputy) of the ACC, and the Aboriginal NRM facilitator for the ACC.

The ACC Aboriginal NRM Facilitator met with 60 Native Title claimants of the Southwest Ballardong Tribal claimant group to provide background to the Avon NRM Strategy during March 2004.

The ACC is supporting a major project at Mogumber Mission (known also as the Moore River Native Settlement) that links land productivity and river management with National Heritage sites and Sacred Aboriginal sites of ceremonial, spiritual and artistic significance.

There are six Aboriginal Land Corporation properties (farms) within the region for which there will be support from the ACC with fencing programs, revegetation or possible business opportunity ideas.

The ACC is also working with Aboriginal groups and individual Elders across the region to record and maintain Aboriginal sites on farmlands and other areas, and will create a regional register of sites for future reference.

Success in implementation of the Avon NRM Strategy is dependent upon all sections of the broader Avon community understanding and recognising the priorities for actions and engaging in coordinated regional effort to achieve resource condition targets.

2. Overview of the Avon River Basin

2.1 Avon landscape history

The Avon River Basin is based on ancient landforms derived from crystalline rocks (granite and gneiss) estimated to be 2-3 billion years old of the Archean tectonic unit known as the Yilgarn Craton. Dolerite intrusions to the parent rock due to volcanic activity form up to 15% of the parent rock. These have eroded to form a stable plateau with old river courses and valleys that have been significantly in-filled by alluvial and colluvial sediments during periods from 5 million to 43 million years ago. The depth of these sediments is approximately 20 metres in the valley floor and 60 metres in the palaeo-channels.

The western section of the basin was uplifted to form the Darling Scarp more than 2 million years ago. The eastern axis of this uplift is known as the Meckering Line. Landforms to the east of this line are described as the Zone of Ancient Drainage, and to the west are known as the Zone of Rejuvenated Drainage. The location of these zones is shown in Map 3 and typical landform sequences within these two zones are shown in Figure 4.

Map 3 The zones of ancient and rejuvenated drainage in the Avon River Basin Glassford and Semeniuk (1995)

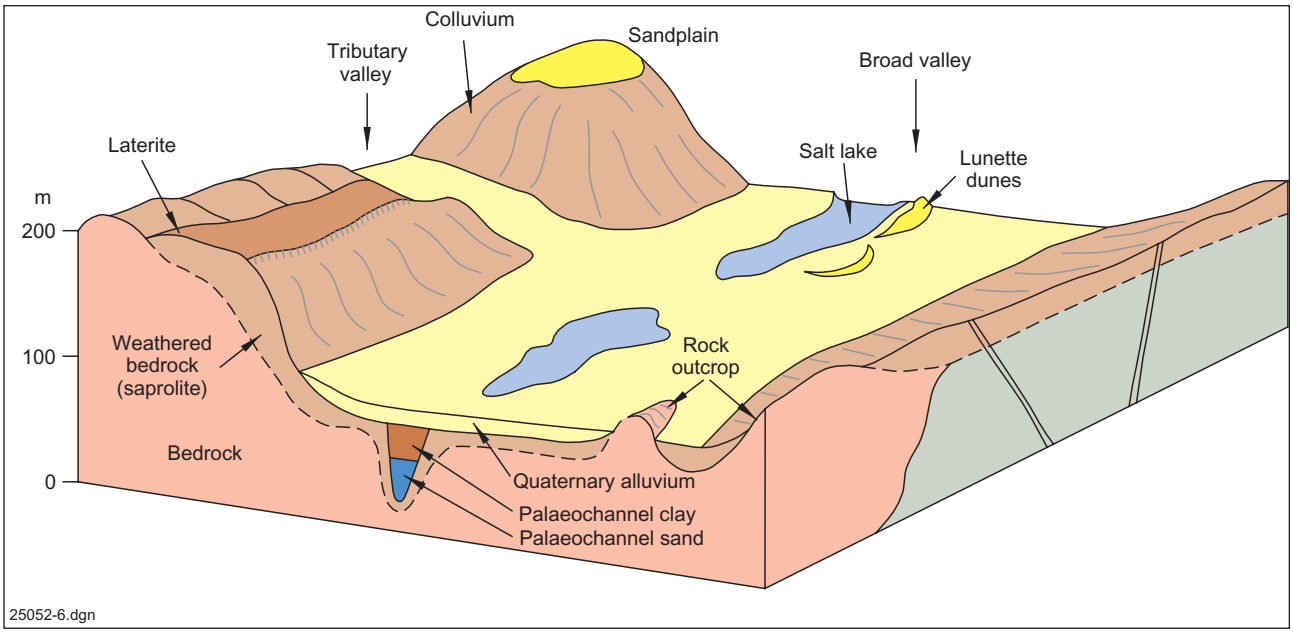


Figure 4 Block diagram showing schematic geology of a Wheatbelt valley Commander et al. (2001)

The broad valley floors of the Avon River Basin are 5-15 km wide and are generally 100-150 metres below the plateau surface. The current Lockhart catchment is thought to have previously drained to the Southern Ocean but the flow has since been reversed by southern uplift. The hydraulic gradient of these valleys is exceptionally low (0.037 m/km). The gradient of valleys in the Yilgarn catchment are also low (0.38 m/km) but greater than those to the south.

Valleys west of the Meckering Line are narrower and have greater relief and steeper hydraulic gradient (0.50-1.9 m/km).

2.2 Climate

The Mediterranean-type climate of the Avon River Basin is typified by mild wet winters and hot dry summers controlled primarily by 'southern oscillation of the anticyclonic belt' with relatively small influence of the *El Nino* effect. There is some cyclonic influence during summer months. Annual rainfall decreases from about 700 mm in the west to 325 mm in the east of the basin. Approximately 70% of annual rainfall falls during the 5-month growing period (May-September) and is of relatively low variability. Frosts also occur during this period.

Wet winters or intense rainfall events cause occasional flooding. Major flooding has occurred in 1910, 1917, 1926, 1930, 1945, 1946, 1955, 1958, 1963, 1964, 1983 and 2000.

The potential for change in climate may be significant to natural resource management in the Avon River Basin although the extent to which this could occur remains uncertain. Some changes predicted (CSIRO, 2001) by about 2070 (compared with 1990) include:

- higher temperatures (1-5 degrees Celsius warmer)
- changing rainfall trends (seasonal and annual averages)
- higher evaporation rates
- more frequent extreme weather events.

The agricultural industry is a substantial contributor of the greenhouse gas emissions that are considered to be a cause of climate change.

2.3 Regional landform and soils

The landform and soils of the Avon region have been mapped within Soil-Landscape Zones that are related to the ancient and rejuvenated drainage zones of the region. There are nine Land Resource Sub-regions within these zones in the Avon region. Approximately 150 Land Systems and 900 Land Sub-systems (soil-landform units) have been mapped within the sub-regions. The application of digital elevation models (DEMs) and high-resolution radiometric information adds value to understanding the distribution of soils in the region.

The Land Systems can be identified in three broad categories for management:

1. Uplands
2. Mid-slopes
3. Valleys

The Land Resource assets are identified by grouping of Land Systems within the broad categories. However, available information does not allow the Land Systems to be

consistently grouped according to these categories so the Land Resource Sub-regions are currently adopted as the assets. The topographical sequence of Land Systems from uplands to valleys provides an important basis for integrated action for NRM implemented at a landscape scale.

The soils of the Avon River Basin can be generally described as being of low fertility. Duplex textured profiles are most common in which sub-soils have low hydraulic conductivity. Deep sandy soils have a naturally acidic trend. The dominant soil types are shown in the Land Resource Supporting Document.

2.4 Groundwater and salinity

The deeply weathered soil profiles of the ancient landscapes in the Avon River Basin have extensive regional groundwater aquifers and localised unconfined aquifers. Groundwater resources in the Avon Region are generally not suitable for irrigated agriculture due to poor water quality, however some fresh superficial aquifers have potential for commercial use and farm water supply. Some saline groundwater is used for mining.

Groundwater in the Avon River Basin is monitored locally where wells are installed for salinity risk investigations. An inventory of long-term monitoring information of regional aquifers is maintained in AQUABASE which is coordinated by the Department of Environment. Community-based monitoring information is coordinated through COMBORES which is managed by the WA Department of Agriculture. An analysis of monitoring information shows a trend of regional groundwater rise in most areas. Monitoring has also shown groundwater in the region to be acidic.

The regional groundwater aquifers are generally saline, with water quality generally exceeding 30 000 mg/L. Local groundwater flow systems range from fresh to saline. The groundwater processes of the region are well understood although groundwater flow systems of the Avon River Basin have not been mapped. Regional groundwater aquifers between catchments are thought not to be connected. The very low gradient and poorly transmissive soils in the valley floors delay the rate at which groundwater aquifers change but also delay the response by aquifers to groundwater management.

The full potential impact of salinity has been estimated from interpretation of Digital Elevation Models and satellite imagery (the Land Monitor Project). This shows that 5.4% of land used for agriculture within the region is currently affected by salinity but this could eventually increase to 27.5%. This information is consistent with estimates for the region by the National Land and Water Resources Audit (NLWRA, 2001). An analysis of the threat of salinity within the Avon region is provided in the Land Resource Supporting Document.

2.5 Rivers and wetlands

Rivers

The Avon River is typical of rivers in the West Australian Wheatbelt but differs significantly from other river systems in that the gradient of the river channel increases downstream, the channel width and floodplain decrease downstream and the annual rainfall gradient increases away from the source. It is a river system that drains an ancient plateau landscape through the uplifted Darling Scarp to the Swan Coastal Plain where it is renamed the Swan River.

The Avon-Swan River has a total catchment area of 125 000 km² extending from Dalwallinu in the north, Southern Cross in the north-east and Lake King in the south-east down to the mouth at Fremantle. The Avon River Basin is Australian Water Resource Council (AWRC) basin number 615.

The Avon River Basin east of the Meckering Line (the eastern axis of topographic uplift to form the Darling Scarp) is an ancient and very flat landform (the Yilgarn Plateau). It is thought that drainage from the plateau was originally to the Southern Ocean but that uplift of the south coast landform (the Ravensthorpe Ramp) reversed flow to the north. It is also thought that the Avon may have discharged to the Hotham River at one stage but was 'captured' by the Swan River that eroded through the Darling Scarp near Toodyay.

The major tributaries to the Avon River are the Lockhart and Yilgarn rivers. Both are characterised by chains of lakes and intermittent streamflow. The confluence of these tributaries is at the Caroline Gap south of Kellerberrin from where the Salt River flows south-west to the Yenyenning Lakes and into the Avon River.

The Yilgarn River, which originates north-east of Southern Cross from Lake Seabrook and Lake Deborah, drains an area of 55 900 km².

The Lockhart catchment is an area of 32 400 km² drained by three major rivers:

- The Lockhart River originating from Lake Magenta
- The Camm River draining from Lake King through Hyden to Kondinin where it meets the Lockhart River.
- The Pingrup River which arises near Lake Cairlocup and flows north to Lake Grace and the Lockhart River.

Stream flow measured in the Yilgarn and Lockhart rivers since 1976 shows there to be annual flow through these

systems although flow volume is highly variable. Annual flow in the Lockhart River was in excess of 10 GL in seven out of the 25 years of record, while in 10 years it was less than 1 GL.

The main channel of the Avon River originates at Yealering Lakes (wetlands of national significance) upstream of the confluence with the Salt River at Yenyenning Lakes, and drains a catchment area of 3 200 km². Downstream from the Yenyenning Lakes, it flows past Beverley and York to the confluence with the Mortlock River at Northam. The catchment area of the Avon River at Northam is 8 100 km², while the Mortlock River adds a further 16 800 km².

The Yenyenning Lakes are a series of lakes less than one kilometre in diameter but with a combined length of 15 km. The bed of the lakes system has very low gradient (1:20 000). Construction of a permanent causeway with culverts at the Avon River confluence (Qualandary Crossing) provides a controlled outlet so that water levels can be maintained for recreation use and water birds, and release of hyper-saline water from the lakes can be controlled.

The Brockman River, Ellen Brook, Helena River and Wooroloo Brook are also tributaries of the Avon-Swan river system. Management of natural resources within these two catchment areas is coordinated through the Swan Catchment Council.

Wetlands

The aquatic ecosystems of the region comprise fresh and saline wetlands and salt lakes. Most freshwater wetlands are located in the Avon Arc zone with several significant fresh wetlands in the Wheatbelt and Rangelands areas.

A number of the region's fresh and saline wetlands are of national or sub-regional significance with a large number of other wetlands identified as important.

There are extensive chains of salt lakes in the Avon River Basin, with the Lake Grace system being of national significance but their hydrological and ecological processes are not well understood.

2.6 Biodiversity

The south-west of Western Australia is identified as one of 25 internationally significant biodiversity 'hotspots' where there is exceptionally rich biota and high endemism particularly for ecosystems of the Wheatbelt such as occur in the Avon River Basin (Myers et al., 2000). Four broad biodiversity asset classes are relevant to the Avon River Basin:

1. Native Species – all naturally occurring flora and fauna species of the region;
2. Natural Ecological Communities – groups of native species co-existing in characteristic assemblages;
3. Ecosystems – discrete sets of ecological communities and their interaction with the distinctive physical environments they inhabit;
4. Ecoscapes – the mosaic of ecosystems that span the topography from one ridge in the landscape to the next.

Whole of basin

Estuarine ecosystem impacts are considered as the Avon River discharges to the Swan-Canning Estuary, however management of the estuary is included within the Swan Regional NRM Strategy.

Terrestrial ecosystems are identified within IBRA regions (Interim Biogeographic Regionalisation of Australia). For the Avon River Basin, they are:

AVON WHEATBELT 1 (AW1 – Ancient Drainage Sub-region),
AVON WHEATBELT 2 (AW2 – Rejuvenated Drainage Sub-region),
COOLGARDIE 2 (COO2 – Southern Cross Sub-region),
MALLEE 2 (MAL2 – Western Mallee Sub-region), and
JARRAH FOREST 1 (JF1 – The Darling Range).

The Australian Terrestrial Biodiversity Assessment provides a national review of terrestrial biodiversity by use of the IBRA framework (Environment Australia, 2000). The 384 IBRA sub-regions are grouped within 85 bioregions on the basis of common landforms, vegetation, geology and soils.

The natural biota of the Avon region includes:

- over 4000 species of vascular plants with approximately 60% being endemic to the region (Keighery and Lyons, 2001)
- 62 species of mammals
- 203 species of birds (including 55 species of water birds)
- 16 species of frogs
- 110 species of reptiles
- 10 species of fish
- An unknown number of invertebrate species (the region's wetlands are significant - over 560 invertebrates have been identified there during recent biological surveys, with 45% restricted to fresh water).

There are 99 Vegetation Associations mapped within the Avon River Basin. Most of these are inadequately represented (less than 10% of their original area) within the existing reserve system within the region.

Map 4 Map of the six pastoral leases, mining and Crown Land

The land used for agriculture has been substantially cleared of natural vegetation and now only 1.14 million hectares (13.2%) of this area retains its original vegetation cover. There are 648 000 hectares (7.5% of the alienated area) of natural vegetation in 'reserved Crown Land' (reserves for conservation, recreation and other purposes) and 491 000 hectares (5.7%) on private land.

The area of remnant vegetation on private land in the south-west of Western Australia is estimated to be 2.8 million hectares (13.5%). Of this area of remnant vegetation on private land, 17.5% occurs within the Avon River Basin.

The area of natural vegetation in reserves and other land secured for conservation is 14.4% of all reserves in the south-west of the state.

2.7 Crown Land and pastoral use

The area of the Avon River Basin is over 11.8 million hectares. Of this area, 8.3 million hectares has been made available primarily for freehold agricultural use and 3.5 million hectares in the east of the basin is vacant Crown Land. Within this area there are five pastoral leases (Bronte, Carrinta, Ennuin, Golden Valley and Kawana) that cover an area of 244 167 ha (approximately 7% of the Crown/Pastoral zone and 2% of the Avon River Basin) for the purpose of grazing (Map 4). The remaining 93% of the Crown/Pastoral zone is currently managed for conservation purposes under a variety of Crown Land tenures including CALM reserves and leases, Crown leases and vacant Crown Land.

In addition there are 401 individual mining leases totalling 160 076 ha that cover other land tenures. The mining industry, in particular gold mining, comprises a diverse group in terms of size of operators and types of operations. These range from individual miners working small alluvial deposits to major companies with large open pit and underground operations.

Very little is known about resource condition in the Crown/Pastoral zone.

2.8 Regional industry, infrastructure and economy

The development of broad-acre agriculture is a dominant land use feature of the Avon River Basin. After initial European settlement in 1831, economic development began with an expanding sandalwood industry until 1848 when the resource became over-exploited. Subsequent regional development was based on pastoralism. The lack of transport, water supply and communications infrastructure constrained further development of the region.

The regional economy is now based on agriculture, particularly the grain industries. There are smaller mining, commerce, manufacturing, and tourism industries in the region. Estimates of the Gross Regional Product for the Wheatbelt for 2001-02 were $2.8 billion (Department of Local Government and Regional Development estimates). The value of agricultural production in the Wheatbelt was $2.2 billion in 1999-2000 of which $1.2 billion was the value of wheat production. Wool was valued at $216 million and livestock disposals $218.3 million. Agricultural productivity is rising by about 4 per cent per annum. Structural adjustment within the industry is occurring as a trend towards fewer but larger farms.

The economy of the Crown/Pastoral zone is based on grazing, mining, harvesting of timber (currently sandalwood and eucalypt burl).

Commercial enterprises are located primarily in the centres of Northam and Merredin. The tourism industry is growing in some areas, particularly in the Avon Arc.

Regional infrastructure is primarily to support the rural industries and communities. Towns, roads, rail and grain-handling facilities were constructed in valley floor locations. These are the areas now at greatest risk from rising regional groundwater and salinity.

2.9 Social communities and values

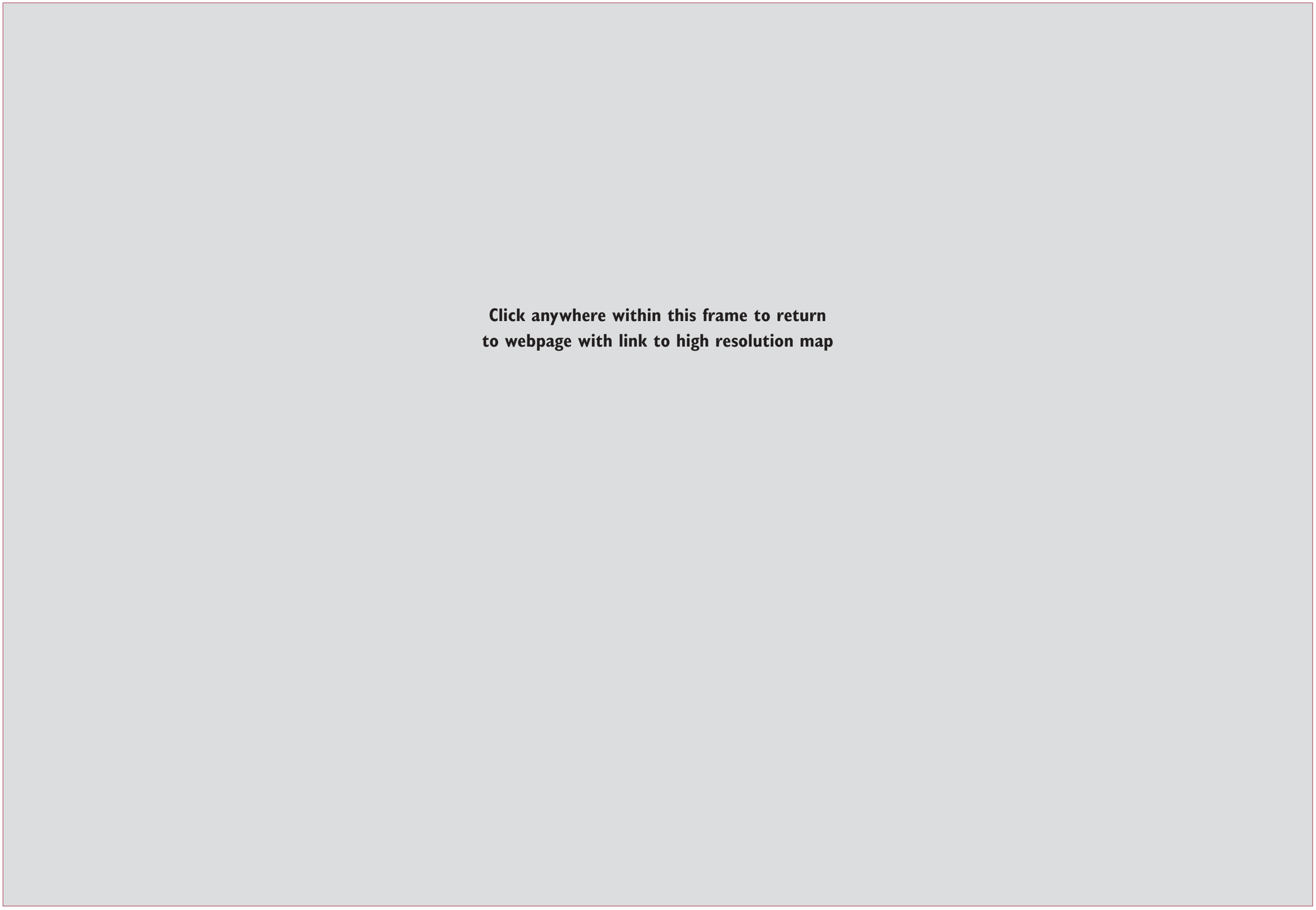
The Avon River Basin forms a large part of a region that is referred to as the Wheatbelt in Western Australia. This region has been the home of many Aboriginal groups for many millennia, giving it a rich cultural diversity and history.

Map 5 shows the areas of tribal groups within the south-west of WA that occur in the Avon River Basin. Aboriginal settlements tended to congregate around the local water holes usually associated with granite outcrops.

Note: The foldout map overleaf is a general representation of socio-linguistic groups within the Avon River Basin. The boundaries are not definitive or exclusive. Further information is available at <http://www.foundingdocs.gov.au/pathways/index.htm>.

It is also one of Western Australia's regions with the longest period of non-Aboriginal settlement, some areas being settled for over 160 years. During this period, a well-established network of infrastructure and a stable population base has been established.

The people of the region are recognised for innovation and persistence, qualities that are integral to developing and achieving a vision for the future.



Map 5 Aboriginal tribal areas within the Avon River Basin

The Avon River Basin has a population of 46 000 people. The population has been fluctuating since the 1940s but is now declining and ageing. There is continued pressure on the region to encourage people, particularly younger people, to the region, with improvement in employment opportunities and 'quality of life' facilities. Many young people leave the region in pursuit of employment or higher education and few return.

Areas close to Perth (the Avon Arc) are increasing in population. This could lead to a population increase in the Avon Arc of 43% – 147% by 2026 (ECS, 2003).

The percentage of Aboriginal people in the region is above the state average, and their influence in economic, social and cultural life is growing.

There are approximately 25 000 people employed in the local government areas of the Avon River Basin (including adjacent areas). Of these, 34.7% are employed in primary industry. A further 24.7% are employed in the major secondary industries (wholesale, retail, manufacturing and construction) and 17.7% are employed in the major tertiary industries (education, health and government administration).

Local communities are generally identified by their association with Shires within the region. There are 36 local government authorities (LGAs) in the Avon River Basin (35 Shires and the Town of Northam). Of these, 17 occur entirely with the region and a further 12 have more than 50% of their land areas within the region (Table 2) The location of LGAs within the Avon River Basin is shown in Map 6.

A significant change to local government administration within the region is the formation of Regional Organisations of Councils (ROCs). These provide opportunities for neighbouring communities to associate and undertake cooperative planning and action for regional natural resource management.

Aboriginal values and heritage are significant within the region. The Avon Catchment Council recognises the importance of protocols for identifying and respecting Aboriginal heritage vales (AHC, 2002) and has completed a study in the Avon River Basin (Bidjamarni Consulting, 2003).

The heritage values of buildings and other infrastructure is identified through surveys coordinated by the Wheatbelt Development Commission.

2.10 Regional capacity

Although the population of the region is relatively small, local communities are cohesive and express a strong interest in and attraction to the landscape. They identify healthy landscapes as being important to enjoyable rural

Table 2 The area and population of LGAs within the Avon River Basin

LGA	Area (ha)	% in ARB	Population[1]
Beverley	236 761	80.3	1 620
Brookton	160 006	100	1 046
Bruce Rock	272 327	100	1 250
Coolgardie	3 040 247	30.7	4 241
Corrigin	268 011	100	1 227
Cuballing	119 443	4.0	840
Cunderdin	186 092	100	1 490
Dalwallinu	722 048	16.3	1 767
Dowerin	186 145	100	861
Dumbleyung	253 855	16.7	701
Dundas	9 428 772	1.3	1 800
Gnowangerup	426 304	8.3	1 724
Goomalling	183 380	100	1 008
Jerramungup	651 641	0.2	1 208
Kellerberrin	191 398	100	1 165
Kent	562 376	64.3	634
Kondinin	742 657	100	1 186
Koorda	283 058	50.7	596
Kulin	470 988	96.0	1000
Lake Grace	1 038 252	96.4	1 539
Menzies	12 573 757	0.1	353
Merredin	329 248	100	3 808

LGA	Area (ha)	% in ARB	Population[1]
Moora	375 982	7.9	2 780
Mt Marshall	1 017 981	32.2	649
Mukinbudin	342 832	100	820
Narembeen	383.153	100	1020
Northam (S)	140 342	78.7	3 600
Northam (T)	2 593	100	7 000
Nungarin	116 285	100	300
Pingelly	129 297	73.6	1 135
Quairading	201 499	100	1 058
Ravensthorpe	1 347 531	4.2	1 482
Tammin	110 106	100	420
Toodyay	169 167	44.6	4 200
Trayning	165 000	100	492
Victoria Plains	254 864	26.9	1 029
Wandering	190 331	14.3	380
Westonia	331 803	99.3	330
Wickepin	203 864	55.1	716
Wongan-Ballidu	336 307	89.6	1 546
Wyalkatchem	159 420	100	620
Yilgarn	3 044 298	88.0	3 000
York	213 085	75.5	3 484

Note (1) Population is for total LGA.

Map 6 Location of LGAs within the Avon River Basin

lifestyles and local community development. Because of this, local communities of the Avon region have well-established involvement in managing natural resources within local catchments.

Formal and informal networks increase the capacity for local NRM. These include:

- Landcare and catchment groups;
- Landcare networks, community networks and associations of networks (coordinated through the Avon Catchment Council's Information Network);
- Conservation networks such as through Greening Australia (WA), Wildflower Society and the WWF Australia;
- Local conservation organisations such as the York River Conservation Society, Toodyay Friends of the Avon River and many others;
- Community-led research and development (R&D) groups such as Western Australian No-Till Farmers Association, Lucerne Growers Association, the Kondinin Group, Oil Mallee Association, Saltland Pastures Association, Australian Master Tree Growers Network and the Avon Sandalwood Network;
- Local productivity groups such as the Facey, the Freebairn and the Ningham groups;
- NRM and agricultural knowledge brokers such as professional consultants, marketing groups and service organisations;
- Heritage groups (e.g. historical societies, National Trust, local museum groups).

The knowledge and skills for NRM within the region have been developed through programs and initiatives including:

- The Decade of Landcare initiatives;
- The Avon Landcare Program and Landcare Vision;
- Recovery programs for threatened species and ecological communities;
- The Bushcare program in the Avon region;
- The community-based Living Landscapes, Woodland Watch and Land For Wildlife programs;
- The Avon Rivercare Program;
- Agricultural industry extension programs, such as the 'Time to Lime' initiative for soil acidity, and,
- Farm forestry extension, including Farm Forestry Support and Tree crops for Sustainable Agriculture programs.

In recent years, the capacity of communities for local NRM has been developed and maintained through Community Support Officers (CSOs) located throughout the region. Approximately 25 CSOs have been employed for landcare, bushcare and rivercare programs.

3. Developing a 'Preferred Future'

3.1 Introduction

The Avon Catchment Council has previously developed a vision for improved regional prospects for present and future generations through sustainable use, enhancement and conservation of natural resources. Avon Catchment Council also recognises the inter-relationships between social, economic and environmental values within the region.

While the vision statement provides a sense of direction for desirable future outcomes, it does not provide a process for communities to build the future they want within the region considering social, economic and environmental change that will occur. The Avon Catchment Council has adopted a 'preferred future' approach based on adaptive management processes.

The 'preferred future' for the Avon River Basin is based on two components:

1. Analysis of the processes of change (Section 3.3), and
2. The Core Values of communities that live within the region (Section 3.5).

This approach to understanding and managing the processes of change towards a preferred future for the Avon River Basin is linked to the Wheatbelt Futures program of the CSIRO Healthy Country Flagship Project in which the 'drivers' of a range of scenarios for the future are analysed. This project will provide the basis for management to adapt with change through time.

The Avon NRM Strategy provides direction and programs to build the social and economic capacity required to develop the preferred future for the region.

3.2 Understanding change within the region

Change in social, economic and environmental circumstances within the Avon River Basin is expected by regional communities. Substantial economic and social change has occurred in Australian farming systems over the past 25 years and is expected to continue in the next 25 years (Kingwell, 2002).

The factors of social change in the Wheatbelt of WA are outlined in *Living in the Regions: the Wheatbelt Report* (Wheatbelt Development Commission, 2002) in which the views of West Australians on preferences for living in regional areas are considered.

Prospects for economic change within the region are considered in *Shaping the Future: 1997-2010* (Wheatbelt Development Commission, 1997) and in the *Wheatbelt Economic Perspective* (Dept. Local Govt. and Regional Development, 2003).

Considering also the predicted increases in the extent of salinity within the region, substantial change can be expected in the Avon River Basin over the next 50 years.

Communities in the Avon River Basin have been consulted to consider the prospects of change at a number of meetings:

- Development of a 'Shared Vision' for Wheatbelt Valleys at a conference held in Merredin, 2001;
- Identification of regional strengths, weaknesses, opportunities and threats at a Sustainability Workshop convened by WA Collaboration, 2002;
- Focus group meetings with communities in the Avon River Basin during 2003 and 2004.

3.3 Drivers and indicators of regional change

The effectiveness of the Avon NRM Strategy is dependent upon an understanding of the factors that drive social, economic and environmental change and on indicators that show the direction and magnitude of change.

The Western Australian Government has policies and strategies that influence drivers and identify indicators of the processes of change within the region. They are:

- *Hope for the Future: The Western Australian State Sustainability Strategy* (2003)
- Regional Policy Statement for Western Australia (2002)
- Indicators of Regional Development in Western Australia (2003)

The CSIRO Healthy Country: Wheatbelt Futures project is assessing future scenarios for the Avon River Basin. Possible drivers of change in the Avon River Basin identified from these processes are:

- Alternate fuels
- Animal industries

- **Biodiversity**
- **Capacity building**
- Climate
- Demographics
- Education
- Emerging industries
- **Infrastructure**
- **Land**
- Manufactures and other industries
- Marketing the Avon River Basin
- Minerals and energy
- New large-scale industry
- Perth – metro-centricity
- **Plant industries**
- **Policy and governance**
- **Salinity**
- Service industries
- Society and culture
- Telecommuting and work
- Tourism
- **Water**

For each driver the underlying critical issues are being documented, including global demand for fibre and wool, salinity, commodity prices, genetic modification and interactions between land use and nature conservation.

The drivers of change that can be most influenced by the Avon NRM Strategy are shown above in bold. It is clear that Avon Catchment Council and the communities of the Avon River Basin require strong partnership arrangements with many other key stakeholder groups to develop their preferred future for the region but that they do have a significant and perhaps leading role within it.

3.4 Trends of regional change

An Avon Catchment Council analysis of economic and social trends (Economics Consulting Services, 2003) identified significant differences between expected trends in the Wheatbelt and Avon Arc zones in the Avon River Basin. The Crown/Pastoral zone of the region was not identified separately in this analysis. The broad long-term trends expected are:

Wheatbelt

- Fewer farms with a higher proportion of large farms and fewer medium-sized enterprises;
- Increased economies of scale will require higher skill levels in farming;
- Continuing farm profitability will require rapid innovation introduction, marketing and business management skills;
- Business risks will change with larger operations, leading edge technology and climate changes;
- Consumer demands will increase pressures on farm management systems;
- Community expectations for improved land management will increase particularly near Avon Arc areas and large towns;
- Lower farm population;
- Fewer youth and females on farms;
- Lower population in small towns and fewer small towns;
- Higher population average age on farms and in towns;

Avon Arc

- Average age in Avon Arc area slightly lower;
- Higher infrastructure maintenance costs with lower rural rate base in broad-acre areas;
- Increased farm commuting;
- Higher Avon Arc population with rural residential living popular;
- More diversified and dynamic economy in Avon Arc areas; and
- Restricted funding base for Shires outside the Avon Arc.

This study included analysis of five investment scenarios for NRM in the Avon River Basin (Economics Consulting Services, 2003). They are:

1. Diminished NRM – a reduction in funding and investment in natural resource management within the region;
2. Status Quo – continuation of current public and private levels of investment;
3. Protection of Infrastructure – a focus on investment in protection of public assets;
4. Conservation Focus – investment focused on restoration of existing or identified potential recovery catchments; and
5. Full Catchment Restoration – assuming that at least 70% of the agricultural land is restored to a similar condition prior to clearing (i.e. revegetation).

Table 3 shows the expected economic and social effects for each scenario. This information provides a guide to the way that economic and social trends may be influenced by investment in regional NRM.

3.5 Our core values

Communities in or associated with the Avon River Basin are concerned about threats to regional 'Icons' and to the core values of lifestyle, landscapes and community assets.

The Avon River Basin has many **defining landscape characteristics** – some are natural, others are built. Figure 5 provides a profile of the Avon River Basin.

Core values provide the reasons for meaningful, enjoyable and responsible living within the region. Ecological, social and economic core values are wide ranging within the region, including those of farmers, families, small business, town residents, Aboriginal communities, state and local government authorities, industry representative groups

Table 3 Predicted economic and social trends for future scenarios

	Notes	Diminished NRM	Status Quo	Protection of Infrastructure	Conservation Focus	Full Catchment Restoration
Agriculture						
Area lost to agriculture	Million hectares	1.7	1.4	2.0	2.4	3.0
	Change from 2003	90%	40%	100%	140%	200%
	Proportion of catchment	14.0%	11.6%	17.0%	20.0%	25.0%
Farm population	Compared to 2003	-33%	-25%	-35%	-40%	-50%
Natural environment						
Conservation estate area	Area compared to 2003	no change	no change	+76%	+300%	+500%
Conservation land area	Million hectares	0.34	0.34	0.6	1.34	1.94
Public infrastructure						
Infrastructure condition	Index compared to 2003	worse	no change	+50%	+25%	+50%
Downstream flooding		worse	no change	no change	improved	much improved
Economic strength						
Farm income		down	no change	down	down	down
Economic diversity	Compared to status quo	weaker	no change	slightly more	more	more off-farm
Demographics						
Population change in broadacre						
Avon Arc population change	Rate of growth	1.75%	2%	2.50%	3.00%	3.50%
Avon Arc population	Compared to status quo	220%	250%	310%	400%	500%
Average age	Compared to status quo	higher	similar	similar	lower	lower
Youth proportion	Compared to status quo	lower	similar	slightly younger	higher	higher
Education attainment	Compared to status quo	lower	similar	slightly higher	higher	higher
Social networks	In broadacre areas cf 2003	weaker	weaker	weaker	weaker	weaker

Economics Consulting Services (2003)

Key to collage of photographs opposite ▶

No.	Accreditation for use of photograph
1	Avon Catchment Council
2	Courtesy of Department of Agriculture, WA
3	Avon Catchment Council
4	Courtesy of Marilyn Chester
5	Courtesy of Department of Environment
6	Courtesy of Department of Agriculture, WA
7	Courtesy of Jenny Davis, Murdoch University
8	Courtesy of Department of Agriculture, WA
9	Courtesy of Department of Agriculture, WA
10	Courtesy of Department of Agriculture, WA
11	Avon Catchment Council
12	Courtesy of Brendan Oversby
13	Courtesy of Department of Agriculture, WA
14	Courtesy of Louise Butcher, Bodallin
15	Courtesy of Department of Agriculture, WA
16	Avon Catchment Council

Figure 5 A profile of the Avon River Basin ▶

The Prioritisation Workshop at Northam Lessor Hall, February 2004, led to the development of RCTs, MATs and MAs. This workshop involved Council members, staff, and people from agencies, community and local government.

and many others. These values are influenced by history and traditions.

Some core values are fundamental to living in landscapes of the Avon River Basin. Communities of the Avon River Basin aim to maintain these values in the short-term and add to them in the future.

Our core values have been developed during consultation with communities in the region. Some of these values are:

- Our landscapes including land, water and biodiversity assets
- The Avon River and its tributaries and their connection with the Swan River and Perth
- Profitable agricultural industries
- The community's response to adversity (e.g. salinity, fire and drought) through innovation, resilience and cooperative effort
- Making a contribution towards global sustainability
- Keeping people in the landscape – a sense of 'rural community living'
- Aboriginal knowledge of landscape and heritage values
- A spiritual and cultural 'sense of place' in the landscape
- Local knowledge, wisdom and skills in landscape and associated land use management,
- Our built infrastructure (roads, rail, towns, grain bins etc.)
- Personal communications and social networking
- Democratic processes in local governance
- Services for farm and other small businesses
- The community recreating and celebrating together
- Providing 'Country Outreach' for city-based people.

3.6 A 'preferred future' model

The Avon Catchment Council recognises the need for substantial development of a preferred future model but also recognises the complex nature of doing so. Change management towards a preferred future requires an understanding of not only economic and market mechanisms but also of social choice. Ideals of economists, including efficiency and public benefit, need to be associated with the social concepts of fairness and social choice (Economics Consulting Services, 2003). Other factors of knowledge, justice, decision and change processes also relate to the Avon River Basin (Kelly et al., 2003; Black, pers. comm.).

Workshops based on the economic and social trend analysis (Economics Consulting Services, 2003) to further develop a preferred future for the Avon River Basin suggest there are many concepts to be considered and that there is a further requirement to refine these concepts towards a more focused preferred model for the Avon River Basin. There is an opportunity to do this through partnership arrangements with the CSIRO Healthy Country – Wheatbelt Futures project.

The Avon Catchment Council recognises the ongoing requirement to develop the preferred future model for adaptation of strategic NRM based on change with time. These processes are considered to be a component of organisational management and are included as actions within the regional strategy.

3.7 Components of a 'preferred future'

Considering the core values of communities within the Avon River Basin and the trends of change, the preferred future for the region that can be influenced by natural resource management coordinated through the Avon Catchment Council is expected to be built on the following components:

- Sustainable rural industries are combining current profitable best practice with new enterprise initiatives to improve land productivity and to contain or reduce threats to land resources (especially salinity).
- Farming systems with financial capacity are investing in natural resource management.
- New primary industries based on perennial vegetation (pastures, shrubs and trees) are restoring catchment water balance, providing ecosystem services, and contributing to regional energy generation and to global greenhouse gas reduction,
- Salt-affected land and water resources are used productively in ways that contribute to farm profitability, provide new industry opportunities, generate regional water supply and reduce off-site impacts of salinity.
- Surface water is managed on and between properties to increase farm and community water supplies, reduce drought risk and dependence on public water supply, reduce water erosion, waterlogging and flooding risk, and to provide adequate water for environmental requirements.
- Groundwater is managed to ensure sustainable and profitable use of valued water resources for maximum community benefit. Rising groundwater tables causing salinity are contained or used productively for new enterprise or regional water supply.
- The Avon River is an iconic measure of improving catchment and ecosystem health and is recognised for its connection with the Swan River that is central to the City of Perth.
- The river and major tributaries are managed as functional ecosystems (including river pools) that sustain life and social values, are resilient to drought and have the capacity to flood.
- Creeks that have been significantly altered during land development are being reconstructed as functional waterways with increasing ecological values.
- Wetlands and salt lakes are understood, valued and managed as functional water bodies (including their flood detention capacity) and ecosystems.
- Private and public capacity is combined to manage remnant natural vegetation in reserves and on farms to ensure the intrinsic values of regional ecosystems are retained or improved, especially those that are threatened by salinity and further fragmentation.
- The loss of natural species and ecological communities is halted or at a practical minimum, due to effective public and private (government and community) efforts.
- Further threats to the built infrastructure within the region (especially rural towns and roads) are reducing.
- Heritage values (including identified Aboriginal heritage) are maintained and further threats to these values through changing environmental conditions is minimal.
- Active Aboriginal groups are maintaining knowledge and ongoing connection with country, and managing some natural resource areas.
- Statutory planning arrangements and policies that influence land tenure and natural resource management are flexible to the requirements of landscape change and innovative investment in regional asset protection.
- The natural resource and heritage assets identified according to local, regional, state, national and global interests are managed as shared values.
- The capacity of community and the public sector is adequate to deliver the outcomes of the regional strategy through long-term investment planning and effective partnership arrangements.
- Communities in the region have a sense of assured common purpose and have pride in their combined achievements towards recognised resource condition targets set for their preferred future.

The Avon Catchment Council recognises the difficulties of developing a fixed vision now for the future but instead suggests that some if not all of the components listed above will provide direction for preferred future outcomes.

3.8 A preliminary 'vision' for the region

The ACC intends developing a 'preferred future' vision based on the regional core values and 'drivers' of change as a part of development and adoption of the regional delivery model for NRM. The ACC's vision statement provides clear direction for future management but is also responsive to the realities of social, economic and environmental change.

The ACC also recognises the importance of strong support by community and associated organisations within the region for the 'preferred future' vision. Many other organisations have their own interpreted vision for the future of the region. The intent of the ACC is to provide new direction for a 'preferred future' vision as it relates to natural resource management in the region for these organisations.

A preliminary vision suggested for natural resource management in the Avon River Basin is:

> *to enjoy a socially, environmentally and economically sustainable rural lifestyle within a healthy and beautiful landscape, including land, water, biodiversity and built infrastructure, which is characterised by innovation, co-operation, the use of local wisdom and skills, strong social engagement and democratic processes, and a willingness to share our rural culture with others both inside and outside the region in a manner that contributes to global sustainability and celebrates our 'sense of place' within our unique landscape.*

4. Developing Goals and Targets

4.1 National matters for which Goals and Targets are set

The Avon NRM Strategy recognises the national outcomes identified in the National Framework for NRM Standards and Targets and ensures that regional goals and targets relate to the following issues:

1. Land salinity
2. Soil condition
3. Native vegetation communities integrity
4. Inland aquatic ecosystems integrity (rivers and other wetlands)
5. Nutrients in aquatic environments
6. Turbidity/suspended particulate matter in aquatic environments
7. Surface water salinity in freshwater aquatic environments
8. Significant native species and ecological communities
9. Ecologically significant invasive species.

The Strategy is based on four broad asset groups:

- Water resources,
- Land resources,
- Biodiversity conservation, and
- Infrastructure.

Cultural and heritage values for each of these are considered.

The Strategy provides relevant information required for development of regional goals and targets:

Aspirational goals set within a 50-year timeframe.

These goals reflect the aspirations of communities and organisations within the Avon River Basin for social, economic and environmental values of natural resource management and infrastructure assets. The goals are closely linked with development of the 'preferred future' vision.

20-year Targets (resource condition targets) to be achieved within a 20-year period.

The 20-year Targets for the Avon NRM Strategy are derived from assessment of:

- The regional assets (identified as natural or infrastructure resources),
- Threats to valued assets, and
- Feasibility of improving resource condition.

The intended strategic response for each of the 20-year Targets is identified as being:

Preventative through threat reduction
Maintaining current asset values
Recovery of previous high asset values
Adaptation to new or altered asset condition
New Opportunity by creation of additional asset value.

Management Action Targets (MATs) for key actions to be achieved within a 3-5 year timeframe.

The MATs are derived from an assessment of the options for management and consideration of the level of effort required to achieve targeted resource condition change.

Indicators are identified for 20-year Targets and MATs to enable monitoring and evaluation of resource condition and implementation efficiency.

The 20-year Targets are specific, measurable, achievable, relevant and time-bound (SMART) where possible. Actions are identified to ensure that all targets are 'SMART' within the next 2-3 years.

All 20-year Targets are considered to be of high priority. They are linked with similar targets for building regional capacity, developing new regional enterprise opportunities and maintaining social, heritage and cultural values. They provide the foundation for strategic investment for NRM within the region.

The following sections provide a strategic analysis of the MATs based on a Sequence of Eight steps:

1. Asset identification
2. Threat identification and risk assessment
3. Assessing the feasibility and cost benefits of management options
4. Setting and reviewing targets (RCTs and MATs)

5. Planning for key management actions (Key Actions)
6. Building capacity for implementation
7. Investment in implementation
8. Monitoring, evaluation and review.

The eight steps provide a robust basis for identifying the targets and key actions for investment.

Criteria for assessment of **Trade-off values** are identified for asset classes. These criteria include:

- **Existing priorities** set at national, state or regional level;
- **Prior investment** in management projects that are considered effective;
- **Urgency** for management action based on the level of threat; and
- **Sequencing** of management actions (other actions that are not able to proceed without this action or target).

A Trade-off Assessment is undertaken based on these criteria in setting priorities for investment (Section 5).

4.2 Water resources

The Avon River Basin has only limited water resources suitable for water supply. There is virtually no irrigated agriculture and town and farm water supplies are significantly supplemented by external sources provided through the Goldfields Water Supply Scheme. On-farm water supply and some town water supplies harvested from surface water runoff are important. Potable groundwater supplies are limited to the west of the region and are generally of limited quantity. Saline groundwater resources are allocated under licence arrangements for mining east in the region.

The waterscape assets of the region are known although are generally little understood. The Avon River and its pools are well documented and freshwater wetlands are regularly monitored. Little is known about the hydrological and ecological functions of tributaries to the Avon River and the salt lakes within the region.

The biodiversity values of water resource assets are considered in Section 4.4.

4.2.1 Water resource assets identification

The Avon NRM Strategy is based on management of priority natural resource assets within the region. The water resource assets for the Avon River Basin are identified in six Asset Classes. The regional assets within each class are derived from State priority water assets identified through the SIF processes, and local water resource assets identified as an ongoing part of developing Loca Area Plans.

Asset Class 1
The Avon River and Swan-Canning Estuary

The Avon River and the Swan-Canning Estuary are State priority assets. The Swan River and estuary have been identified as the first Icon Asset by the WA State Government.

The Avon River discharges to the estuary.

Coordination of management for the estuary is undertaken through arrangements with the Swan Catchment Council and the Swan River Trust.

The assets of the Avon River system include the river channel, floodplain, fringing vegetation and the remaining river pools.

The main channel and floodplain of the Avon River extends from the Yenyenning Lakes downstream to the confluence of the Wooroloo Brook at Walyunga, and includes the South Branch through the town of Brookton. The main river channel was originally braided, with many small channels interweaving between thickly vegetated islands, and punctuated by numerous deep, shady pools. The Avon is now a highly disturbed river system due to clearing the catchment for agriculture and establishment of towns adjacent to the river. It was also deliberately disturbed to reduce flood impacts on towns and agricultural land in the floodplain under the River Training Scheme undertaken during 1958-72.

A survey of 191 km of the river channel and river pools was undertaken in 1996. This shows the condition of river assets for 18 of the river sections and in particular, the ongoing change due to channel erosion and sedimentation. Eleven Recovery Plans have been prepared in consultation with local communities for all river sections. Implementation has commenced for seven of these with up to 20% of actions competed.

The Avon River has high variability of stream flow. Minor tributaries have low flow during most years. Larger tributaries cease flow during summer. Major flooding events due to extreme rainfall events, typically associated with tropical cyclones, have occurred in 1926, 1930, 1945-46, 1955, 1958, 1963-64, 1974 and 2000. The annual flood flow in the Avon is presented in Figure 6.

Significant rain during January 2000 resulted in a 1 in 20 year summer flood. This delivered 270 gigalitres of discharge to the Swan-Canning Estuary – five times the volume of the estuary. The Swan River was closed to public use as a result of this flood event.

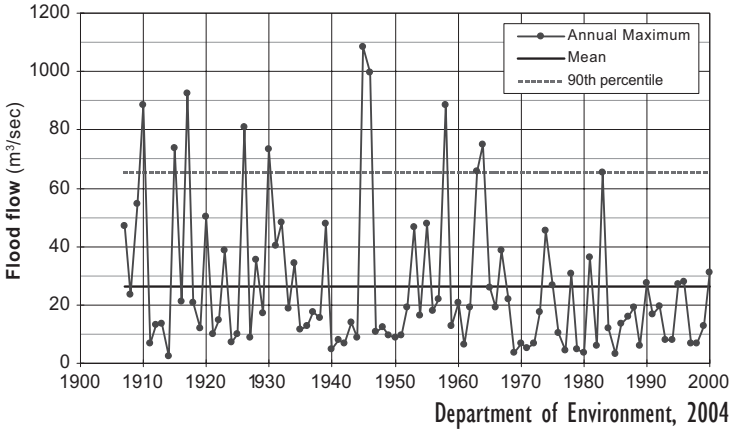


Figure 6 Annual floodflow for the Avon (at Walyunga)

Asset Class 2
Tributaries to the Avon River

The Avon River Basin has significant tributaries as described in Section 2.5, including the Lockhart and Yilgarn rivers which combine to form the Salt River which flows to the Yenyenning Lakes. These tributaries are generally of very low gradient and are associated with extensive chains of salt lakes. Stream flow is intermittent and generally low.

The tributaries that contribute directly to the Avon River channel downstream from Yenyenning Lakes include:

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

The tributaries that flow directly to the Avon River are generally from smaller catchments in the more dissected landscapes of the Avon Arc. They have steeper channel gradient than the inland tributaries, with the exception of the Mortlock River system which is of low gradient. These tributaries have a relatively high coarse sediment load and have high suspended sediment concentrations following intense rainfall events.

Stream flow of tributaries has increased. Flows that were 1% of rain rose to 4% after clearance and 6.6% after seeps developed.

The riparian ecosystems of major tributaries are generally degraded and further threatened by many factors, including salinity. Weeds commonly dominate the understorey vegetation.

The riparian ecosystems of the tributaries to the Avon River have attributes that are being identified through surveys to assess the condition of channels and foreshores as a part of the Avon Rivercare Program. Surveys are complete for the Mackie River, the Mortlock River (North), Spencers Brook, Talbot Brook and Toodyay Brook.

The Brockman River, Ellen Brook, Helena River and Wooroloo Brook are also tributaries to the Avon River although they are considered within the Swan region for management. These river systems have a lower annual salt load than the Avon River. Management initiatives under the National Action Plan for salinity and water quality (NAP) are arranged with the SCC through a Memorandum of Understanding (MOU).

Minor tributaries to the Avon River (creeks and small waterways) are very extensive throughout the Avon River Basin and are generally significantly altered on land used for agriculture. These waterways have only intermittent stream flow although are subject to high peak flows during occasional intense rainfall events. Many are cleared of fringing vegetation and pools are uncommon. Creek channels generally carry a medium to high sediment load although this load is of low mobility with normal stream flow.

Runoff from small catchments has increased significantly since clearing of natural vegetation for agriculture. The channel capacity of most small waterways has eroded since clearing to accommodate these higher flows. Many are continuing to erode during exceptional events although most are stabilising.

Minor tributaries are extensively affected by salinity and this impact is expected to increase significantly with time (Land Monitor project information). Many landholders are seeking to remove sediments from creeks or other works to increase flow capacity. Some landholders propose deeper excavation of these waterways as a part of arterial drainage systems to recover land and other assets from salinity. These actions can be beneficial for land and fringing vegetation although the benefits are not consistent in all areas. There are also the risks of deleterious effects on adjacent landholders, water receiving bodies, infrastructure and other regional assets. The extent of these impacts is generally not well known. Some drainage proposals are limited by road infrastructure (culverts and floodways).

While it is recognised that most minor tributaries are substantially altered, some sections are valued locally for specific reasons (fringing vegetation, rock crossings, Aboriginal values or historic sites). Many of these are

identified as local assets through ongoing planning processes.

Asset Class 3
Surface Water Runoff (overland flow)

Surface water runoff is important for farm and town water supply especially where reticulated scheme water is not available in the region. Surface water is generally considered an asset for supply and also for environmental flows.

Farm and town water supply is reticulated to the region through two schemes, both of which have source dams external to the region. The Goldfields and Agricultural Water Supply Scheme provides water to 2 400 farming properties and 29 rural towns (Water Corporation, 1998) sourced from the Helena River reservoir near Mundaring. The Great Southern Towns Water Supply Scheme provides water to 1 400 farming properties and 38 rural towns within the region sources from the Harris River reservoir near Collie (Water Corporation, 1998). The total volume of reticulated water for farm and rural town water supply in the region is 5 374 ML each year. These schemes provide convenient access to water supply for farm and domestic purposes and effectively provide relief during drought.

Farms and rural towns with access to scheme water have not fully utilised opportunities of surface water runoff supply. Some have invested in enhanced runoff and storage capacity (including 'roaded' and paved catchments) but there is limited incentive to do so. There are few examples of community-based water supply or shared arrangements with neighbours.

Excess use of reticulated water to some rural towns is considered to be a part of the cause of high water tables affecting built assets. The opportunities for local water supplies integrated with surface and groundwater management and including water recycling are not fully realised.

Allocation of surface water is not regulated in the Avon River Basin. The demand for surface water resources within catchments is increasing as the number of small-scale landholders increases, particularly in the west of the region.

Asset Class 4
Groundwater (fresh and saline)

Groundwater resources in the region are generally unsuitable for agricultural use although saline groundwater is used by the mining industry. Some significant fresh to brackish groundwater resources are located in the higher rainfall western area.

Management of groundwater flow systems is important for control of salinity in the region rather than for protection of aquifers as priority assets. Saline groundwater is considered as an asset as there are some commercial opportunities for its use where it is artificially discharged for salinity control.

Groundwater salinity ranges from less than 2 750 mg/L to the west of the region, to 5 500 – 11 000 mg/L in the centre of the region, through to more than 25 000 mg/L in the east. A recent assessment of groundwater monitoring shows that acidic groundwater (pH < 4) is extensive within the region (Ghauri, 2004).

Groundwater is allocated under statutory licensing arrangements through the Rights in Water and Irrigation Act 1914. Town water supply for Bolgart and Brookton is allocated under licence arrangements through the Water Corporation (total annual allocation is less than 90 000 kilolitres). There are 22 groundwater allocation licences with a total annual allocated volume of 26.47 gigalitres for mining within the region. The water allocated to mining is for mine processing, dust suppression as well as dewatering and is generally of low quality (relatively high salinity). Discharge of wastewater from mine sites is controlled by licensing arrangements under the *Environmental Protection Act 1986*.

Asset Class 5
Heritage and Cultural Values

Water has been central to the lives and values of both pre and post-European settlement communities particularly through supply of water, droughts and floods. The location and movement of Aboriginal communities was determined largely by water supply and wildlife near water. This is reflected in heritage values associated with the Avon River, including the Wagyl rainbow serpent and birthing rocks near river pools. Gnamma holes in rock outcrops were used for water supply.

The strong affinity with the Avon River of those living and working near it is has been represented through a collection of photographs and nostalgic recollections (Avon Reflections, Moore, 2000). Towns on the river maintain natural or artificial pools for scenic and amenity values. Some pools, including Burlong Pool near Northam, provided a social centre for water-based recreation before they were filled with sediment or the water quality declined.

The annual Avon Descent paddle and power boat event attracts international interest and provides a significant link to the river for people living in Perth. Some of the lakes also provide recreation opportunities for local and visiting communities. These include Lake Baandee, Lake Bryde, Lake Meares, and the Yenyenning Lakes.

Many other places provide attractive sites for picnics or contemplative time, including lakes, rock pools and some agricultural area dams.

Asset Class 6
Social, Economic and Environmental Values

Water resources in the Avon River Basin have social value to local communities particularly through historic, cultural and heritage association. The Avon River, and particularly the river pools, is of iconic value to those who live near it. The Avon Descent white water boating event is now a defining characteristic of the region. Some of the lakes are important for recreation, including water sports. Many rock pools have significance to local communities, especially those with Aboriginal value.

The economic value of groundwater resources within the region is primarily for water supply to mining and to supplement some rural towns. There are no major irrigated industries based on ground or surface water supplies. There are some known fresh aquifers that are used for small-scale irrigation projects. Not all of these water resources are used to their sustainable yield capacity. It is expected that hydro-geological surveys could identify additional productive groundwater resources. Communities within the region have identified the importance of maximising sustainable use of these resources.

Farm water supply is limited in many areas within the region due to unsuitable groundwater, low rainfall or poor prospects for harvesting surface water. A significant proportion of the region receives reticulated water supply (the Goldfields and Agriculture Water Supply Scheme) sourced from the Helena River (Mundaring Reservoir) near Perth. Local communities recognise the value of this secure supply although have expressed interest in reducing their dependence upon it. The State Government Rural Water Plan provides opportunities for other landholders to develop farm water supplies.

Water is significant to environmental values within the region because of the very limited areas where it is fresh and because of only intermittent detention of surface water in the major lake systems. The amount and timing of water flows or retention (hydro-period) is significant for wetland and waterway management. The values of saline ecosystems in the region are not well understood but are considered to be potentially significant.

4.2.2 Water Resources Threat Assessment

Salinity

Land and stream salinisation following clearing was observed in south-west WA as early as 1897. The link between clearing and salinity was described in 1907, and the mechanism largely understood by 1920. The rate of salinisation has been high for the Avon River compared with other rivers in the south-west of Western Australia (Olsen & Skitmore, 1991).

Estimates show that of the 7.4 million ha of land cleared for agriculture in the Avon River Basin, 388 000 ha (5.3%) is presently saline, with 2 million ha (27.4%) at risk of salinity in the future (Land Monitor, 2002). Long-term trends indicate that groundwater in the central Wheatbelt is expected to rise across the region at a rate of 15 mm to 25 mm per year. These changes threaten freshwater wetlands, waterways and some fresh groundwater supplies.

The rate of stream flow salinisation for the Avon River has been high. The average annual salt load discharged from the Avon River is now 2 160 000 tonnes. Table 4 shows the relative contributions from the catchments.

Stream flow and salinity are monitored through a network of gauging stations within the Avon River Basin. The location of these stations and trend analyses of monitoring information over the past 20 years is provided in Appendix 2. This analysis shows salinity to be relatively stable at Walyunga, slightly increasing at Northam and significantly increasing upstream from York. Similar analyses show the salt load of the major tributaries to be significantly increasing where stream flow has increased. This is generally not causing increased salt concentration of stream flow.

Nutrient enrichment

The Avon River is a major contributor of nutrients to the Swan-Canning Estuary. Based on monitoring information up to 1992, 50% of the total estimated load of nitrogen came from the Avon River Basin primarily due to large annual flow discharge (62% of total flow to the estuary). About 30% of the phosphorus load to the estuary came from the Avon River. The total annual average nitrogen (TN) and total annual average phosphorus (TP) discharged from the Avon catchment is estimated to be 194 and 7.7 tonnes,

Table 4 Summary salinity statistics for gauged rivers in the Avon catchment

River	Area (km^2)	Clearing (%)	Salinity (mg/L)	Salt Load (kt)	O/I ratio
Lockhart	32 377	85	29 700	377	6
Yilgarn	55 921	85	20 500	214	2
Avon	119 000	65	5 200	2 160	10

Ruprecht and Hatton (2002)

In the above table,

- Salinity = Mean annual flow weighted salinity TDS mg/L
- Salt load = Mean annual salt load TDS
- O/I = Mean annual O/I, where O/I denotes salt load output from catchment divided by salt input from rainfall.

respectively (D.A. Lord and Associates, 2001). However, waterways that drain from the Darling escarpment, including the Avon, have relatively low TN (typically less that 1.0 mg/L) and TP (typically less that 0.05 mg/L) concentrations (Swan River Trust, 2001). Table 5 shows the relative contributions from within the region.

Following intense algal blooms in the Swan-Canning Estuary in 1994, a draft Environmental Protection Policy for the Swan and Canning rivers proposed a target phosphorus load of 6.4 tonnes per year from the Avon River.

While the most significant sources of nutrients are diffuse, there are point source contributors. These have been identified in the Avon catchment (Ryan & Cobb, 1999). The total annual point source contribution (from four wastewater treatment plants) of N and P are 12.7 and 1.2 tonnes per year, respectively (D.A. Lord & Associates, 2001).

Flooding

Major flooding of the Avon River has occurred on at least 11 occasions over the past century (1910, 1917, 1926, 1930, 1945, 1946, 1955, 1958, 1963, 1964 and 1983). Flooding of riverside towns (Beverley, York, Northam and Toodyay) and of agricultural land along the river was the principal concern that led to initiation of the River Training Scheme undertaken during the 1956-75 period during which the channel was widened and ripped so that scouring would add depth to the river channel. The effect was to mobilise river bed sediments and infill river pools. The success of the scheme in ameliorating townsite flooding is unresolved as floods since this time have been small possibly due to reduced rainfall.

The main channel survey for 191 km of the Avon River down from the Yenyenning Lakes during 1996 has shown the river to be significantly affected by sedimentation. Twelve pools are now filled and others are threatened.

Following significant rainfall in the Avon River Basin during January 2000 (in excess of 100 mm in a large area from east of Hyden to Beverley), there were high river levels from Lake King to Perth. This event was estimated to have an average recurrence interval of 1 in 8 years (using all records since 1970), and an average recurrence interval of 1 in 20 years for summer events.

Monitoring of this event showed that 58% of the total nitrogen load (470 tonnes) and 54% of the total phosphorus load (19 tonnes) came from the large inland Lockhart and Yilgarn salt lake sub-catchments. This event caused the Swan River to be closed for public use due to health risks associated with algal blooms. Most nutrients were transported in suspended sediments.

Sedimentation

Mobilisation of bed load sediments in the Avon River following the River Training Scheme has caused significant infill to most river pools. The erosive processes in the river channel are continuing, particularly in the South Branch of the river. The river channel survey undertaken in 1996 (summarised by Black, 1998) shows in detail the channel erosion and sediment deposition locations.

Most major tributaries also carry a high sediment bed load which is mobilised downstream, particularly during flood events. Minor tributaries have eroded significantly due to increased surface water runoff following clearing and because there is commonly no riparian vegetation. Sediments in these tributaries are a major cause of culvert blockage and localised flooding.

Suspended sediments in stream flow are high following most intense rainfall events or during floods. Waterways in the Avon River Basin have very limited sediment and nutrient stripping capacity.

Table 5 Summary of annual flows and estimated loads (based on flow and concentration observations) for selected gauging stations of the Avon River

GAUGING STATION	**GAUGED FLOW** (GL/year)		**TN** (tonnes/year)		**TP** (tonnes/year)	
	AVERAGE	RANGE	AVERAGE	RANGE	AVERAGE	RANGE
Upper Avon	97.9	32.7-244.9	245	68-623	13	2-40
Middle Upper Avon	132.9	42.9-322.2	404	108-1 097	43	5-147
Mortlock River South Branch	17.8	3.9-52.5	36	12-80	3	1-6
Mortlock River North Branch	23.7	5.3-78.9	55	11-137	5	1-12
Brockman River	52.8	12-103.1	95	8-146	3.3	0.3-5.5
Wooroloo Brook	49.0	25.7-96.5	52	28-113	1.8	0.6-5.1
Lower Avon	362.5	121.4-717.3	492	182-1 149	17.4	5-47

Department of Environment (2004)

Acid groundwater

Acid groundwater (pH < 4) is present in approximately 20% of groundwater bores monitored in the Central Agricultural Region (Ghauri, 2004). It is recognised as occurring naturally although is considered an environmental risk with discharge at the surface due to rising groundwater or pumping and drainage. The detailed extent of this threat is currently not well understood.

4.2.3 Current management strategies and actions

National and state context

The scope for management of water resources in Western Australia is outlined in the *Water and Rivers Commission Act 1995* and is described for State Government as:

> *a clear mandate to manage the State's 'water resources', which embrace all watercourses, lakes, wetlands, estuaries, rivers and aquifers and underground drainage, surface and surplus water, and to concentrate on the assessment, conservation, protection and management of those water resources and their environment.*

In this Strategy, water resources with biodiversity values (including salt lakes, wetlands and riparian ecosystems) are considered in Section 4.3.

The State Government recognises the importance of managing water resources with increasing water demands and in the face of changing environmental factors, including salinity and climate, and is a participant in developing the COAG Water Reform Framework. The State Water Strategy for Western Australia (Government of WA, 2003a) responds to water supply requirements for the future considering these factors of change.

Other state legislation for regulation of water resources relevant to the region includes:

- *Rights in Water and Irrigation Act 1914*
- *Waterways Conservation Act 1976*
- *Country Areas Water Supply Act 1947*
- *Metropolitan Water Supply, Sewerage and Drainage Act 1909*
- *Swan River Trust Act 1988*

The State Salinity Strategy (State Salinity Council, 2000) has responded to the threat of salinity to water resources according to strategic goals:

- *To protect and restore key water resources to ensure salinity levels are kept to a level that permits safe, potable water supplies in perpetuity;*
- *To protect and restore high value wetlands and natural vegetation, and maintain natural (biological and physical) diversity within the south-west region of Western Australia.*

The State Natural Resource Management Council (NRMC) has adopted a strategic approach for investment in salinity management. In Phase I of the Salinity Investment Framework (SIF), assets that are a priority to the State and the threats from salinity to these assets are identified (Department of Environment, 2003). Water resource assets are considered in two categories:

Water supply assets significant to the State generally include:
- Both current and proposed Public Drinking Water Source Areas and Recovery Catchments;
- Groundwater areas, irrigation districts and waterways proclaimed under the *Rights in Water and Irrigation Act 1914;*
- Local town water supplies not proclaimed under legislation
- Referrable dams for drought relief, Water Corporation.

Waterscape sub-class generally comprises:
- Significant wetlands, including Ramsar Convention (UNESCO, 1971), JAMBA[1], CAMBA[2] and Environment Australia significant wetlands;
- Waterways identified in the Wild Rivers Report (Taylor, 1988) and Priority 1 waterways from the Statewide Waterways Needs Assessment (Water and Rivers Commission, 2002);
- Waterways proclaimed under the *Waterways Conservation Act 1976;*
- Reaches of rivers identified as having pristine and good quality riparian vegetation (various WRC reports)

Phase II of the SIF processes assesses the feasibility of a range of actions for management of priority assets.

Policies and management frameworks for the Swan-Canning Estuary are considered in the Swan NRM Strategy (Swan Catchment Council 2004).

Current management actions

Management of the Avon River and floodplain is guided by the Avon River Management Program (1996). Under this program, recovery plans have been prepared in consultation with local communities for all 18 sections of the main channel of the Avon River. As a result of community interest, over 85% of the river is now fenced to control livestock in the riparian zone. Other actions to stabilise

[1] Japanese Australian Migratory Birds Agreement
[2] Chinese Australian Migratory Birds Agreement

bedload sediments within the river channel and to remove sediments from some river pools are underway.

Condition assessment surveys of major tributaries have also been completed. The number of proposals for modification of minor tributaries (including drainage) is increasing. These should demonstrate potential benefit to the waterway, especially for locally identified assets at risk to salinity and sedimentation. Reconstruction of minor tributaries as functional hydrological and ecological systems is considered as a management option.

The recently revised Rural Water Plan (Department of Environment, 2004) provides direction for rural water supply that encourages higher levels of local self-sufficiency. This plan is a component of the State Water Strategy.

There are many initiatives for large-scale management of regional groundwater aquifers for salinity control. These include commercial tree crops, drainage schemes and salt land rehabilitation. These options are not currently coordinated and delivered in a way that has significant regional effect on resource conditions.

Groundwater allocation for mining and town water supply is currently regulated under the *Rights in Water and Irrigation Act 1914* and disposal of waste water from mining operations is regulated under the *Environmental Protection Act 1986*.

4.2.4 Assessing options for management

The options for integrated management of water resource assets are wide-ranging. The key options that are considered most appropriate within the region based on current information are assessed in Table 6. The assessment is based on informed opinion for criteria relating to the **feasibility** of the action to be effective, the potential for **cost-effective benefits**, and the potential for unacceptable **impacts**. It is recognised that other options may be considered, and that the assessment of criteria may change with access to new information.

Integrated planning and management of water resources at a landscape scale is recognised by the ACC as essential. The ACC proposes that this occurs at a range of scales:

Regional planning – this is required particularly for adoption of large-scale engineering options by ensuring that proposed works are integrated with local-scale planning and also with assessment of potential off-site impacts;

Local Area planning – undertaken within LGA boundaries to ensure that infrastructure assets (including road and rail culverts or floodways) are integrated within plans;

Integrated catchment plans – to facilitated integrated management between neighbouring properties on a catchment basis;

Individual property plans – for individual landholder action undertaken within the context of integrated catchment plans and including farm water plans.

The ACC also recognises the significance of regional groundwater management within the Avon River Basin due to the potential for extensive impacts by salinity. On this basis, options for regional-scale groundwater management are reviewed.

Regional groundwater management

Management of groundwater is a focus of many catchment group actions and research initiatives. These include options for reducing groundwater recharge and for enhancing discharge. Management of local flow systems and groundwater aquifers is considered as a part of farming systems where rising groundwater is affecting land assets and agricultural productivity. This section considers options for management of groundwater aquifers at a regional scale.

It is generally recognised that regional groundwater aquifers will continue to rise in the area of land used for agriculture within the Avon River Basin unless there is very significant intervention by large-scale revegetation or engineering options. The scale at which these are required is significantly greater than can be influenced by individual farm enterprise decisions and they are best considered through regional planning and management.

'No action' as an option

The ACC has also considered the option of taking no action to manage groundwater rise and accept that approximately 27% of the land used for agriculture may become salt-affected. This option is attractive only in that it recognises that regional-scale management of groundwater aquifers requires very high investment, has uncertain outcomes and may cause substantial conflict and have significant impacts. However, the core values expressed by the communities of the Avon River Basin include protection of assets and lifestyles from the effects of rising water tables so to take no action is not an option without full consideration of the regional-scale management options that do exist.

Options to 'maintain' current water levels or 'recover' asset values

The ACC recognises that there are potential plant and engineering options to maintain regional groundwater at current levels or recover asset values currently affected at a regional scale, however these options currently are

either not economically viable, not of proven feasibility or do not have broad community support.

The major regional-scale options for effective groundwater maintenance or asset value recovery include:

- Extensive revegetation with trees and shrubs (perhaps 80% or more of some local catchments);
- Extensive adoption of high water-use perennial pastures (which will require increased prominence of live-stock industries with the region);
- Regional drainage and groundwater pumping schemes (which will require coordinated management, ongoing maintenance and potential for off-site impacts).

There are currently available effective options for control of groundwater in local flow systems or small catchments with commercial tree crops. The options include maritime pines, sandalwood, and other species with fodder or other commercial value. These options are limited by low rainfall. Oil mallees are suitable to lower rainfall although currently limited by product market opportunities.

There are a range of research and extension initiatives evaluating options for regional-scale groundwater management relevant to the Avon River Basin, including:

- The Cooperative Research Centre (CRC) for plant-based solutions to salinity based at the University of Western Australia;
- The Avon Tree Crops Development Strategy;
- Regional hydrology and drainage option assessment through the Engineering Evaluation Initiative (EEI) coordinated by the Department of Environment;
- Arterial drainage concept planing by the WA Channel Group;
- The oil mallee industry is being developed by a range of organisations, including the Oil Mallee Association (representative industry organisation), CALM and Western Power;
- Carbon sequestration options developed through the Greenhouse Office, WA State Government, Japanese government and industry initiatives;
- Sustainable farming systems development through the CSIRO Water for a Healthy Country Flagship program (with additional GRDC support);
- Perennial pasture use developed and extended through the WA Lucerne Growers Association;
- New commercial tree options suitable for the Wheatbelt are being evaluated through the Search project undertaken by CALM;
- Commercial tree crop share-farming for maritime pine, eucalypt sawlogs and sandalwood being arranged by the Forest Products Commission (including the Infinitree program);
- The Grain and Graze initiative (with LWA support), Focus Catchment and Rapid Appraisal, Catchment Demonstration Initiatives, sustainable grazing on saline land, and groundwater research coordinated by the Department of Agriculture, WA.

Options for 'adapted use' of salt-affected resources

Regional-scale options for adapting land use to salt-affected resources currently exist. Establishment of salt-land shrubs and pastures can be productive as well as lowering localised water tables and adding biodiversity values. Extensive areas of salt-affected land are suitable for establishment with fodder shrubs.

Evaluation and extension of these options is led by the Saltland Pastures Association with support through the WA Department of Agriculture. The IMPULSE project aims to revegetate 1 million hectares of salt land in agricultural areas of WA within the next ten years.

Partnership opportunities

The ACC acknowledges the significant challenge to manage regional groundwater aquifers with water tables that are continuing to rise. It recognises the importance of meeting this challenge through partnership arrangements with the research, development and extension organisations. A key role of the ACC is to facilitate partnership arrangements with these organisations.

Table 6 Assessment of management options for water resource assets

Notes: 1, 2, 3: √ = Low, √√ = Medium, √√√ = High

Asset	Management Options	Feasibility[1]	Cost-Effective Benefits[2]	Potential Impacts[3]	Comments
River and Tributary Management	• Fencing to control livestock access.	√√√	√√√	√√	Enables regeneration of natural vegetation but may require increased weed management.
	• Fire risk reduction.	√√√	√√√	√	For areas where property and assets are at risk.
	• Weed and feral animal control.	√√	√√	√	
	• Tree planting for salinity risk reduction.	√√	√√	√	Need to identify areas at risk and ensure adequate areas planted.
	• Recovery Plan preparation.	√√√	√√√	√	Important for community engagement.
Sediment Control	• Excavate sediments from river pools.	√√	√√	√	High cost but with some commercial benefits. High potential for sediment re-fill. Some impacts with sediment disposal.
	• Sediment traps and riffles for stream flow velocity reduction (major tributaries).	√	√√	√	Limited effect.
	• Sediment traps and riffles for stream flow velocity reduction (minor tributaries).	√√	√√	√	Can be effective but maintenance required.
	• Bed load sediment stabilisation (natural regeneration).	√√√	√√√	√	Requires minimal disturbance.
	• Channel erosion reduction (engineering works).	√	√	√	High cost without assured success.
	• Landscape erosion reduction (surface water control).	√√√	√√√	√	
Nutrient Risk Reduction	• Risk area identification (soils based).	√√	√√√	√	More detailed soils mapping in risk areas may be required.
	• Nutrient management planning.	√√√	√√√	√	Applying nutrients according to soil testing is cost effective.
	• Nutrient stripping (artificial/enhanced) wetlands.	√√	√	√	High cost with uncertain benefits – trial required within the region.
	• Riparian zone nutrient stripping.	√√√	√√√	√	Depends upon floodplain condition and tributary discharge mechanisms.
	• Wastewater treatment plant processes.	√√√	√√	√	Higher level processing of waste water.
Flood and Floodplain Management	• Flood prediction modelling and risk assessment (for development proposals).	√√√	√√	√	Important for assessment of future flood prediction and the potential impacts on proposed and existing developments.
	• Planning for reduced development in the floodplain.	√√√	√√√	√	Effective options through the Avon Arc Strategy and Town Planning Schemes.
	• Pollution risk reduction.	√√	√√	√	Storm water management in rural towns and pollution hazard reduction for industrial areas considered.
	• Riparian zone flooding (for perched aquifer recharge).	√√	√√	√√	Riparian ecosystem is altering due to reduced flood frequency.
	• Floodplain salinity management (risk assessment, surface water control and tree planting).	√√√	√√	√	Relatively high risk of salinity expected. Prevention is easier than recovery.
Water Supply	• Farm Water Plan preparation and assessment.	√√√	√√√	√	Significant opportunity to identify new opportunities linked with integrated landscape management.
	• Graded interception drainage and water harvesting.	√√√	√√√	√	Multiple benefits for relatively low cost.
	• Community or neighbour water sharing/ trading.	√√√	√√√	√	Significant opportunities for high yielding areas within the landscape to supply areas with limited water harvesting potential.

Asset	Management Options	Feasibility[1]	Cost-Effective Benefits[2]	Potential Impacts[3]	Comments
Rising Groundwater Management	• Recharge reduction – lucerne.	√√√	√√	√	High cost to establish but effective *in situ* groundwater reduction.
	• Recharge reduction – surface water control.	√√√	√√√	√	Cost effective and with multiple benefits.
	• Recharge reduction – tree crops.	√√	√√√	√	Effective if undertaken over extensive areas.
	• Recharge reduction – 'carbon credit' revegetation.	√	√√√	√	Currently not feasible due to existing policy arrangements.
	• Discharge enhancement – engineering options (drainage and pumping).	√√	√√	√√√	Effectiveness depends upon site conditions, generally high cost, the potential for impact may be high.
	• Discharge enhancement – salt land shrubs and pastures.	√√	√√√	√	Some groundwater reduction, productive use potential.
Groundwater Disposal	• Evaporation basins.	√√√	√√	√√	Expensive to construct, potential for leakage.
	• Lakes and other wetlands.	√√√	√√√	√√√	High risk to wetland ecosystems.
	• Natural drainage system.	√√√	√√√	√√√	Potential risk to riparian ecosystems.
Groundwater Allocation	• Licence arrangements for groundwater allocation and disposal for mining operations.				
Monitoring	• Stream flow gauging.	√√√	√√√	√	Existing system relevant.
	• Water quality monitoring (continuous and 'snapshot').	√√√	√√	√	
	• Groundwater monitoring.	√√√	√√√	√	High number of monitoring bores although not strategically located.
Heritage and Cultural Assets	• Management through Local Area Plans.				

Avon Catchment Council community workshop

4.2.5 Goals and targets

Goals and targets have been developed for each of the water resource asset classes as outlined in Section 4.2.1. Consideration of trade-off criteria and target indicators for the 20-year Targets is also provided in the tables below.

W1 Avon River and Swan-Canning Estuary

Goal Statement: *The community takes ownership of the restoration of the natural functions of the Avon River and its floodplain for the long-term benefit of all.*

Issue Statement: The Avon River is perceived to be a major contributor to the nutrient load of the Swan-Canning Estuary, which causes occasional algal blooms and fish kills. Targets are set for nutrient load reduction to the estuary under the Swan and Canning Rivers EPP. The risk of exceeding the target is greatest during summer flood events.

To avoid flooding of towns and farmland adjacent to the Avon River, channel works were implemented to measure stream flow velocity causing massive channel erosion and sediment mobilisation. As a result, river pools are filling with sediment and floods have reduced access to the floodplain, hence there is reduced nutrient stripping capacity.

Table 7 Avon River and Swan-Canning Estuary targets, trade-off criteria and indicators

20-Year Target		Trade-off Criteria [1]	Target Indicators
$W_1T_{20}1$	The average monthly concentration of total nitrogen and total phosphates and total suspended solids (TSS) will not exceed targets of 1 mg/L (N), 0.1 mg/L (P) (TSS to be determined) at Walyunga gauging station. (Cf: Environmental Protection Policy Swan-Canning).	**EP:** The Swan River (including the Swan-Canning Estuary) is a State Icon that is central to the character of Perth. River pool protection priorities identified.	• Total nitrogen and phosphorus leaving the Avon River Basin. • Mass sediment transport and Total Dissolved Solids (TDS).
$W_1T_{20}2$	The current hydrological capacity[1] of Avon River Pools is not reduced by more than 20% by 2025. (Note 1: Based on 1996 survey data for pool volume water and depth).	**PI:** Considerable prior investment in estuary restoration through the Swan-Canning Cleanup Program and in river restoration through the Avon River Management Program.	
Strategic Response: **Prevention** of further sediment mobilisation. **Maintenance** or reduction of non-flood flow nutrient transport. **Recovery** of river pool volume.		**U:** Sedimentation processes are ongoing and some pools are continuing to fill rapidly. **S:** Preventative action for both sedimentation and nutrient transport are more effective than remedial action.	

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

W2 Tributaries

Goal Statement: *Locally identified priority sections of major and minor tributaries are improving to provide social and ecological benefits.*

Issue Statement: Major tributaries within the Avon River Basin are not well understood in relation to their ecological and hydrological functions, but are significantly altered by rising water table, erosion, sedimentation and other threats. Some sections are altered to a condition beyond recovery.

Minor tributaries are very extensively altered by clearing for agriculture. Only few sections retain natural values. Proposed drainage of these waterways may be beneficial to them if well designed, but there are also risks.

Salt lakes and other wetland ecosystems are associated with major tributaries. Some of these have threatened biodiversity values. Proposals for major engineering works include modification of tributary flow parameters and use of lakes for discharge detention.

Table 8 Tributaries targets, trade-off criteria and indicators

20-Year Target		Trade-off Criteria [1]	Target Indicators
$W_2T_{20}1$	Priority sections of major and minor tributaries, identified for sediment and nutrient management purposes, or for salinity control, have improved by at least one 'foreshore condition' class (Pen & Scott, 1995) by 2025 (Note: priority sections to be identified and a specific 20-year Target to be set by 2007).	**EP:** Existing priorities are identified for the Mortlock River system and tributaries in the Avon Arc due to potential for nutrient loss.	• The extent and condition of priority sections of major and minor tributaries.
Strategic Response: **Recovery** of priority riparian ecosystems.		**S:** There is a requirement to identify priority assets and assess potential impacts prior to implementation of major engineering works.	

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

W3 Surface Water Runoff

Goal Statement: *Local communities have minimal water deficits, dependence on reticulated water is decreasing and, in the Avon Arc, provisions of water for environmental requirements is adequate. Local area flooding and inundation is minimised.*

Issue Statement: Surface water runoff from catchments cleared for agriculture has increased causing flooding and erosion in some areas. However, many farms and small communities have inadequate water supply, especially during droughts. There are opportunities to reduce annual water deficits (when demand is greater than supply) by increased water harvesting and also reduce flooding and erosion. However, it is important to retain adequate stream flow for environmental requirements.

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Table 9 Surface water targets, trade-off criteria and indicators

20-Year Target		Trade-off Criteria [1]	Target Indicators
$W_3T_{20}1$	By end 2025, 50% of agricultural properties in the Wheatbelt zone and 50% of agricultural properties in the Avon Arc zone have zero annual water deficits.	**EP:** Increasing water supply self-sufficiency on farms or within neighbourhood groups is a State Government priority through Farm Water Plans.	
$W_3T_{20}2$	Environmental surface water requirements are maintained within the Avon Arc zone until 2025 and beyond.	**S:** Integrating surface water runoff for water supply provides benefits by reducing flooding, erosion, waterlogging and salinity risks.	

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence.

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W4 Groundwater

Goal Statement: *Groundwater resources with potential for water supply or production use are identified and managed in a sustainable way.*

Rising regional groundwater aquifers are well understood with the impacts of increasing salinity and flooding having minimal impacts on land, water, biodiversity, infrastructure and other community assets, as a result of considered and well-informed decisions that have broad community support.

The impacts of the abstraction, injection and disposal of groundwater resources are understood and managed in a sustainable way.

Issue Statement: Rising levels of unconfined and regional groundwater aquifers are causing extensive impacts through salinity, waterlogging and flooding.

Some groundwater resources are used for productive use but other than for town water supply. There is no current requirement for regulation of use. There is potential for additional productive use aquifers to be identified.

Discharge of groundwater abstracted for mining or discharge from engineering options for salinity control has potential for environmental harm.

Acid groundwater discharge and disposal is of increasing concern.

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Table 10 Groundwater targets, trade-off criteria and indicators

20-Year Target		Trade-off Criteria [1]	Target Indicators
$W_4T_{20}1$	Groundwater aquifers suitable for domestic or productive use are identified by 2010 and are maintained at a defined sustainable level and quality.	**EP:** Monitoring the rise of saline groundwater is a priority identified in the State Salinity Strategy. Discharge of groundwater from mining operations currently regulated through licensing arrangements·	• Rate of rise for regional groundwater aquifers. • Ecological health of receiving water bodies (with discharge waters from mining operations or engineering options for salinity control).
$W_4T_{2}02$	Regional groundwater aquifers are managed to minimise the impacts of salinity and flooding according to sub-regional groundwater management plans (Note: 20-year Target to be set in 2005 following regional groundwater and surface water assessment currently undertaken as a part of the EEI program.)	**PI:** Considerable prior investment in research, implementation and capacity building for salinity management.	
$W_4T_{20}3$	Disposal of groundwater from mining operations is managed according to statutory licence conditions by 2009.	**U:** The need to manage discharge of groundwater from engineering options for salinity control is urgent.	
$W_4T_{20}4$	Disposal of groundwater from agricultural operations is managed according to acceptable best practice guidelines by 2009.		
Strategic Response: **Maintenance** of the rate of saline groundwater use, where it is feasible and cost-effective to do so. **Maintenance** of groundwater yield and quality. **Recovery** of assets affected by salinity where the required intervention is feasible and cost-effective. **New Opportunities** through location of additional water resources. **Prevention** of environmental harm through groundwater disposal.		**S:** Management guidelines for groundwater discharge from engineering options for salinity control required before acceptable large-scale works are implemented.	

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

W5 Heritage and Culture

Goal Statement: *Heritage and cultural values are respected and protected.*

Issue Statement: The heritage and cultural values of water resource assets are generally not well recognised.

Table 11 Heritage and culture targets, trade-off criteria and indicators

20-Year Target		Trade-off Criteria [1]	Target Indicators
$W_5T_{20}1$	Known water heritage and cultural values are maintained and enhanced by 2025.	**EP:** Aboriginal cultural values are a recognised priority.	
Strategic Response: **Prevention** of further impacts to heritage and cultural assets.			

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

Management Action Targets (MATs)

W1 Avon River and Swan-Canning Estuary

20-Year Targets: **$W_1T_{20}1$** The average monthly concentration of total nitrogen and total phosphates and total suspended solids will not exceed targets of 1 mg/L (N), 0.1 mg/L (P) (TSS to be determined) at Walyunga gauging station. (Cf: Environmental Protection Policy Swan-Canning).

$W_1T_{20}2$ The current hydrological capacity[1] of Avon River Pools is not reduced by more than 20% by 2025. (Note 1: Based on 1996 survey data for pool volume water and depth).

Table 12 Avon River and Swan-Canning Estuary Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
I. Asset Identification			
II. Threat identification and risk assessment	**W_1 MAT II.1**	Areas of high risk nutrient loss in the Avon Arc and Mortlock River System are identified and mapped by 2007.	• Identify soil types and land uses with high potential to cause nutrient loss. • Undertake salinity risk assessment investigative drilling, land-based geophysical surveys for the river floodplain. • Map areas of bridal creeper, tamarisk and boxthorn in the river environment. • Model future flood risk potential in the Avon River Basin. • Floodplain risk assessment for non-urban floodplain areas. • Statutory processes for assessment of development proposals within the floodplain including risk assessment.
	W_1 MAT II.2	A report on salinity risk to Avon River floodplain is prepared by end 2006.	
	W_1 MAT II.3	The mapped extent of bridal creeper in the river environment is reduced by 75% and tamarisk and boxthorn are eradicated from the Avon River Basin by 2009.	
	W_1 MAT II.4	A report of the predicted long-term potential for increased frequencies of 1-in-25 year probability flood events considering both rising water tables and climate change is prepared by end 2005.	
	W_1 MAT II.5	Flood risk modelling and mapping for non-urban floodplain areas is complete by 2006 and is being adopted through statutory processes for assessment of development proposals to ensure that long-term flood impedance is not more than 5% of present conditions.	
	W_1 MAT II.6	A report with assessment of options and description of best management practice for nutrient use reduction in farming systems, increased nutrient stripping capacity of wetlands and riverine ecosystems is prepared by end-2006.	
	W_1 MAT II.7	Ten sites demonstrating best practice response options for salinity for high priority risk areas in the riparian zone and floodplain are implemented by 2008.	
	W_1 MAT II.8	By 2009, 25% of identified high nutrient loss locations adopt 'zero nutrient loss' targets and strategies.	
	W_1 MAT II.9	The Northam Wastewater Treatment Plant has zero nutrient release to the Avon River by 2009.	
	W_1 MAT II.10	Priority for restoration of major river pools is established by 2005.	

Sequence of Eight	MATs (3-5 years)		MAs
III. Assessing the feasibility and cost benefits of management options	**W_1 MAT III.1**	Eleven River Recovery Plans are complete and endorsed by local communities for the Avon River by 2005 (Note: all are currently in at least draft form).	• Assess land and water management practices including riparian vegetation management, erosion control and best practice for zero loss nutrients from farming systems. • Floodplain sites are evaluated for tree crops to reduce salinity risk. • Evaluate options for zero nutrient release from the Northam WWTP, including local water re-use.
	W_1 MAT III.2	Sediment management plans for 12 priority river pools are complete by 2009. (Note: Sediment management plans have been prepared for Beverley, Blands, Gwambygine, Boyagarra, Burlong and Northam Town Pool).	
	W_1 MAT III.3	Flood and floodplain management plans that account for expected environmental change are incorporated within Town Planning Schemes of the five Local Government Authorities within the Avon Arc by 2010.	
	W_1 MAT III.4	By 2008, all towns and rural communities adjacent to the river in the Avon Arc have Flood Response Plans.	
	W_1 MAT III.4	By 2008, all towns and rural communities adjacent to the river in the Avon Arc have Flood Response Plans. .	
IV. Setting and reviewing targets (RCTs and MATs)	**W_1 MAT IV.1**	An information kit is prepared and five workshops are held for landholders or facility managers in high risk nutrients loss locations about the risk potential and management options by 2007.	• Prioritise river pools based on value, risk and feasibility of action.
	W_1 MAT IV.2	10 community-based 'River Recovery' groups formed and supported by end 2009.	
V. Planning for key management actions	**W_1 MAT V.1**	Information sets for nutrient loss reduction developed by end 2006.	• Prepare Management Plans for priority river pools. • Provide appropriate information through the Avon Arc Sub-Regional Strategy for LGAs to amend Town Planning Schemes.
	W_1 MAT V.2	By 2009, 95% of agricultural land adjacent to the Avon River is fenced both sides.	
	W_1 MAT V.3	Locally endorsed River Recovery Plans have implemented 30% of identified management actions for the 18 Avon River sections by 2008.	
	W_1 MAT V.4	Commercial operations are removing more than 20 000 m^3 of sediments annually from priority river pools by 2009.	
VI. Building capacity for implementation			• Awareness and information programs arranged for nutrient and sediment loss reduction. • Facilitated processes and support for community group development. • Flood and floodplain management awareness program. • Initiate community engagement and education in river management issues (water quality, riparian values and flood management).
VII. Investment in implementation			
VIII. Monitoring, evaluation and review			• Farms in high nutrient loss locations to demonstrate nutrient use according to 'zero loss' strategies. • Measurement of sediment transportation and rate of river pool infill. • Flood levels monitored and compared with model predictions.

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W2 Tributaries

20-Year Targets: W_2T2_0I Priority sections of major and minor tributaries, identified for sediment and nutrient management purposes or for salinity control, have improved by at least one 'foreshore condition' class (Pen & Scott, 1995) by 2025 (Note: priority sections to be identified and a specific 20-year Target to be set by 2007 based on MATs 1.3.1, 1.3.2, and 1.3.3).

Table 13 Tributaries Management Action Targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*	**W_2 MAT I.1**	Foreshore and channel assessment surveys are complete for 13 major tributaries within the Avon Arc and Mortlock River system by 2009.	• Undertake foreshore and channel surveys for priority major and minor tributaries in the Avon Arc and Mortlock River system. • Undertake reconnaissance surveys of major tributaries in the Lockhart and Yilgarn catchments. • Assess minor tributaries within Local Area Planning processes. (Note: Assessment criteria to include social values, environmental values, prior investment and the level of threat).
		W_2 MAT I.2	A report on reconnaissance-scale surveys of the major tributaries in the Lockhart and Yilgarn catchments is complete by end 2006.	
		W_2 MAT I.3	Priority minor tributary assets are identified within 30 Local Area Plans by end 2005.	
II	*Threat identification and risk assessment*	**W_2 MAT II.1**	The extent of salinity risk, flooding and sedimentation, threatening processes is mapped for 13 major tributaries within the Avon Arc and Mortlock River system by 2009.	• Assess and map salinity, flooding and sedimentation risk through regional hydrological modelling.
		W_2 MAT II.2	A report identifying the extent of threatening processes, including salinity risk, flooding and sedimentation to major tributaries and associated wetland systems within the Lockhart and Yilgarn catchments, is complete by end 2006.	
III.	*Assessing the feasibility and cost benefits of management options*	**W_2 MAT III.1**	A tool kit with best practice guidelines for tributary restoration based on ecological and hydrological principles is developed through consultative processes by 2006.	• Develop management guidelines for major tributaries in response to threatening processes based on environmental and social values. • Develop management guidelines for minor tributaries in consultation with local communities.
IV.	*Setting and reviewing targets (RCTs and MATs)*			
V.	*Planning for key management actions*	**W_2 MAT V.1**	Management Action Plans to be prepared for 13 priority sections within tributaries in consultation with local communities in the Avon Arc and Mortlock River system by 2009.	• Prioritise tributaries for management planning (including proposals for engineering works as a criteria). • Undertake management planning according to the prioritised schedule.
		W_2 MAT V.		
VI.	*Building capacity for implementation*	**W_2 MAT VI.1**	Local capacity for priority waterway assets management is built through 10 river restoration workshops completed by 2009.	• Undertake river restoration workshops.
VII.	*Investment in implementation*	**W_2 MAT VII.1**	A document outlining best practice guidelines for protection or improvement of priority local assets through modified drainage is prepared by 2007.	• Assessment of potential benefits and impacts of modified drainage to major and minor tributaries is prepared.
		W_2 MAT VII.2	Local priority waterways identified within Local Area Plans with modified drainage have demonstrated 'net benefit' (to be determined). (Not expected to be retrospective).	
		W_2 MAT VII.3	Fencing 200 km of priority sections of major tributaries is complete by 2009.	
		W_2 MAT VII.4	Revegetation, including commercial tree crop options, of 2000 ha adjacent to priority major tributary sections by 2009.	

Sequence of Eight	MATs (3-5 years)		MAs
VIII. Monitoring, evaluation and review	**W_2 MAT VIII.1**	Stream flow monitoring requirements for major and minor tributaries reviewed on the basis of threat assessment and new facilities installed by 2009.	• Existing stream flow monitoring is maintained continuously. • Additional requirements for stream flow monitoring assessed and installed

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W3 Surface Water Runoff

20-Year Targets: **W_3T20 1** By end 2025, 50% of agricultural properties in the Wheatbelt zone and 50% of agricultural properties in the Avon Arc have zero annual water deficits.

W_3T20 2 Environmental surface water requirements are maintained within the Avon Arc zone until 2025 and beyond.

Table 14 Surface water runoff Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
I. Asset Identification			
II. Threat identification and risk assessment			
III. Assessing the feasibility and cost benefits of management options			
IV. Setting and reviewing targets (RCTs and MATs)	**W_3 MAT IV.1**	The volume of water used annually for farm and town supply from reticulated schemes is identified within 30 Local Area Plans and targets for reduced use are set by 2007.	
V. Planning for key management actions	**W_3 MAT V.1**	By 2007, five integrated plans are prepared to demonstrate on-farm self-sufficiency for water supply.	
	W_3 MAT V.2	Proposals for new dam constructions within the Avon Arc are referred through provisions of the *Town Planning and Development Act 1928* for environmental assessment by 2009.	
	W_3 MAT V.3	The Avon Arc planning strategy and local government Town Planning Schemes within the Avon River Basin include planning for provision of environmental water requirements by 2009.	
VI. Building capacity for implementation	**W_3 MAT VI.1**	More than 10 accredited people with farm water planning skills are providing services within the region by 2009.	
VII. Investment in implementation	**W_3 MAT VII.1**	50% of landholders within demonstration projects have a self-sufficient water supply by 2009.	
VIII. Monitoring, evaluation and review	**W_3 MAT VIII.1**	Monitored reduction in scheme water use established by 2007.	

Avon Catchment Council community workshop

W4 Groundwater

20-Year Targets: **W_4T_{20} 1** Groundwater aquifers suitable for domestic or productive use are identified by 2010 and are maintained at a defined sustainable level and quality.

W_4T_{20} 2 Regional groundwater aquifers are managed to minimise the impacts of salinity and flooding according to sub-regional groundwater management plans (Note: 20-year Target to be set in 2005 following regional groundwater and surface water assessment currently undertaken as a part of the EEI program.)

W_4T_{20} 3 Disposal of groundwater from mining operations is managed according to statutory licence conditions by 2009.

W_4T_{20} 4 Disposal of groundwater from agricultural operations is managed according to acceptable best practice guidelines by 2009.

Table 15 Groundwater Management Action Targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*	**W_4 MAT I.1**	A report on surveys of groundwater resource with potential productive yield within the region is prepared by 2009.	• Develop appropriate groundwater survey database and survey methods. • Undertake preliminary regional assessment for prospective aquifers. • Arrange assessment of potentially beneficial aquifers within the region.
II.	*Threat identification and risk assessment*	**W_4 MAT II.1**	By 2009, 30 Local Area Plans have included salinity risk assessments related to local and regional priority assets. (Note: salinity risk assessment includes the 'extent' of the potential impact, the expected 'time to full onset' and the 'responsiveness' to management intervention).	• Develop appropriate salinity risk assessment techniques suitable for application within Local Area Plans, including catchment-scale salinity risk modelling and appropriate adoption of geophysical techniques. • Undertake salinity risk assessments according to identified areas of high value regional assets considered to be potentially at risk. • Assess groundwater monitoring information for groundwater pH.
		W_4 MAT II.2	A report on the extent of acid groundwater within the Avon River Basin and the potential risk it poses due to groundwater rise and as a result of engineering options based on existing groundwater monitoring information, is prepared by 2006.	
		W_4 MAT II.3	The potential impacts due to saline groundwater abstraction for use in mining and also impacts due to groundwater disposal at sites of potential risk are identified and documented by 2009.	
III.	*Assessing the feasibility and cost benefits of management options*	**W_4 MAT III.1**	The feasibility and effectiveness of salinity risk assessment methods for application within the Avon River Basin are assessed and documented by 2006.	• Review geophysical assessment techniques. • Review salinity risk assessment model options. • Review of plant-based options. • Review of engineering options. • Arrange trial of acid groundwater treatment options, including lime beds and use of ameliorant solutions.
		W_4 MAT III.2	A report that reviews plant-based options for groundwater management and provides best practice guidelines relevant to the region is complete by 2008.	
		W_4 MAT III.3	A report that reviews engineering options for groundwater management and provides best practice guidelines relevant to the region complete by 2008.	
		W_4 MAT III.4	Assessment of treatment methods for safe disposal of acid groundwater by 2008.	
IV.	*Setting and reviewing targets (RCTs and MATs)*	**W_4 MAT IV.1**	The 20-year resource condition targets for regional groundwater management are set by end 2006.	

Sequence of Eight	MATs (3-5 years)		MAs
V. Planning for key management actions	**W_4 MAT V.1**	A Regional Drainage Plan based on regional assessment and best practice guidelines is prepared by end 2006.	
	W_4 MAT V.2	Ten Local Area Plans have regional groundwater management strategies included by 2009.	
	W_4 MAT V.3	The Avon Regional tree crops strategy is completed by 2004.	
	W_4 MAT V.4	Management plans for 10 areas identified as being of high risk due to groundwater abstraction and disposal prepared by 2009.	
VI. Building capacity for implementation	**W_4 MAT VI.1**	Development of farm forestry skills and extension of information appropriate to the region is undertaken through four training courses completed by 2008.	• Information about groundwater harvesting and supply made available. • Initiate further skills training, for farm water management planning. • Arrange farm forestry skills training courses. • Initiate adaptive management framework for large-scale land use change management.
	W_4 MAT VI.2	An adaptive management framework for planning, assessing and negotiating regional-scale engineering options for groundwater management is developed and being adopted by 2007.	
VII. Investment in implementation	**W_4 MAT VII.1**	Significant groundwater resources are identified and managed for maximum community benefit by adoption of water allocation best management criteria by 2009.	• Arrange large-scale drainage feasibility assessment. • Negotiate contract arrangements for establishment of tree crops. • Development of best practice guidelines for groundwater disposal. • Saline groundwater resources are allocated for mining operations according to licence conditions.
	W_4 MAT VII.2	A large-scale demonstration of regional engineering options is planned, assessed and, if feasible, implemented by 2007.	
	W_4 MAT VII.3	Best practice guidelines for groundwater disposal from engineering options for salinity control are prepared by 2005 and are being adopted for all new proposed engineering works by 2006.	
	W_4 MAT VII.4	Commercial tree crops are established on more than 10 000 ha of additional suitable land where there will be groundwater control benefits by 2009.	
	W_4 MAT VII.5	Licence conditions for discharge of groundwater used for mining operations under the *Environmental Protection Act 1986* are audited and reviewed according to best practice by 2005.	
VIII. Monitoring, evaluation and review	**W_4 MAT VIII.1**	A regional groundwater monitoring strategy for the Avon River Basin is developed and being implemented by 2007.	• Maintain records of farm water for plan preparation. • Initiate monitoring of scheme water use within Local Area Plans.

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W5 Heritage and Cultural Values

20-year Targets: W_5T_{20} 1 Known heritage and cultural values are maintained and enhanced by 2025.

Table 16 Heritage and cultural values Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
VII. Investment in implementation	**W_5 MAT VII.1**	A report is prepared that outlines protocols to ensure heritage and cultural values identified in local and regional plans are considered in NRM programs and projects by 2006.	

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4.3 Land resources

4.3.1 Description of land resources in the Avon River Basin

Land resources in the Avon River Basin include many soil types, landforms and soil-water interactions (described in Section 2.3). The landscapes are varied and range from high rainfall zones (700 mm), with distinctly undulating landscapes in the west through to low relief landscapes dominated by broad valley floors and low rainfall (300 mm) in the east. The soils of the region are documented in databases (Department of Agriculture, 2003a).

The value of land resources is in the life support systems that are sustained, including agriculture and biodiversity. The agricultural industry in the Avon River Basin is significant in supporting communities as well as the secondary and tertiary industries that are derived from it.

The land resources of the Avon River Basin have been described in nine sub-regions as shown in Map 7 and Table 17. The threats and associated management responses have been identified according to these sub-regions. This information is provided in detail in a Land Resource Supporting Document (supporting documentation for the Avon NRM Strategy).

All land is considered to be a valuable asset in the region. The Avon Catchment Council does recognise differing land values but does not differentiate land resources on asset value. Instead, management of land assets is focused on managing threats to the land resources.

4.3.2 Use of land resources for agriculture

Agriculture is the dominant use of land resources in the Avon River Basin. The area of land used for agriculture is 7.4 million hectares – the total area of the Avon River Basin is 11.8 million hectares. The region contains 25% of WA farms and accounts for 39% of all farmland in the State's agricultural area.

Agricultural activity in the Avon River Basin contributes 34% ($1 467m) of the State's gross value of agricultural production. Over 60% of this contribution is currently derived from wheat production. Agriculture in the Wheatbelt (of which the ARB is a significant proportion) generates 58% of the wealth and employs 41% of the region's workforce (Wheatbelt Development Commission, 1997).

A number of factors which contribute to determining the value of land used for agriculture. These include:

- **Location** – in relation to reliability of climatic conditions and levels of risk from land degradation. The areas with least climatic variability are on the western fringes of the region. Land values in these areas have historically been high due also to proximity of major towns, road networks, and urban populations willing to invest in lifestyle properties.
- **Land capability** – land can be classed according to its capacity to support a land use without causing degradation. This assessment is undertaken to determine potential for new industries but not as a regional assessment for existing and potential enterprises.

Table 17 Land Resource sub-regions within the Avon River Basin

Land Resource sub-region	Catchment	Total area (ha)	Area used for agriculture (ha)	Percentage[1] of total area used for agriculture.
Carrabbin	Yilgarn	2 032 700	1 794 000	24.3
SE Lakes	Lockhart	2 010 900	1 604 000	21.7
Mortlock	Avon	1 370 000	1 326 000	18.0
Avon Valley	Avon	833 100	813 000	11.0
Northern Sandplain	Avon and Yilgarn	738 000	687 000	9.3
Yealering Lakes	Lockhart	679 300	661 000	8.9
Southern Cross	Yilgarn	248 800	189 000	2.6
Dale/upper Avon	Avon	169 300	163 000	2.2
Darling Range	Avon	224 000	148 000	2.0
Land unallocated to sub-regions[2]		6 100	2 000	<0.1
Total		**8 313 200**	**7 387 000**	**100.0**

Notes: 1 – refer to Department of Agric., WA (2003a)
2 – excluding land in the Crown/Pastoral zone

Department of Agriculture (2004)

Map 7 Land Resource sub-regions of the Avon River Basin

- **Production capability** – this is highly variable, depending on the systems, rotations and production methods utilised by landholders.
- **Enterprise preference** – dependent on individual land managers.

Agricultural production is from broad-acre cropping (wheat, barley, lupins and canola) and annual pasture systems. Wool, sheep meat and to a minor extent beef production make up the animal component of farming enterprises throughout the region.

Increasing diversification of agricultural enterprises is occurring particularly in the Avon Valley, Darling Range and Dale/Upper Avon Land Resource sub-regions. Specialised plantations/orchards for such products as wine grapes, citrus, olives and pistachios have increased following sub-division of larger holdings. Some plantation timber is also grown in the higher rainfall areas in the Darling Range sub-region. Although the range of options is limited, diversification in the Wheatbelt zone is also occurring. Tourism offers some potential for new enterprise development in these areas.

Adoption of commercial tree crops, including, maritime pine and sandalwood as well as short rotation tree crops such as oil mallee, is determined largely by soils, rainfall, topography and distance to potential markets.

4.3.3 Threats to land resources

An assessment of threats to land resources (WA Department of Agriculture, 2003a) has identified the following significant issues for the Avon River Basin:

- Salinity currently affects 388 000 ha (5.3% of agricultural land) and has the potential to affect 2 027 000ha (27.4% of agricultural land).
- Soil acidity is the second highest degradation risk to land and soil, with over half the ARB having a moderate to high risk of sub-surface acidification. Thirty-two per cent of soils have a high risk of sub-surface acidification.
- Sub-surface compaction affects 42% of agricultural land. Soil structure decline affects up to 40% of the Carrabbin and Southern Cross sub-regions and up to 20 to 30% of the Mortlock, SE Lakes and Northern Sandplain sub-regions .
- Waterlogging is significant and occurs frequently in areas of low relief and where rainfall is greater than 400 mm (western areas). As a result, 24% of soils in the region are prone to waterlogging in an average year.
- Water erosion is significant in areas of shallow duplex soils and loamy soils in the eastern wheatbelt. These areas are also susceptible to erosion because of the high frequency of intense widespread and cyclonic rain events. Sheet erosion and rill erosion are evident in western areas. Average soil losses through sheet erosion range from 6.6 – 9.8 t/ha/yr.
- Wind erosion occurs in small areas during most years although can be widespread under exceptional conditions.
- Soil fertility is naturally low in most soils in the Avon River Basin. Continued loss of soil fertility (especially

Table 18 Current extent of salinity and the potential for further salinity impact in Land Resource sub-regions of the Avon River Basin

Land Resource sub-region	Area of land used for agriculture ('000 ha)	Current extent of salt-affected land		Land at risk to salinity impact	
		ha	%	'000 ha	%
S E Lakes	1 604	98 000	6.1	399[1]	24.9
Darling Range	148	2 700	1.8	24	16.1
Avon Valley	813	47 000	5.8	195	23.9
Dale/Upper Avon	163	5 300	3.3	33	20.4
Northern Sandplain	687	34 700	5.1	209	30.4
Mortlock	1 326	111 800	8.4	431	32.5
Carrabbin	1 794	49 500	2.8	553[2]	30.8
Yealering Lakes	661	35 900	5.6	123[3]	19.1
Southern Cross	189	3 200	1.7	60[4]	31.7
Total	**7 385**	**388 300**	**5.3**	**2 027**	**27.4**

Notes: 1 – upland valleys, soil mapping limitations
2 – low relief, incomplete Land Monitor coverage
3 – soil mapping limitations
4 – overestimation, deep regolith and water tables

Land Monitor project Department of Agriculture (2004)

Table 19 The potential extent of threats to land resources within the Avon River Basin

Land Quality/ Land Quality value	Phosphorus export (000 ha and %)	Soil structure decline (000 ha and %)	Subsurface acidification (000 ha and %)	Subsurface compaction (000 ha and %)	Water erosion (000 ha and %)	Waterlogging/ inundation (000 ha and %)	Water repellence (000 ha and %)	Wind erosion (000 ha and %)
Extreme	76 (1%)				64 (<1%)			<0.5 (<1%)
Very high	670 (9%)				92 (1%)	213 (3%)		251 (4%)
High	74 (1%)	10 (<1%)	2171 (30%)	3000 (42%)	178 (2%)	132 (2%)	978 (14%)	1204 (17%)
Moderate	2267 (32%)	716 (10%)	1906 (27%)	2883 (40%)	1147 (16%)	1346 (19%)	2517 (35%)	2225 (31%)
Low	3998 (56%)	6362 (89%)	2766 (39%)	1200 (17%)	2652 (37%)	898 (13%)	317 (4%)	3440 (48%)
Very low					2945 (41%)	1263 (18%)		
Presently acid			145 (2%)					
Nil						3225 (45%)	3177 (44%)	
Not applicable	79 (1%)	76 (1%)	177 (2%)	82 (1%)	87 (1%)	87 (1%)	175 (2%)	45 (<1%)
Total	**7165 (100%)**	**7165 (100%)**	**7165 (100%)**	**7165 (100%)**	**7165 (100%)**	**7165 (100%)**	**7165 (100%)**	**7165 (100%)**

Department of Agriculture (2004)

where investment has occurred for its increase) threatens land resource viability.

- Weeds, feral animals and other biosecurity issues are significant across the region.

Little data is currently available to quantify the extent to which the threats affect the land resource assets. Instead the results of regional land resource surveys have been interpreted to calculate the area susceptible to threats. This was undertaken by using the characteristics of the soils and landscape, where the information is available for private land used for agriculture, as defined by National Land and Water Resources Audit (NLWRA) data (van Gool and Moore, 1999).

Salinity is a substantial threat to land resources. Table 18 shows that up to 8.4% of land is affected in each sub-region, however this is expected to increase to more than 30% in some sub-regions. The extent of other threats to land resources is shown in Table 19.

Other threats to land resources and agricultural productivity include:

Biosecurity – the management of plant, animal and disease risks to agricultural production and the environment. Potential impacts include:

- Significant problems for land managers (cost to agricultural industries estimated at over $3.3 billion per annum nationally);
- Weed invasion can cause soil acidification and may alter nutrient cycling patterns;
- Pest animals degrade the landscape and affect native animals and plants.

The extent of introduced animal and plant pests that impact on agricultural production and environmental values varies across the region. Vertebrate pests such as foxes, cats and rabbits have the greatest impact, while in western areas native parrots have a significant effect on activities such as horticultural production. In eastern areas, such as the Carrabbin sub-region, wild dogs are considered a major pest for sheep production. Plant pests such as skeleton weed have a cross-regional impact. In western areas, bridal creeper, cape tulip and tagasaste are a considerable environmental problem. In eastern areas introduced grasses are thought to be the biggest threat to agriculture.

Footrot disease in agricultural stock requires ongoing monitoring and primary producers need to be vigilant to guard against tuberculosis, brucellosis, johne's disease (ovine and bovines), anthrax and liver fluke, all of which have been detected in isolated incidents within the state in the past.

Climate change – the potential for change in climate is significant to agriculture. There is considerable uncertainty about the extent to which climate will change due to human activity and there is further uncertainty about the extent to which climate change will be deleterious to agricultural production.

There are significant opportunities to reduce gas emissions or provide carbon trading off-set for other areas with excess gas emissions, through tree plantation industry development with the Avon River Basin as a part of the agricultural industry or through independent industry development.

The threats to land resources were assessed on a sub-regional scale based on industry expertise (cf. Land Resource Supporting Document). Table 20 shows eight high-priority threats to land resources: dryland salinity, soil acidity, soil compaction, soil structure decline, waterlogging, water erosion, wind erosion, and plant and animal pests and diseases.

Table 20 Priority of threats for each Land Resource sub-region

Land Resource Threat	Avon Valley	Dale Upper Avon	Darling Range	South East Lakes	Mortlock	Northern Sandplain	Southern Cross	Yealering Lakes	Carrabbin
Soil acidity	**High**	**High**	Moderate	**High**	**High**	**High**	Low	Moderate	**High**
Dryland salinity[1]	**High**	**High**	Moderate	Moderate	**High**	**High**	Moderate	**High**	**High**
Sub surface compaction	Moderate	Moderate	Moderate	**High**	Moderate	Moderate	Low	**High**	**High**
Waterlogging	Moderate	**High**	**High**	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Water erosion	Moderate	Moderate	**High**	Low	Moderate	Low	Low	Moderate	Low
Soil structure decline	High	Moderate	Low	Moderate	Moderate	Low	Low	Low	Moderate
Flooding	High	Low	Low	Low	Moderate	Low	Low	Low	Low
Water repellency	Low	Low	Low	Moderate	Moderate	Moderate	Low	Moderate	Low
Surface water supply shortages	Low	Low	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Wind erosion	Low	Low	Low	Low	Moderate	Moderate	Low	Moderate	Low
Nutrient loss / eutrophication	Moderate	Moderate	Low	Low	Low	Low	Low	Low	Low
Land use pressure	Low	Moderate	Low	Low	Low	Low	Moderate	Low	Low
Soil fertility decline	Low	Low	Low	Low	Low	Low	Low	Low	Low
Biosecurity [2]	**High**	**High**	**High**	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Note: 1: Salinity discussions identified that there is potentially an extended period between current and predicted full extent of salinity. This could be perceived to lower the priority of activities. However, the rate of management response is also slow, and it was deemed important that management activities occur as a priority in order to prevent or minimise a future impact.

Note 2: Biosecurity was ranked as a key threat across the sub-region. This issue is a management issue rather than a physical resource issue. It was identified as a key industry issue and has been addressed here.

Department of Agriculture (2004)

Considering these issues, the use of land resources in the Avon River Basin by the agricultural industry under current management systems is not sustainable. It is however recognised that developing sustainable agricultural systems and maintaining profitability within the agricultural industry is important for natural resource management in the Avon River Basin.

4.3.4 Management strategies and options

The range of management options for each of the issues that affect land resources are outlined together with an assessment of the effectiveness of the options is also provided.

Dryland salinity

Modelling of groundwater flow systems for the WA Wheatbelt shows that regional groundwater systems are not directly responsive to even a substantial reduction in groundwater recharge rates, especially in the medium to low rainfall areas of the ARB. It is estimated that the considerable catchment management intervention needed to achieve a 50% reduction in groundwater recharge will delay the time but not reduce the full extent of salinity (State Salinity Council, 2000). However, some components of groundwater systems are responsive to intervention. The range of options for intervention that are currently available and economically, socially and environmentally acceptable are currently limited.

Assessment of salinity under different management scenarios has been made as a part of developing the Salinity Investment Framework for WA (George and Kingwell, 2003). This assessment also identifies the probability of adoption and technical feasibility of management scenarios for salinity control.

Management options: Effective management of secondary or dryland salinity includes managing both the catchment and the salt-affected land. Options for management (summarised from Tille et al., 2001 and Moore, 1998) are outlined below:

1. Adopting low recharge farming systems

Replacement of current agronomic practices with alternative, economically viable systems that increase evapotranspiration and reduce the amount of water percolating below the root zone. The options include:

- *Improve annual crop and pasture agronomy (Contain):* – species and variety selection, fertiliser applications, weed control, and timing of treatments;

- *Use of perennial plants (Contain):* pastures (e.g. lucerne) which are capable of growing throughout the year, and trees (e.g. oil mallees) or fodder shrubs (e.g. tagasaste) which combine the advantages of deep root systems and year round growth with higher water use;
- *Managing soils with major chemical and/or physical limitations (Contain and Adapt):* as they may create a severe productivity limit and are often also major recharge and/or erosion sites; and
- *Manage remnant vegetation (Contain and Adapt):* to maintain existing water use and contribute to reducing groundwater recharge.

Research for new initiatives in low recharge farming systems relevant to the region is undertaken through the Cooperative Research Centre (CRC): Plant-based Solutions for Dryland Salinity and many other initiatives, including development of the potential oil mallee industry, a Search project to identify new tree crop options and opportunities for 'carbon credit' benefits through revegetation. The Avon Tree-Crops Strategy outlines a range of options.

Effectiveness – management of soils to reduce chemical or physical restrictions to root penetration and agronomy to improve plant growth have benefits, however there is only a limited potential for increasing the water use of conventional annual crops and pastures. Improving cereal agronomy to reach close to theoretical yield potentials will only increase the water use of an average crop by approximately 4 per cent.

Perennials are most effective when used to manage salinity derived from local flow systems. Lucerne currently has best potential for extensive recharge reduction. It is better suited for western parts of the region although establishment can be difficult due to low soil pH and low rainfall. Establishment in eastern areas has also proved successful but with greater risk. Commercial tree crops are also effective but the range of profitable production is limited by distance and rainfall.

Remnant vegetation kept in good condition will have a similar water use to the native vegetation before it was cleared.

2. Engineering solutions

A range of options exist to reduce recharging groundwater aquifers or remove saline water from the catchment. The options include:

- *Managing surface water (Recover and Contain):* incorporating water harvesting, pumps, banks and drains into farm and catchment water management strategies; and
- *Managing groundwater (Recover and Contain):* options to lower water tables, preventing continued accumulation of salts while allowing rainfall to leach salt from the upper soil profile. These techniques, including deep open or closed drains, pumps or siphons, function by increasing the rate of discharge, and consequently reduce the area affected by groundwater discharge.

Evaluation of engineering options within the region is a key initiative of the State Government in partnership with ACC and CSIRO (the Engineering Evaluation Initiative). Outcomes of this evaluation are of considerable interest to many within the region who speculate that engineering options provide effective salinity control.

Disposal of water discharged from engineering options is an important consideration. On-site evaporation basins can be constructed, or temporary detention in an acceptable receiving water body could occur. Many consider that drainage water could be discharged directly to natural waterways but others are concerned about the possible impacts on aquatic ecosystems and other values by discharge waters that are highly saline or acidic.

Effectiveness – the effects of salinity are reduced if waterlogging and inundation is controlled. Well-designed surface water management also effectively reduces groundwater recharge. Interception drainage, works to reduce local flooding and coordinated discharge through road and rail culverts or flood ways are a priority.

Deep drainage has benefits where soils are adequately permeable, and there is sufficient landscape gradient and safe disposal for discharge water. These works are expensive to construct and often have high maintenance costs. While benefits can be demonstrated, there is a requirement to ensure that the net benefit considering economic, social and environmental factors is positive. Recovery of productive land is an uncertain outcome of deep drainage.

Groundwater pumping trials generally show that this option is most beneficial if applied to high value assets, particularly public infrastructure.

3. New productive use of salt-affected resources (Living with Salinity)

Options for productive use of land and water that is already salt-affected include:

- *Saltland pastures and crops (Adapt):* revegetation of saline areas with salt and waterlogging tolerant species will increase water usage and lower water tables;

- *Aquaculture (Adapt and some Recovery and Containment through associated works):* there is some potential for aquaculture ponds using disposal water from surface water or groundwater drainage;
- *Salt harvesting from evaporation basins (Adapt and some Recovery and Containment through associated works):* basins can be used to evaporate groundwater with limited potential for harvesting of salt;
- *Desalination (Adapt and some Recovery and Containment through associated works):* converts saline or other water into fresh water of drinking quality (potable) and for industrial use (Department of Agriculture, 2003b);
- *Mineral extraction (Adapt and some Recovery and Containment through associated works):* from saline water for use by industry, animal nutrition and other uses.

Significant initiatives through the Saltland Pastures Association and other organisations are developing these options within the region.

Effectiveness – saltland plants can provide profitable production from salt-affected land, however the extent to which additional fodder can be utilised within current farming systems is limited. Increased focus on animal-based systems will improve profitability of saltland agronomy.

Operating costs, water quality (including acidic groundwater) and distance to markets limit the potential for aquaculture within the region, however some profitable enterprises and new research initiatives are increasing the aquaculture opportunities.

Most other commercial salt products are currently not financially viable within the region although combined with other management benefits, such as reduced salt risk to public infrastructure, the viability of these options should improve.

Soil acidity

Management options: The management options for soil acidity are detailed in Moore and McFarlane (1998) and summarised as:

1. Application of lime and other alkaline reagents (Recover and Contain)

Applying lime to increase surface-soil pH as a top dressing and by banding or incorporating at depth to increase subsoil pH is the major management option. Other alkaline reagents (e.g. fly ash from cement kilns, dolomite) are limited alternatives.

2. Reduction the rate of acidification (Contain)

Reducing the input of acidifying fertilisers (ammonium-based nitrogen and elemental sulphur), reducing the rate of product removal from the paddock (e.g. hay cutting to alkaline soils) and reducing nitrate leaching (by reducing or splitting nitrogen fertiliser applications and by use of perennials that access nutrients from deeper in the soil profile) will reduce acidification.

3. Plant acid tolerant species (Adapt)

Establishing pastures and growing crops that tolerate acid soils.

Effectiveness – liming is effective and economically viable for surface acidity, and also effective at ameliorating the sub-surface acidity over a longer time period. A key issue is to ensure that landholders are adequately aware of the potential benefits and profitable outcomes of lime applications.

Adoption of acid tolerant pastures and crops is a short-term measure as it allows soil acidification to continue.

Water erosion and waterlogging

Management options: Management options for water erosion and waterlogging are best implemented as integrated catchment water management. These are outlined by Coles and Moore (1998), Moore and McFarlane (1998) and Tille et al. (2001) and summarised below:

1. Farm planning (Recover and Contain)

Realigning of fences, tracks, stock watering points, gateways and lane-ways to avoid accelerated runoff and to isolate areas of high erosion risk.

2. Maintaining vegetative cover (Recover)

Establishment of suitable vegetative cover and management of grazing pressure of risk areas.

3. Reduced tillage, contour cultivation and improved soil structure (Recover and Contain)

Minimum tillage or no tillage cropping systems with cultivation along the contour or at a slight gradient to slow runoff. Application of gypsum.

4. Soil conservation earthworks (Recover and Contain)

Options include constructing contour sills, graded drains, broad-based banks and interceptor drains to intercept rainfall runoff, waterways for safe disposal of discharge water, and gully head sills, flumes, hay bales, drains and

gully filling to control and rehabilitate erosion gullies. Waterlogging may also be controlled with shallow collector drains, mole channels or tube drains discharging to open drains to remove subsoil water.

5. High water use and water tolerant farming systems (Contain and Adapt)

Establishment of high water use pasture, crops and trees up slope to reduce recharge and waterlogging, and those with tolerance to waterlogging.

6. Bedding and mounding (Contain)

Installing raised beds to lift plant roots above saturated soils.

Options for integrated water management should be also assessed for water harvesting potential. The State Government Farm Water Plan initiative encourages landholders to implement works to increase farm water supply.

Effectiveness – farm planning for integrated surface water control provides an effective process for implementing any of the management options listed above. The multiple benefits that can be derived by works to reduce soil erosion, including increased productivity and reduced salinity risk, generally justify the investment within current farming systems. Sub-soil drainage for waterlogging control can be cost effective but usually for areas of intensive agriculture.

There has been a very rapid rate of adoption of no-till farming practice in Western Australia (Figure 7). This trend has also occurred within the Avon River Basin. Many landholders consider that this practice has significantly reduced surface water runoff and, as a result, reduced the need for erosion and other rainfall runoff control. Some are advocating removal of existing erosion control structures as these are considered to interrupt efficient cropping programs, particularly those now based on 'precision farming' or 'constant track' cultivation. Further research is required to establish the extent to which water erosion risk is reduced by minimum or zero tillage (compared with there being a period of reduced rainfall).

There are many landscapes within the region where reduction in water erosion and waterlogging is further required, especially for exceptionally intense rainfall events or exceptionally wet years.

Bedding and mounding are providing increased crop yields.

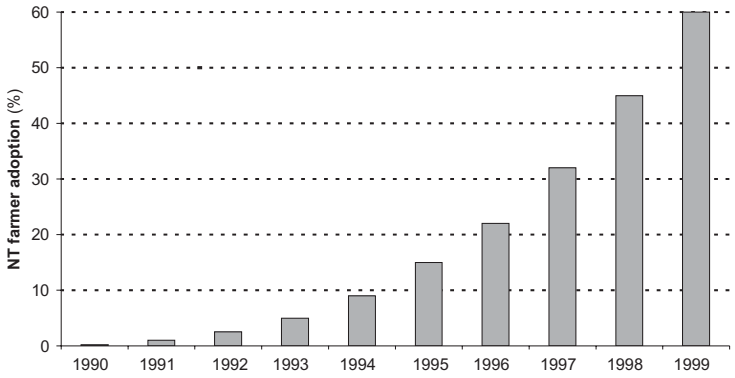

Figure 7 Estimated farmer adoption of no-till in WA

Wind erosion

Management options: Wind erosion can be managed either by reducing wind speed or by reducing the amount of exposed loose soil.

1. Windbreaks (Contain)

Tree belts have been demonstrated to reduce wind speed.

2. Maintain vegetative cover (Recover and Contain)

Stubble retention and pasture management practices to maintain groundcover at above 50% for susceptible soils.

3. Problem area management (Contain)

Susceptible areas can be managed separately by fencing to soil type and ensuring farm layout has watering points, gateways, feedlots sited away from risk areas.

Effectiveness – Windbreaks can be effective through increasing surface roughness although it is unlikely that sufficient belts of trees could be planted to provide control during major erosion events. Maintaining at least 50% vegetative cover and problem area management are considered most effective.

Following a season of high crop yield, many landholders burn stubble extensively in order to reduce subsequent seeding blockage. Others do so for crop disease control. This causes increased wind erosion risk. The awareness of the need for wind erosion control varies between districts and over time.

Soil Structure and Compaction

Management options: The principal strategy to maintain good structure and minimise compaction is to reduce the impact of farming practices. Effective remedial management depends on many factors. Options include:

1. Minimum and constant-track cultivation (Recover, Contain and Adapt)

Reducing the speed of cultivation as well as the frequency and extent of using heavy equipment.

2. Deep ripping and gypsum applications (Recover)

Deep cultivation to loosen sub-surface layers. Gypsum applications improve soil structure.

3. Stock control (Contain)

Reduce or remove stock from soils at risk.

4. Increase organic matter (Recover)

Retain stubble to protect against raindrop impact and to provide a long-term binding agent. Increasing organic matter by green manuring, brown manuring and green mulching has economic and soil structure benefits.

5. Soil condition monitoring

Effectiveness: Minimising tillage has significant economic advantages, however the benefits of no-till are variable. Controlled traffic benefits relate to avoiding compaction between 'tramlines'. Deep ripping is effective but best when combined with using gypsum.

Increased organic matter leads to yield increases and rainfall infiltration rates may increase.

Plant and Animal Pests and Diseases (Biosecurity)

Management options – the range of options include:

1. Legislation

State legislation and policies on weeds and animal pests include the *Agriculture and Related Resources Protection Act 1976*, and the State Weed Plan provides for the control of declared weeds. Other relevant legislation includes the *Plant Diseases Act 1918*, Stock Disease Regulations 1968, and the *Stock Identification and Movement Act 1972*.

2. Prevention

Barrier quarantine at the State border to prevent the entry of quarantine risk material.

3. Incident response, eradication, control and containment

Incident management carried out by the WA Department of Agriculture for incursions or outbreaks of exotic pests and diseases affecting agriculture.

4. Coordinated programs and community involvement

Plant pest management programs, including biological control research targeting declared plants and weeds of national significance and regional significance. Information systems on extent and occurrence of plant and animal pests and biosecurity risks.

Effectiveness – Dealing with pests and diseases through coordinated community/industry action is most effective because of the reduced potential for re-infestation or spread compared with individual management actions.

4.3.5 Goals, targets and actions

The long-term aspirational goals for management of land resources within the Avon Arc and Wheatbelt zones are derived from community consultation and relate to the three Threat Classes:

Soil Condition – *Soil health and productivity is significantly improved through the management of acidity (top and sub-soil), soil compaction, soil structure decline, waterlogging, water erosion, wind erosion and the use of chemicals.*

Dryland Salinity – *The extent of impact of surface and groundwater salinity on productive agricultural land is contained and where possible, reduced. Land that is salt-affected is used productively or to enhance conservation values.*

Biosecurity – *Cooperative action undertaken by local communities across landscapes is effectively controlling or has eradicated plant and animals pests as well as diseases across the region. Additional biosecurity threats are contained or avoided.*

The impacts of pastoral use on land resources in the Crown/Pastoral zone are currently not well known. However, it is expected that in the long-term, continuing pastoral use will be on a sustainable basis.

The strategic context for development of 20-year Targets for resource condition is described below for each Threat Class.

Soil Condition

Soil structure and compaction: Heavy textured soils are most prone to soil structure decline, especially in the agricultural areas of Carrabbin, SE Lakes and Southern Cross sub-regions. A 50% level for the 20-year Target is considered feasible and achievable using current 'best management' practice. It is anticipated that continuing adoption of minimum tillage practices and increasing carbon levels in soils will allow this target to be exceeded in the longer term.

The capacity to manage sub-surface compaction depends on environmental conditions and significant changes in management practices. However, it is considered that a 50% reduction in compaction is feasible in the mid-term. As technology progresses and agricultural practices are modified (e.g. introduction of 'controlled traffic' cultivation), it is expected that sub-surface compaction can be comprehensively dealt with across the region.

Soil acidity: The focus for addressing soil acidity is on capacity building activities, aimed at land managers as this threat can be directly managed in agricultural systems and as methods for addressing surface soil acidity are well established.

Sub-surface soil acidity is presently difficult to manage, however development of best management practice will address this issue in the context of acidity management.

Water erosion and waterlogging: Water erosion problems in average rainfall years are manageable on slopes of classes from 1-10%. In many western areas slope class can, however, be greater than 10%. Management of water erosion on such slopes is difficult and long-term management such as revegetation may be the only feasible technique. This issue has influenced the target level of 50% nominated in the 20-year Target.

Flooding in the Avon Arc zone is also considered in association with this resource condition, as management of 10-20 year flood events may be feasible through application of actions proposed, however the capacity to deal with 50-100 year flood events is beyond the scope of most planned activities in a land use context.

The extent and impact of waterlogging depends upon environmental conditions (soil types and climate). The 20-year Target is focused on managing areas with the highest risk and where waterlogging is having the highest impact. A 50% level of reduction is considered feasible in average rainfall years using current management techniques.

Wind erosion: Wind erosion is an issue that can be managed relatively easily and there is sufficient management information to allow land managers to significantly reduce the incidence of this problem (hence the 80% level for the 20-year Target). Investment required should be focused on capacity building.

Dryland Salinity

The strategic context for managing the salinity threat to land resources is the Salinity Investment Framework (Department of Environment, 2003). This assessment indicates that no land resources in the ARB are Tier One assets (i.e. high value, high threat). Targets for reduction of the impacts, or threat of salinity, to land resources within the region are set with recognition of these state priorities for land resource asset management in the region. On this basis, it is recognised that investment to achieve regional resource condition targets for land assets will be undertaken in a way that will also achieve other natural resource condition targets.

The broad strategic directions adopted by the Avon Catchment Council for salinity management in the ARB are:

- **Recovery** of the land resource to productive agricultural use;
- **Containment** of the threatening process;
- **Adaptation** to make alternative commercial use of the salinised land resource; or
- **Rehabilitation** of land with modified ecosystems that provide environmental and social benefits.

Recovery: The current understanding of groundwater flow systems in the Avon River Basin suggest that there are few options for control of rising regional groundwater that affects the broad valley floors. The options to recover land affected by salinity are:

- Large-scale revegetation with deep-rooted perennials (trees and shrubs) that reduce recharge to groundwater systems (treating the cause of salinity); and
- Engineering options (including deep drainage and groundwater pumping) that reduce discharge at the surface.

Full recovery of land resources from the impacts of salinity is not achievable within the 50-year timeframe of the Avon NRM Strategy. The cost of non-commercial catchment revegetation, including the agricultural production foregone, would considerably exceed the economic benefits from land recovery. Development of profitable perennials suitable to landscapes of the ARB may provide future potential for recovery of land although there would be considerable time delay before significant benefits are derived.

Engineering options do provide opportunities to recover land resources however the high cost, including the costs of maintenance and the risk of off-site impacts, bring into question the scale at which these options can be applied.

Local recovery of land resources can be achieved through revegetation or engineering options in some parts of landscapes. The potential for recovery by management of local flow systems in middle and upper landscape positions is recognised.

Containment: Full containment of the salinity threat is not achievable with currently available options considering

the cost and potential social and environmental impacts. However, there are effective options to reduce the threatening processes in some parts of the landscape. Investment in these options requires an understanding of:

- **Salinity risk at a landscape scale** to identify where within local catchments investment should be made to effectively contain localised processes;
- **Salinity risk at a regional scale** to identify where within each Land Resource sub-region investment in catchment-scale processes will be most effective.

Targets for resource condition need to be based on landscape and regional-scale risk assessment to ensure that investment in containment of the threat of salinity will be most effective.

Adaptation or rehabilitation: Land resources affected by salinity that are unsuitable for recovery for arable agricultural production can be used for other productive or conservation uses. There is a range of currently available options, including salt-tolerant pastures and shrubs. These options are currently not widely adopted.

Some areas of land are severely affected by salinity and may not be suitable for current or adapted productive use. These areas erode and are a significant cause of sedimentation. Severely degraded land in valley floors with water tables at or near the surface also increases flood risk. Individual or community action is required to rehabilitate non-productive saltland so as to reduce the risk of off-site impacts and to add on-site biodiversity and amenity benefits.

Regional priorities: Salinity risk estimates show that the extent of land used for agriculture within the ARB that is affected by salinity will increase from 5% now to 27% in the future. The extent to which this increase will occur varies considerably across the region. The variation will be greater when considered at a local scale.

There is a need to identify where salinity risk is greatest and the estimated time for that risk to occur. This assessment has been made on a sub-regional basis using Land Monitor project information and by assuming that the risk in lower rainfall areas has a longer timeframe. However, this scale of risk assessment is too broad for investment in regional delivery of salinity management programs. The ACC has adopted a threat-based approach to investment in land resources. For this purpose, a more detailed assessment of the risk within the region will be required.

The approach proposed is to provide an assessment of catchments (defined as third order terminal catchments) in areas of agricultural land use. The basis of assessment would be:

- Salinity risk based on extent and time to impact (High, Medium or Low); and
- Response to intervention (High, Medium or Low).

There are an estimated 550 catchments in agricultural land use. An assessment of catchments will be made as a component of Local Area Plan preparation by application of appropriate groundwater flow system models. This assessment will provide direction for investment according to targets based on recovery, containment, adaptation or rehabilitation.

Biosecurity (Plant and Animal Pests and Diseases)

The identification, containment and where possible eradication of 100% of national, state and regional priority plant pest species is an ongoing activity and where possible plant pests should be managed according to their declaration category. There are opportunities for plant pests, especially environmental weeds, to be managed in a landscape context and with coordinated regional planning.

Rabbits, cats, foxes and feral dogs are the key target species for animal pest management in the agricultural areas of Avon River Basin from a land resource degradation and an economic perspective. Management of these species is well developed, however there is a requirement for coordinated action to be undertaken on both private and public land.

The identification, containment and control of all national, state and regional priority plant and animal diseases is ongoing. Industry standards need to be identified and often reactive responses are required to disease management. Links need to be made to quarantine regulations and planning by all land managers.

L1 Soil Condition

Goal Statement: Soil health and productivity is significantly improved through the management of top and sub-soil acidity, soil compaction, soil structure decline, waterlogging, water erosion and wind erosion.

Threat Sub-classes: 1. Soil Acidity. 2. Soil Structure Decline and Compaction. 3. Soil Erosion and Waterlogging. 4. Wind Erosion. 5. Soil Fertility.

L1.1 Soil Acidity

Issue Statement: Soil acidity is most prevalent in sandy soils with a low capacity to buffer pH change. Identification and remediation of sub-soil acidity (10-30 cm) is difficult. Cost-effective techniques for remediation of sub-soil acidity are still to be developed.

The focus for addressing this issue is on capacity building activities, aimed at land managers. The response can be directly managed in agricultural systems as methods for addressing soil acidity are well established.

Table 21 Soil acidity targets, trade-off criteria and indicators

20-year Target		Trade-off Criteria[1]	Target Indicators
$L_{1.1}T_{20}1$	Soil acidity levels (top and sub-surface) at or above pH 5.5($CaCl_2$), in all soils with low capacity to buffer pH change by 2020*. Priority areas for immediate action include Carrabbin, Avon Valley, Mortlock and Yealering Lakes Land Resource sub-regions (total area of 55 000 ha). *pH buffer capacity refers to the soil's ability to resist changes in pH after the addition of an acid or base. Organic carbon levels, exchangeable aluminium levels and percentage clay are the key criteria for determining a soil's buffering capacity.	**EP:** High priority for the agricultural industry. The high level of private benefit by addressing this issue is recognised. **PI:** Significant prior investment in extension for lime application. Ongoing investment levels will be low but return on investment is expected to be high. **U:** Deep white sands and wodjil soils, where it is considered uneconomic to attempt to increase pH levels, are excluded for immediate action but should be considered in the longer term due to their extent. **S:** The extent and severity of sub-soil pH levels needs to be determined, over the time period noted. The documented long-term detrimental impacts of not managing sub-soil acidity is the driver for management action.	• Soil pH. • Surrogates: – Lime application rates (Australian Bureau of Statistics and industry information). – Questionnaires on aluminium toxicity.

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

L1.2 Soil Structure Decline and Compaction

Issue Statement: Soil structure decline is generally a result of tillage. Medium and fine textured soils are most affected. Structure decline can cause surface crusting ('hard setting') which has the effect of reducing water infiltration.

Sub-soil compaction is due to frequent use of heavy equipment, trampling by stock, and cultivation. Coarse textured soils are most affected.

Table 22 Soil structure decline and compaction trade-off criteria and indicators

20-year Target		Trade-off Criteria [1]	Target Indicators
$L_{1.2}T_{20}$ 1	A 50% reduction in the area of soils affected by soil structure decline and sub-surface compaction by 2020. Priority areas for immediate action: – 182 000 ha of coarse textured soils in Carrabbin, Northern Sandplain and Mortlock Land Resource sub-regions. – 587 000 ha of medium to heavy textured soils in Carrabbin, SE Lakes and Southern Cross Land Resource sub-regions.	**PI:** Current industry investment in 'controlled traffic' farming systems. **U:** The capacity to manage sub-surface compaction is dependent on a range of environmental conditions and significant changes in management practices. With such limitations in mind it is considered that a 50% reduction in compaction is feasible. **S:** As technology progresses and agricultural practices are modified, e.g. introduction of tramlining, it is predicted that sub-surface compaction will eventually be comprehensively dealt with across the region.	• Structure decline: – Soil stability scores and aggregate testing. – Surrogates - rates of gypsum application (Australian Bureau of Statistics information). – Surrogates - minimum tillage adoption rates. – Surrogates - stubble incorporation. • Compaction: – Penetrometer readings. – Surrogates - controlled traffic usage and ripping rates.

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

L1.3 Soil Erosion and Waterlogging

Issue Statement: Water erosion problems in average rainfall years are manageable on slopes of classes from 1-10%. In some priority areas, the slope class can be greater than 10%. Where management of water erosion is difficult, long-term management such as revegetation may be the only feasible technique. Note that local-scale management of flooding in the Avon Valley is dealt with under this issue. This approach considers that 10-20 year flood events may be manageable, however 50-100 year flood events are beyond the capacity of most landscape planning management.

Waterlogging depends on many environmental conditions (soil types and climate). The response to this issue is focussed on managing areas with the highest risk and where waterlogging is having the highest impact (combined with erosion).

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Table 23 Soil erosion and waterlogging trade-off criteria and indicators

20-year Target		Trade-off Criteria [1]	Target Indicators
$L_{1.3}T_{20}$ 1	A 50% reduction in the area of land most affected by soil erosion and waterlogging by 2015. Priority should be given to land with slope classes between 3-10%[1] which have very high to extreme water erosion problems. In areas[2] with slopes less than 3% the combined impact of waterlogging (perched water tables at 50 cm for 3-6 months in an average year) and water erosion should be the focus. (Note 1: The Avon Valley, Darling Range, Dale/ Upper Avon and Mortlock (West) Land Resource sub-regions (sheet and rill erosion issues potentially affecting 87 000 ha)). (Note 2: The Lockhart, Darling Range, Avon Valley, Mortlock and Yealering Lakes Land Resource sub-regions (219 000 ha)).	**S:** Waterlogging is important as the combined effects of waterlogging, sub-surface compaction and salinity can have major on- and off-site impacts. **PI:** Current investment is very low and reactive to seasonal conditions. Predictive modelling/ forecasting could assist forward planning for susceptible areas. **U:** Needs to be addressed as a significant contributor to salinity and nutrient loss/ eutrophication of water bodies.	• Direct: – Satellite imagery. – Yield deficiencies (related to waterlogging). – Caesium measures (for soil loss). • Surrogate: – Length, type and landscape position of earthworks. – Extent of creeklines protected and excluded.

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

L1.4 Wind Erosion

Issue Statement: Wind erosion is significant, although not widespread throughout the Avon River Basin due to insufficient ground cover, dry soil on the surface, poor stock management and erosive winds (more than 8 m/second at a height of 2 m). While wind erosion is exacerbated during droughts it is also a recurring problem in below average rainfall years.

The true economic costs of wind erosion are poorly defined and management responses are focussed on prevention rather than addressing management of post-wind erosion events.

Anecdotal evidence suggests that stubble burning is increasing in average rainfall years, associated with high stubble densities, and is used as a management tool to control disease in crops and to control weed resistance. This action potentially increases the risk of wind erosion, if carried out at the broad scale.

Table 24 Wind erosion trade-off criteria and indicators)

20-year Target		Trade-off Criteria [1]	Target Indicators
$L_{1.4}T_20\ 1$	Annual average wind erosion extent is determined for at-risk sandy duplex soils in the Lockhart and Yealering Lakes sub-regions, on deep sand and sandy and loamy duplex soils in the Northern Sandplain and on heavy textured soils in the Avon Valley by 2009. Wind erosion is reduced by 80% over the determined benchmark by 2020.	**PI:** Wind erosion is an issue that can be managed relatively easily and there is sufficient management information to allow land managers to significantly reduce the incidence of this problem (hence the 80% target). Low investment is generally required, aimed at capacity building activities. Investment in management of wind erosion effectively ceased in the mid-1980s. **U:** The risk of wind erosion is often underestimated. While the problem is seasonal, any investment in this area needs to consider annual climate and yield prediction modelling to allow preventative actions to be carried out. This is an annual priority.	• Direct: – Caesium measures (for soil loss). • Surrogate: – Satellite measures of ground cover. – Extent of stubble burning.

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

L1.5 Soil Fertility

Issue Statement: Most soils in the Wheatbelt zone have naturally low soil fertility levels, although this has improved to some extent through application of agricultural fertilisers and trace elements. Fertility loss occurring through soil degradation and mismanagement is common, however, the lack of broader understanding about the chemical and physical and biological interactions within soils often leads to opportunities to improve soil fertility being overlooked.

Table 25 Soil fertility trade-off criteria and indicators

20-year Target		Trade-off Criteria [1]	Target Indicators
$L_{1.5}T_{20}$ 1	100% of soils with recognised fertility issues (elements, organic matter and microbial activity) are identified within 5 years and a 30% improvement over benchmarked fertility levels is achieved by 2020.	**EP:** Improving soil health is a recognised national priority action. **PI:** Individual investment on farms to improve soil fertility is generally focussed on improving crop and pasture yields and fertilser application. Understanding of soil fertility in a natural resource context is generally low and little investment has been made into understanding and monitoring the full range of soil fertility parameters. **U:** Variable and often incorrect advice is currently being provided to land managers, which could have long-term impacts on the sustainability of land resource use and flow-on impacts for water and biodiversity resource areas.	• Soil test information (industry source) – trace element focus. • Soil carbon and microbial content.

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence. Avon Catchment Council community workshop

L2 Dryland Salinity

Goal Statement: The extent of impact of surface and groundwater salinity on productive agricultural land is contained and, where possible, reduced. Land that is salt-affected is used productively or to enhance conservation values.

Issue Statement: Over 25% of land currently used for agriculture may eventually have reduced productivity due to salinity.

Salt-affected land is also susceptible to soil loss and is a further cause of surface water runoff.

There are limited profitable options to reduce groundwater recharge at a scale that will be significant. Management of this issue over much of the ARB will need to focus on adaptation and containment rather than resource recovery.

Some management options to recover land productivity, including drainage, may have off-site impacts.

Table 26 Dryland salinity trade-off criteria and indicators

20-year Target		Trade-off Criteria [1]	Target Indicators
$L_2T_{20}1$	Reduction in the average rate of groundwater rise on land in middle and upper catchment areas from 15-30 mm/year to 10-20 mm/year[1] by 2025.	**EP:** Management of salinity is a high priority as identified in the State Salinity Strategy (2000), however targets for recovery, containment or adoption in the region have not been established for the State. **PI:** Considerable prior investment is continuing, into evaluating and implementing, works for salinity control. This is ongoing. **U:** The expected increase in the extent of salinity within the region suggests that urgent action is required. Emphasis on salinity risk assessment is required to ensure investment is most effective. **S:** There is a further requirement to develop profitable options to combat salinity within the region.	• Depth to groundwater. • Rate of groundwater rise. • Satellite image assessment and prediction of the extent of impact. • Surrogate – rate of revegetation species change (to salt-tolerant perennials). • Surrogate – extent of salt land pasture establishment.
$L_2T_{20}2$	The extent of valley floor salinity[2] is less than 12% of land used for agriculture by 2025. (Note: the areas currently affected is 5.4%. This is expected to eventually increase to over 27%)[3]. (Note 1: The target for middle and upper catchment area refers to very significant reductions in groundwater rise. This action is considered essential to allow recovery and containment and ongoing utilisation of the land resources). (Note 2: The target for the valley floor recognises that saline land has a value in its own right and the intent is to contain salinity in these areas and utilise saline land as a resource). (Note 3: The rate at which land resources in valley floors are affected by salinity is related to the time since clearing native vegetation and rainfall. This rate varies within the region).		

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence.

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L3 Biosecurity (Plant and Animal Pests and Diseases)

Goal Statement: Cooperative action undertaken by local communities across landscapes is effectively controlling or has eradicated plant and animal pests as well as diseases across the region. Additional biosecurity threats are contained or avoided.

Issue Statement: Biosecurity is management of plant, animal and disease risks to agricultural production, the environment and human health.

Table 27 Plant and animal pests and diseases (biosecurity) trade-off criteria and indicators

20-year Target		Trade-off Criteria [1]	Target Indicators
$L_3T_{20}1$	A 50% reduction in the economic and environmental impacts of all priority animal and plant pests across the region by 2014. (Note: This target is for both regional and state responsibilities for threat reduction, including the statutory requirements currently administered by government. There are opportunities within the region for coordinated management of nearly all pests, especially environmental weeds, foxes, wild dogs and rabbits).	**PI:** Landholder and government investment in research and support for the management of plant and animal pests and diseases is high and statutory requirements in most cases ensure adequate management responses. **EP:** State and national priorities for biosecurity are established under statutory arrangements and recognised in existing strategies. **U:** Relates to specific species in specific areas, e.g. wild dog control in the eastern Wheatbelt. Urgency may increase significantly depending on pest or disease incursion but government investment in managing such issues is usually high.	• Numbers and extent of animal pests. • Extent and density of weeds (priority areas). • Extent of plant and animal pest programs coordinated though community groups.

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence.

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Management Action Targets (MATs)

L1 Soil Condition

L1.1 Soil Acidity

20-year Targets: $L_{1.1}T_{20}1$ Soil acidity levels (top and sub-surface) at or above pH 5.5($CaCl_2$), in all soils with low capacity to buffer pH change by 2020.

Priority areas for immediate action include Carrabbin, Avon Valley, Mortlock and Yealering Lakes Land Resource sub-regions (total area of 55 000 ha).

Table 28 Soil acidity Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
1. *Asset Identification*			
2. *Threat identification and risk assessment*	**$L_{1.1}$ MAT II.1**	Regional database established to record the status of top and sub-soil pH documented for all Land Resource sub-regions by 2008.	• Methodology and monitoring of top and sub-soil pH established (cross-regional). • Land use practice monitored in relation to soil pH (cross-regional).
3. *Assessing the feasibility and cost benefits of management options*	**$L_{1.1}$ MAT III.1**	Field study, report and extension campaign completed for: • Viable alternative options (i.e. other than liming) to manage top soil acidity researched by 2008, and • Viable alternative productive options that reduce the cause of soil acidity researched by 2008.	• Research alternative options including: – Application of ash produced from biomass energy production. – Fertiliser type and application rates investigation. – Lateral translocation of bases from alkaline to acid areas.
4. *Setting and reviewing targets (RCTs and MATs)*	**$L_{1.1}$ MAT IV.1**	Study completed documenting the spatial extent of amelioration actions, linking to a sub-regional scale acidity status map and contributing to ongoing state level status mapping, monitoring and evaluation by 2008.	• Benchmark via biennial targeted land manager surveys. • Changes in uptake of practice. • Resulting contribution to resource condition change (threat focus).
5. *Planning for key management actions*			
6. *Building capacity for implementation*	**$L_{1.1}$ MAT VI.1**	Workshops for education and training in soils management are held at 20 locations within the region by 2006.	• Arrange soil management workshops. • Network arrangements with farm consultants and other information or service providers to ensure best practice advice is provided for soil management. • Extend and review BMP for managing acidity in relation to practice adoption, linking acidity management to overall soil health and cumulative impact on resource condition. Specific BMP for the management of acidic sub-soils developed by 2007. • Recommence soil acidity awareness extension campaign focussing on both top and sub-soil acidity.
	$L_{1.1}$ MAT VI.2	80% of land managers have knowledge of BMP for soil acidity (including economic benefits) by 2008. Note: Surrogate measures include field day and workshop attendance and liming rate application increasing to recommended rates (derived from ABS statistics)	
7. *Investment in implementation*			
8. *Monitoring, evaluation and review*	**$L_{1.1}$ MAT VIII.1**	Establishment of a regional M&E plan with links to State M&E structures by 2005.	

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L1.2 Soil Structure Decline and Compaction

20-year Targets: $L_{1.2}T_{20}I$

A 50% reduction in the area of soils affected by soil structure decline and sub-surface compaction by 2020.

Priority areas for immediate action:

– 182 000 ha of coarse textured soils in Carrabbin, Northern Sandplain and Mortlock Land Resource sub-regions.

– 587 000 ha of medium to heavy textured soils in Carrabbin, SE Lakes and Southern Cross Land Resource sub-regions.

Table 29 Soil structure decline and compaction Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
I. Asset Identification			
II. Threat identification and risk assessment	**$L_{1.2}$ MAT II.1**	A reliable method of assessing the extent of compaction and structure decline is available by 2008.	Develop methods to determine the extent of soil compaction and structure decline in soils used for agriculture (cross-regional).
III. Assessing the feasibility and cost benefits of management options			
IV. Setting and reviewing targets (RCTs and MATs)	**$L_{1.2}$ MAT IV.1**	A report of the spatial extent of management practice implementation linked to extension of information is prepared to enable a review of the 20-year Target by 2008.	• Benchmark via biennial targeted land manager surveys: – Changes in uptake of practice. – Resulting contribution to resource condition change (threat focus).
V. Planning for key management actions			
VI. Building capacity for implementation	**$L_{1.2}$ MAT VI.1**	A 50% increase in the adoption of viable soil structure and compaction management techniques by 2009. Note: Surrogate measures include gypsum application rates (from ABS statistics) and stubble retention rates.	• Extend BMP for soil compaction/structural decline, including tramline and precision farming techniques.
VII. Investment in implementation			
VIII. Monitoring, evaluation and review	**$L_{1.2}$ MAT VIII.1**	Establishment of a regional M&E plan with links to State M&E structures by 2005.	

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L1.3 Soil Erosion and Waterlogging

20-year Targets: $L_{1.3}T_{20}1$

A 50% reduction in the area of land most affected by soil erosion and waterlogging by 2015.

Priority should be given to land with slope classes between 3-10%[1] which have very high to extreme water erosion problems.

In areas[2] with slopes less than 3% the combined impact of waterlogging (perched water tables at 50 cm for 3-6 months in an average year) and water erosion should be the focus.

(Note 1: The Avon Valley, Darling Range, Dale/Upper Avon and Mortlock (West) Land Resource sub-regions (sheet and rill erosion issues potentially affecting 87 000 ha)).

(Note 2: The Lockhart, Darling Range, Avon Valley, Mortlock and Yealering Lakes Land Resource sub-regions (219 000 ha)).

Table 30 Soil erosion and waterlogging Management Action Targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*			
II.	*Threat identification and risk assessment*	$L_{1.3}$ **MAT II.1**	Methodology developed to accurately identify areas at risk from soil erosion and waterlogging by 2008.	Development of a remote sensing based methodology, linked to predictive climate modelling and existing soils data to assist in long-term identification and development of preventative management options for soil erosion and waterlogging.
		$L_{1.3}$ **MAT II.2**	Spatial extent of waterlogging and soil erosion identified and threat/impact prediction methodology in place by 2008.	
		$L_{1.3}$ **MAT II.3**	Preventative management options extended to 20% of land managers of highly affected areas by 2009 (ongoing activity).	
III.	*Assessing the feasibility and cost benefits of management options*			
IV.	*Setting and reviewing targets (RCTs and MATs)*	$L_{1.3}$ **MAT IV.1**	A review of the spatial extent of management practice implementation linked to the spatial extent information is completed, enabling revision of the 20-year Target, identified by 2008.	• Benchmark via biennial targeted land manager surveys: – Changes in uptake of practice. – Resulting contribution to resource.
V.	*Planning for key management actions*	$L_{1.3}$ **MAT V.1**	By 2009, 25% of properties in the area of land most affected by soil erosion and waterlogging have landscape-scale integrated water management plans.	• Develop catchment scale surface water management plans.
VI.	*Building capacity for implementation*	$L_{1.3}$ **MAT VI.1**	By 2009, 50% of the properties with integrated water management plans are using BMP for water erosion (improved surface water management aligned with farm water supply, to minimise erosion and optimise water balance across landscapes).	• BMP for waterlogging extended to land managers, including: – The benefits of waterlogging tolerant pastures (e.g. balansa, tall wheat grass).
VII.	*Investment in implementation*	$L_{1.3}$ **MAT VII.1**	Reduction of the area of waterlogged soils on agricultural land, including due to: – 25% increase in length of reverse interceptor banks in the > 450 mm rainfall area by 2009. – 50% increase in area of waterlogged soils planted to tolerant species, including perennials and commercial tree crops in the > 400 mm zone by 2009.	• Review, revise and extend BMP for water erosion to land managers, including: – Whole of catchment (farm as sub-set) surface water management planning. – Broad-based banks and feedlots. – Tillage methodology (including no-till). – Management for 10-20 year flood events in susceptible catchments (Avon Valley focus). – Guidelines for stubble retention. – Capacity building for catchment planners and technical service providers.
VIII.	*Monitoring, evaluation and review*	$L_{1.3}$ **MAT VIII.1**	Establishment of a regional M&E plan with links to State M&E structures by 2005.	

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L1.4 Wind Erosion

20-year Targets: $L_{1.4}T_{20}I$ Annual average wind erosion extent is determined for at-risk sandy duplex soils in the Lockhart and Yealering Lakes sub-regions, on deep sand and sandy and loamy duplex soils in the Northern Sandplain and on heavy textured soils in the Avon Valley by 2009. Wind erosion is reduced by 80% over the determined benchmark by 2020.

Table 31 Wind erosion Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
I. Asset Identification			
II. Threat identification and risk assessment	**$L_{1.4}$ MAT II.1**	The extent of wind erosion and the environmental and economic loss due to this process estimated across all asset classes by 2009.	• Develop a GIS based system to map the extent of wind erosion and equate loss in a range of climate conditions to benchmark: – The physical extent of wind erosion (from groundcover remaining at the end of summer). – Estimated economic loss based on extent and severity mapping. – Forecasting methodology linked to climate predictions.
III. Assessing the feasibility and cost benefits of management options			
IV. Setting and reviewing targets (RCTs and MATs)	**$L_{1.4}$ MAT IV.1**	A review of the spatial extent of management practice implementation linked to threat identification actions is completed to enable a revised benchmark to be determined by 2008.	• Benchmark via biennial targeted land manager surveys: – Changes in uptake of practice. – Resulting contribution to resource condition change (threat focus).
V. Planning for key management actions			
VI. Building capacity for implementation	**$L_{1.4}$ MAT VI.1**	By 2008, 80% of land managers will be practising BMP methodology to assist in prevention and long-term management of wind erosion on susceptible soils.	• Review, revise and extend BMP for wind erosion, including: – Raised awareness of on-farm risk areas and management possibilities. – Stubble retention and broad-scale livestock management. – Windbreak establishment. – In the Northern Sandplain, BMP to be closely linked to oil mallee establishment. – Feedlot and intensive industry management.
VII. Investment in implementation	**$L_{1.4}$ MAT VII.1**	By 2008, 80% of soils have 50% of anchored groundcover at the end of summer.	
VIII. Monitoring, evaluation and review	**$L_{1.4}$ MAT VIII.1**	Establishment of a regional M&E plan with links to State M&E structures by 2005.	

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L1.5 Soil Fertility

20-year Targets: $L_{1.5}T_{20}I$ 100% of soils with recognised fertility issues (elements, organic matter and microbial activity) are identified within 5 years and a 30% improvement over benchmarked fertility levels is achieved by 2020.

Table 32 Soil fertility Management Action Targets and actions

Sequence of Eight	MATs (3-5 years)		MAs
I. Asset Identification			
II. Threat identification and risk assessment	**$L_{1.5}$ MAT II.1**	6 representative land resource areas (catchment scale) with complete soil fertility mapping and linked criteria by 2009.	Develop and test a comprehensive soil fertility assessment process at the farm and catchment scale that can be linked to other soil management issues such as soil pH by 2006. Method will also utilise the existing soils database and remote sensing to help determine the extent of soil fertility rates in soils used for agriculture (cross-regional).
III. Assessing the feasibility and cost benefits of management options	**$L_{1.5}$ MAT III.1**	By 2008, 10 training courses will have been held with the intended outcome being that 70% of land managers will have an understanding of the benefits of the sustainable management of soil fertility in a resource management context.	• Systems based methodology developed and extended looking at multiple benefits of managing soil fertility to: – Increase the efficiency of fertilser use (reduce usage). – Increase sustainable crop and pasture production on a range of soil types. – Manage associated soil degradation issues, such as structure decline and pH.
IV. Setting and reviewing targets (RCTs and MATs)	**$L_{1.5}$ MAT IV.1**	By 2008 a representative RCT will be developed based on data gathered and analysed in representative land resource areas and up-take of soil management methodology.	• Benchmark via biennial targeted land manager surveys: – Changes in uptake of practice. – Resulting contribution to resource condition change (threat focus).
V. Planning for key management actions			
VI. Building capacity for implementation	**$L_{1.5}$ MAT VI.1**	By 2008, 80% of land managers have knowledge of BMP for maintaining soil fertility. Note: Surrogate measures including fertiliser usage, stubble retention rates and soil test application rates will be used.	• Using existing data, develop and extend BMP for sustainable soils by 2008. BMP to include: – Benefits of increasing organic matter. – Options for increasing major and minor soil elements in deficient soils. – Role, benefits and management of soil microbes and soil macro fauna.
VII. Investment in implementation			
VIII. Monitoring, evaluation and review	**$L_{1.5}$ MAT VIII.1**	Establishment of a regional M&E plan with links to State M&E structures by 2005.	

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L2 Dryland Salinity

20-year Targets: **$L_2T_{20}1$** Reduction in the average rate of groundwater rise on land in middle and upper catchment areas from 15-30 mm/year to 10-20 mm/year[1] by 2025.

$L_2T_{20}2$ The extent of valley floor salinity is less than 12% of land used for agriculture by 2025[2]. (Note: the area currently affected is 5.4%. This is expected to eventually increase to over 27%).

(Note 1: The target for middle and upper catchment areas refers to very significant reductions in groundwater rise. This action is considered essential to allow recovery and containment and ongoing utilisation of the land resources).

(Note 2: The target for the valley floor recognises that saline land has a value in its own right and the intent is to contain salinity in these areas and utilise saline land as a resource).

Table 33 Dryland salinity Management Action Targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*			
II.	*Threat identification and risk assessment*	**L_2 MAT II.1**	High risk groundwater recharge landscape zones identified for all Shires, linked to priority assets by 2009.	• Identify areas of greatest risk within the landscape (including local flow systems) as part of preparing Local Area Plans. • Development of targeted options to manage such sites.
III.	*Assessing the feasibility and cost benefits of management options*	**L_2 MAT III.1**	Review of dryland salinity best practice options by 2006.	• Determine the impacts of minimum tillage on recharge and runoff and investigate alternative tillage methods. • Research and improve salinity options BMP. Specific focus includes: – Phase farming systems which use commercial woody perennial options. – Native pastures for saline lands. – Saltland pastures and salt bush alleys. – Arterial and local drainage feasibility and impact assessment. – On-farm pumping and evaporation basins. – Aquaculture and mineral extraction using pumped groundwater.
IV.	*Setting and reviewing targets (RCTs and MATs)*			
V.	*Planning for key management actions*	**L_2 MAT V.1**	Integrated catchment plans are prepared for 50 catchments as part of Local Area Plans in high dryland salinity risk areas by 2009.	• Identify catchment priorities for integrated planning processes. • Arrange for preparation of five integrated catchment plans each year.

Sequence of Eight	MATs (3-5 years)		MAs
VI. Building capacity for implementation	**L_2 MAT VI.1**	Conduct 50 workshop series for best management practice for dryland salinity as a part of integrated catchment planning processes by 2009.	• Extension of BMP for salinity management, including: – Surface water management. – Phase farming processes that incorporate commercial perennial, annual crop and pasture options targeted to environmental conditions and linked to positive farm productivity outcomes. – Valuing remnant vegetation for resource management protection and farm production. – Salt-tolerant plant species (including plant breeding outcomes), saltland pastures and salt bush alleys and PURSL options. – Farm drainage and pumping guidelines (technical/ legal). – Financial management skills to budget for NRM expenditure. • Extension of BMP for seepage management, including: – Alley farming and block plantings using salt-tolerant commercial and non-commercial species. – Options for desalinisation, siphoning and water usage.
	L_2 MAT VI.2	80% of land managers have an understanding of the benefits and impacts of the application of alternative groundwater management techniques and a systems-based approach by 2009. Note: Surrogate measures will include the extent of saltland pasture establishment (from ABS), tree planting rates by species (from local nurseries), and the drainage extent and type (from ABS).	
VII. Investment in implementation	**L_2 MAT VII.1**	At least 50% of the landscapes identified within Local Area Plans (with a focus on managing local flow systems and points of high recharge, e.g. the base of granite outcrops) managed using best management practice options for salinity by 2009.	• Catchment demonstration of best practice for salinity management.
	L_2 MAT VII.2	More than 100 000 ha of saltland revegetated for production or conservation benefit by 2009.	
	L_2 MAT VII.3	More than 50 000 ha of deep-rooted perennial pastures are established for groundwater management by 2009.	
	L_2 MAT VII.4	More than 10 000 ha of commercial tree crops are established in areas where groundwater control benefits will occur by 2009.	
VIII. Monitoring, evaluation and review	**L_2 MAT VIII.1**	Benchmark groundwater levels and quality consistent with National Land and Water Resource Audit standards by 2008.	• Groundwater level and quality monitored and assessed (cross-regional). • Area of salinity monitored, including improved mapping (cross-regional). • Benchmark: – Changes in uptake of practice. – Resulting contribution to resource condition change (threat focus).

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L3 Biosecurity (Plant and Animal Pests and Diseases)

20-year Targets: L_3T_201 A 50% reduction in the economic and environmental impacts of all priority animal and plant pests across the region by 2014.

Note: This target is for both regional and state responsibilities for threat reduction, including the statutory requirements currently administered by government. There are opportunities within the region for coordinated management of nearly all pests, especially environmental weeds, foxes and rabbits.

Table 34 Plant and animal pests and diseases (biosecurity) Management Action Targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*			
II.	*Threat identification and risk assessment*	**L_3 MAT II.1**	An extension program has provided an outline of the state and national strategic planning for plant and animal pests and diseases to increase understanding by 100% of LGAs, LCDCs and catchment groups within the region by 2005.	• Review, discussion and distribution of state and national strategies for animal and plant pest and disease management with regional stakeholder groups. • Support for the distribution of threat assessment information from state and national governments to local groups. • Utilisation of existing modelling of distribution patterns of target animal pest species, linked to development of appropriately scaled management responses and BMP.
		L_3 MAT II.2	An ongoing program of regular pest and disease updates for local community groups is developed and being delivered by 2005.	
III.	*Assessing the feasibility and cost benefits of management options*			• Utilisation of existing modelling of distribution patterns of target animal pest species, linked to development of appropriately scaled management responses and BMP.
IV.	*Setting and reviewing targets (RCTs and MATs)*			
V.	*Planning for key management actions*	**L_3 MAT V.1**	A regional policy, planning and information framework will be developed by 2007 to ensure that regional responses are coordinated with state and national pest and disease strategies.	• Facilitation of the development of coordinated management plans between all land users at the local community level for implementation of BMP.
VI.	*Building capacity for implementation*	**L_3 MAT VI.1**	By 2008, 80% of land managers have knowledge of the impacts and management of priority plant pest species. Note: Surrogate measures will include the uptake of actions for control such as specific herbicide usage rates (e.g. targeted at woody plant species), attendance at field days, and through representative group surveys.	• Awareness campaign for land managers targeting the environmental and economic impacts of animal pests. • Awareness campaign for land managers targeting identification of priority plant pest species (environmental and economic).
		L_3 MAT VI.1	By 2009, the extent of rabbits, cats, dogs and foxes, their economic and environmental impacts and management options will be understood by 80% of land managers. Note: Surrogate measures will include the uptake of actions for control, such as 1080 poison usage, attendance at field days and targeted group surveys.	
VII.	*Investment in implementation*			
VIII.	*Monitoring, evaluation and review*	**L_3 MAT VIII.1**	Establishment of a regional M&E plan with links to State M&E structures by 2005.	

Avon Catchment Council community workshop

4.4 Biodiversity conservation

Developing a biodiversity conservation strategy for such a degraded natural environment as the Avon River Basin is a major challenge. There is however, no doubt that it is achievable. The first step in the process is to be clear about exactly what is to be achieved and how it is to be achieved. For this Strategy, these two broad objectives are articulated in the form of an aspirational goal that will guide the conservation efforts of the Strategy into the foreseeable future. This goal is:

> *to retain, restore and enhance the Avon Region's natural biodiversity in ways that are consistent with the core values and sustainability goals of the Region.*

The 'what' aspect of the aspirational goal focuses on retaining as much of the region's remaining biodiversity as is feasible; restoring as much of what has been lost as possible; and enhancing the natural environment to ensure the continued persistence of what is retained and restored. The 'how' component of the goal recognises that the success of the Strategy relies on its consistency with the things that are most important to those it seeks to engage. In the Avon River Basin, these issues primarily relate to the core values of the community and sustainable regional development.

The scope of the work required to achieve the aspirational goal is based partly on how the Strategy defines biodiversity (this clarifies what will and will not be included in the retention, restoration and enhancements efforts), and partly on the current condition and continuing threats to the region's biodiversity.

In a strict scientific sense, 'biodiversity' refers to 'the variety of all life forms: the different plants, animals and micro-organisms, and their genes.' However, as the term has come into more widespread use, particularly in relation to Natural Resource Management, its definition has broadened considerably and, for the purposes of this Strategy, is:

> *all native species in their historic diversity and their natural interactions with each other and the physical environments of which they are a part.*

The two aspects of this definition most important to note are:

i) That it refers not only to the diversity of native flora and fauna but also to the plants and animals themselves; and

ii) that as well as native species, it also includes the physical environments they inhabit.

These variations have been made in recognition of the fact firstly, that native species have value in and of themselves and not just in terms of their diversity and secondly, that they do not exist in isolation from their habitat. Development of an effective conservation strategy requires this broader definition to ensure that all critical conservation aspects will be addressed.

4.4.1. A short history of the decline in the region's biodiversity

Prior to European settlement, native vegetation extended over 11.5 million hectares of the Avon River Basin's total area of 11.8 million hectares (the total area of the region less the area of salt lakes). This rich and diverse flora, together with the riverine systems, wetlands and salt lakes, supported a vast array of animal life, from the largest of the region's mammals, the red kangaroo, to the almost microscopic invertebrates inhabiting the many freshwater pools of the Avon River.

With European settlement, came the clearing of land, primarily for agriculture but also for towns and infrastructure. This clearing heralded the beginning of the loss of the region's biodiversity. Over the next one hundred and fifty years, 8.3 million hectares (70 per cent) of the region was selected for freehold agricultural use and systematically cleared of native vegetation. The first and most extensive clearing took place in the valley floors where the richest and most fertile soils occur. This was followed in time by clearing of the mid-slopes, then later, as the agricultural industry adapted to the landscape, the more sandy-textured soils.

The only native vegetation in the agricultural area left relatively intact is in areas of low agricultural productivity, including areas of shallow soils, rock outcrops, and wodjil (acidic sandplain) soils. These constitute only 1.1 million hectares (13.2 per cent) of the area selected for agriculture. The remaining 3.5 million hectares of the region that retains much of its original vegetation cover is in the more arid, eastern part of the basin not suitable for agriculture. This area is either pastoral lease (five leases occupying 7 per cent of this area), reserves, special leases or vacant Crown Land.

On a Shire-by-Shire basis, the proportion of original vegetation remaining varies considerably. The percentage remaining within the Wheatbelt and Avon Arc zones ranges from 81.5 per cent in the Shire of Yilgarn to a very low 2.4 per cent in the Shire of Cunderdin. Five Shires have less than 5 per cent native vegetation, while sixteen have 5-10 per cent and seven Shires have 10-20 per cent. Only Lake Grace and Toodyay Shires have more than 20 per cent remaining native vegetation on private land.

In 1990, further land release was prohibited under the *Environmental Protection Act1986* and clearing of land for agriculture has reduced considerably under the *Soil and Land Conservation Act 1945*. However, in spite of these measures, significant destruction of the region's biodiversity has taken place.

4.4.2 Biodiversity assets of the Avon River Basin

In spite of what has been lost, the Avon region, as part of the south-west of Western Australia, has international recognition as one of the world's 25 biodiversity 'hotspots.' Hotspots are areas where there is exceptionally rich native animal and plant life diversity and high endemism (i.e. animals and plants unique to a particular area). One of its six sub-regions, the Wheatbelt Interim Biogeographical Regions of Australia (IBRA), is also recognised as one of the 15 most important biodiversity hotspots in Australia.

One example of this exceptional species richness is the estimated 4000 plant species that have their home in the Avon region. This constitutes over half of the plant species of the entire south-west of Western Australia (Safstrom et al., 2000). In addition, of those that occur in the region, approximately 60 per cent are found nowhere else in the world. The Australian Terrestrial Biodiversity Assessment (ATBA, 2002) and the recent survey by Keighery and Lyons (2001) also show that the region is particularly rich in Acacia, Dryandra, Grevillia, Verticordia and Eucalypt species.

As well as the high degree of floral and genetic diversity and the high level of regional endemism, other distinctive features of natural biodiversity that are defining characteristics of the Avon River Basin include:

- A diverse range of reproductive systems adapted to the landscape. For example, some 15 per cent of wildflower species are pollinated by vertebrate animals;
- Relic species from Gondwanan times;
- Freshwater wetlands (west of the Meckering Line), salt lakes and gypsiferous dunes of which Lake Chinocup, Lake Magenta and Lake King are good examples;
- Species-rich low heathlands or 'kwongan' (an Aboriginal name for low heath-like vegetation);
- Striking granite outcrops associated with particular types of flora and fauna;
- A range of woodlands including wandoo, powder bark wandoo, gimlet, morrell, York gum and salmon gum).

Research suggests that these biodiversity features are of ancient origin, deriving from times when Australia was connected to Antarctica and South America as part of what is known as the Gondwanan land mass. In more detailed biogeographical terms, the region's biodiversity is dispersed across six relatively distinct sub-regions that have been classified on the basis of typical landforms, vegetation, geology and soils (see Map 8).

Where the region's biodiversity assets are located

As noted earlier, the wealth of the Avon River Basin's terrestrial biodiversity is not distributed evenly across the regional landscape but, in the main, is confined to relatively small pockets not cleared for agricultural purposes. These areas are in four major types of locations:

1. Reserves (CALM, DOLA and LGAs)

There are 463 conservation reserves in the region vested in the Conservation Commission of Western Australia and specifically set aside for nature conservation, with their habitat values fully protected under State legislation. Together, these cover a total area of 870 000 hectares.

There are 296 A-Class reserves (as categorised under the *Land Administration Act 1997*) in the region. These are reserved for various purposes aside from nature conservation including water and recreation. Many reserves are small and there are significant distances between them. Map 8 shows the distribution of reserves across the Avon River Basin.

2. Roadside and rail reserves

There are over 25 000 kilometres of road and rail reserves within the region. Although most of these contain developed roads and railway lines with fringing vegetation and have been fenced from stock access, a significant number have not been developed and some of these are used for agricultural purposes by adjacent landholders. Surveys undertaken on an LGA basis show that 100 of the Declared Rare Flora (DRF) in the Avon River Basin occur in roadside vegetation.

3. Privately owned land

As noted earlier, privately owned or managed land constitutes 74 per cent of the total area of the Avon River Basin, and although much of this is used for agricultural purposes there are estimated to be approximately 50 000 areas of native vegetation on these private landholdings. While most of these are relatively small (57 per cent of less than 20 hectares in size), together they constitute 491 000 hectares or 17.5 per cent of the total remaining native vegetation on private land in Western Australia.

Map 8 IBRA sub-regions and reserves within the Avon River Basin

4. Crown/Pastoral zone (which includes some of the reserves)

This zone occupies 3.5 million hectares or almost 30 per cent of the Avon River Basin and contains more than 75 per cent of the total area of remaining native vegetation in the basin, including 41 documented Vegetation Associations. The area includes five pastoral leases (Bronte, Carrinta, Ennuin, Golden Valley and Kawana) that together cover seven per cent (244 167 hectares) of the zone. The remaining 93 per cent is predominantly unallocated Crown Land (UCL) but also includes conservation reserves and leases, vacant Crown Land and other land tenures that cover the 401 mining leases.

4.4.2.1 A snapshot of the current condition of the region's biodiversity assets

With the decline in native vegetation there has been significant loss and endangering of the region's biodiversity assets. Five flora species are now extinct, 71 species are endangered and over 450 species of vascular plants are at risk from rising water tables. There are 121 Declared Rare Flora (DRF) and 234 Priority Flora (52 Priority 1, 82 Priority 2, 54 Priority 3 and 47 Priority 4) in the region.

Two mammal species are now extinct (twelve are lost to the region) and a further two are endangered. At least three bird species are also now endangered and many of those remaining have a high level of species contraction in their range of occurrence.

Wetlands are also being negatively impacted by altered catchment water balance as a result of native vegetation clearing. As groundwater rises, discharge through beds of wetlands is likely to increase. This, together with the increase in surface water runoff, has very damaging effects on the fragile ecological processes of aquatic ecosystems.

Thirty-four per cent of ecosystems are threatened and the threatened species that are a part of these ecosystems are declining further.

4.4.3 Strategic context for biodiversity conservation in the Avon River Basin

In the face of such large-scale degradation of the natural environment, the task of biodiversity conservation in the Avon River Basin is clearly substantial. Although the chief causal factor in the destruction of the region's biodiversity assets, over-clearing of native vegetation, has been halted, its legacies, in the form of widespread threatening processes such as salinity and waterlogging, are escalating.

Conservation efforts to date have been restricted by a lack of the resources needed (e.g. money, people, knowledge) to make an effective conservation impact, particularly as the remaining biodiversity assets are scattered throughout the region in relatively small, fragmented pockets. These difficulties have been compounded by the lack of a clear, and unified goal among the many groups and organisations working at various levels on different aspects of the conservation effort.

It has become clear that the next key step in increasing the effectiveness of on-ground conservation outcomes in the Avon River Basin is a more unified regional approach that draws together scientific and operational management expertise from government and non-government organisations with local community wisdom and knowledge.

It is this integrated regional approach that underpins the national strategic direction for Natural Resource Management and is the context in which the Australian and State Governments are seeking expanded opportunities for investment in biodiversity conservation. While this approach recognises the importance of consolidating conservation reserves, it also aims to increase regional-scale conservation outcomes by advancing conservation effectiveness in the remainder of the regional landscape, the majority of which is privately owned or managed (Commonwealth of Australia, 1996).

Within the above context, the two clear national strategic directions for biodiversity conservation are:

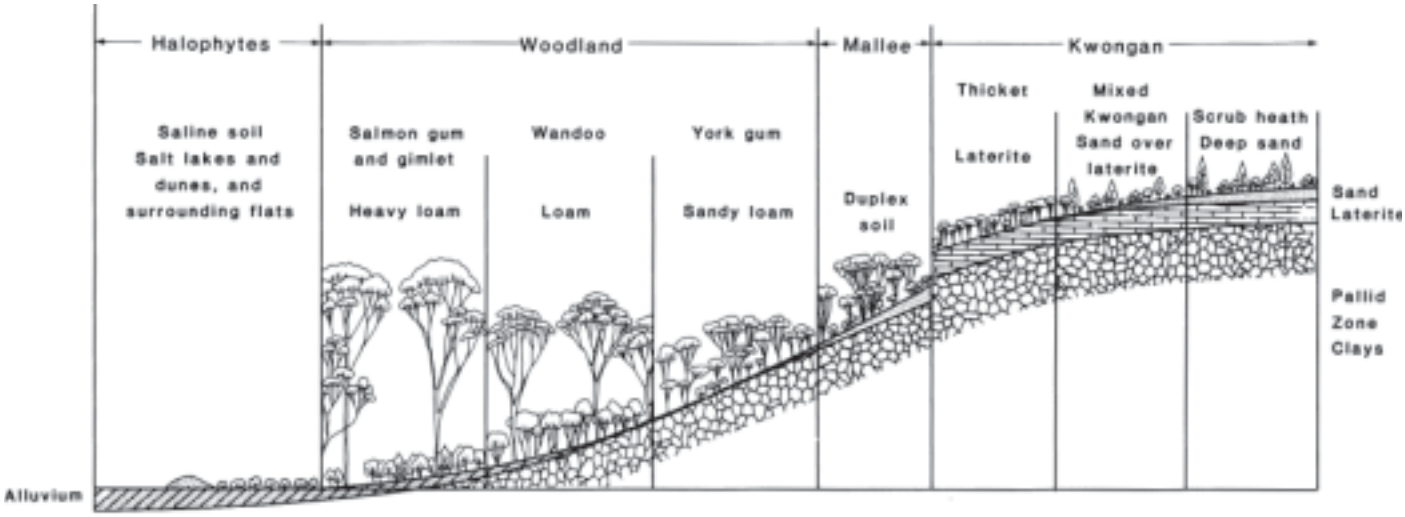
1. Prevention – includes actions related to addressing the causes of major threatening processes to **retain** existing biodiversity assets;

2. Recovery – includes actions that **restore** biodiversity assets in viable numbers and distributions across the regional landscape.

4.4.3.1 Strategic linkages with the region's biodiversity conservation strategy

In developing the biodiversity section of the NRM strategy, the ACC recognises the value of the national strategic perspective outlined above in achieving successful biodiversity conservation outcomes. In addition, it also recognises the importance of other major national and state policies and relevant legislative frameworks (see Appendix 1) in building an effective management framework for biodiversity conservation in the region.

The three predominant elements of the conservation section of the NRM strategy developed for the Avon region, retention, restoration and enhancement, are highly consistent with major national and state strategic guidelines.



Beard (1990)

Figure 8 A natural vegetation association with soils and landform in the Avon River Basin

The specific mechanisms developed to deliver these conservation outcomes, which emphasise 'community/ agency knowledge partnering' and 'private landholder involvement' also reflect national and state strategic guidelines and in addition, are highly consistent with the core values and sustainability goals of the regional community. However, before detailing these mechanisms, it is important to outline the way in which biodiversity assets have been classified and how the conservation priorities of the Strategy have been determined.

4.4.4 Classification of the region's biodiversity assets

Given the above strategic context, there are two major purposes for grouping the region's biodiversity assets into distinct classes. First, it provides the basis for systematic assessment of the various conservation needs and most appropriate intervention options for different types of assets and, second, it provides a sound foundation for the difficult but necessary task of determining conservation priorities. However, in order for these aims to be achieved in ways that are compatible with the overall biodiversity goal for the region, the classification system also needs to demonstrate ecological and strategic integrity. Using these criteria, the classification system developed for the biodiversity section includes the following features:

- It incorporates **all** biodiversity assets irrespective of priority status;
- It is based primarily on **natural** rather than management processes;
- It focuses on **what** is to be conserved irrespective of where it is located.

The catenary sequence shown below is a useful explanatory concept to clarify the underlying ecological foundation for the classification system. A catenary sequence is essentially a way of describing a natural environment in terms of the associations between particular types of flora and the characteristic physical aspects of the ridge-to-ridge landscape they inhabit, i.e. soil, landform and drainage characteristics.

The catenary sequence concept was modified for the current purposes to also include the fauna typically found in a given ridge-to-ridge section of the landscape (Figure 8). It can be seen from the 'sequence' that although the various classes have an element of natural aggregation, they first and foremost define distinct biodiversity entities, each of which is a unique part, in its own right, of the overall biodiversity of the region.

4.4.4.1 Asset Class 1: Native Species

The Native Species Asset Class is defined as 'all naturally occurring flora and fauna species of the region.' These include the myriad plant and animal life that inhabits the Avon River Basin. While some species such as raspberry jam (*Acacia acuminata*) are fairly abundant others, such as Carnaby's cockatoo are relatively few in number and seriously at risk.

As well as the 4000 plant species noted earlier, a study compiled by Safstrom et al. (2000) examining terrestrial biodiversity in the region has identified the following native species:

- 62 species of mammals
- 203 species of birds (including 55 species of water birds)
- 16 species of frogs

- 110 species of reptiles
- 10 species of fish
- An unknown number of invertebrate species. The region's wetlands are significant here with over 560 invertebrates identified during recent biological surveys. 45 of these are restricted to fresh water.

Another recently completed biological survey by CALM and the Museum of Western Australia (Keighery and Lyons, 2001) shows the Wheatbelt sub-regions to be more diverse in their range of species than first thought. For example, 329 species of spiders were identified when only 128 species had been previously recorded.

Condition of the region's native species assets

The condition of native species throughout the region is linked fairly closely to where they are located. Predictably, those situated in areas where the impacts from threatening processes are greatest, such as in valley floors, are the most severely compromised.

For example, the Keighery and Lyons (2001) survey, which focused on the risk of rising water tables, shows there has already been a significant depletion of genetic diversity and a decrease in the abundance of vascular plants. Of the 4000 species they identified, 1500 are located in valley floors and are vulnerable to rising water tables. In addition, with the current trends in salinisation of wetlands, the number of water bird species across the wheatbelt is expected to fall from the current 40 species (of the 60 species that occurred before European settlement) down to just 16.

Because there are state (*State Wildlife Conservation Act 1950*) and national (*Environmental Protection and Biodiversity Conservation Act 1999*) statutory obligations for management of threatened species, there is good information available on species at the highest levels of risk. The following is a summary of those species identified at a state and national level.

Threatened species

Below are the internationally recognised IUCN Red Book categories for assigning rankings to threatened species:

- Extinct (presumed)
- Extinct in the wild
- Critically endangered
- Endangered
- Vulnerable
- Conservation dependent
- Lower risk

Flora

The WA Threatened Flora (WATF) species within the Avon River Basin identified as threatened under the *State Wildlife Conservation Act 1950* are as follows:

Threatened Flora		111 species
Priority 1	few, poorly known populations on threatened lands	47 species
Priority 2	few, poorly known populations on conserved lands or taxa with several, poorly known populations not on conserved lands	71 species
Priority 3	several, poorly known populations, some on conserved lands	33 species
Priority 4	in need of monitoring	36 species

The national EPBC listing for threatened flora species in the region are as follows:

Extinct	5 species
Critically endangered	0 species
Endangered	71 species
Vulnerable	23 species

Fauna

Birds

The state listing for bird species that are threatened or otherwise of significance is as follows:

Threatened	5 species
Otherwise specially protected	2 species
Priority 2	2 species
Priority 3	3 species
Priority 4	9 species

The national EPBC listing for threatened bird species is as follows:

Extinct	0 species
Critically endangered	0 species
Endangered	3 species
Vulnerable	7 species

Mammals

The state listing for mammal species that are threatened or otherwise of significance is as follows:

Threatened	5 species
Priority 4	7 species

The national EPBC listing for threatened mammal species is as follows:

Extinct	2 species

with a further 12 lost to the region but occurring elsewhere

Critically endangered	1 species
Endangered	1 species
Vulnerable	4 species

Reptiles and frogs

The state list for reptiles and frogs that are endangered or otherwise of significance is as follows:

Threatened	1 species
Otherwise specially protected	1 species
Priority 1	5 species
Priority 3	1 species

Invertebrates

Although there are no invertebrate species designated as threatened in the national listing, four threatened invertebrate species have been specially protected under the state's *Wildlife Conservation Act 1950* and seven have been listed as priority species. Many of these (some of which are aquatic) survive precariously in small remnants of native vegetation or wetlands where they may continue provided their habitats are not further degraded or totally destroyed by fire or salinity. Many of these invertebrates are ancient relics from Gondwanan times.

Freshwater fish (and other aquatic fauna)

Although there are no species of freshwater fish identified as threatened under either state or national conservation Acts, they have been severely affected by landscape change and some are considered to have a significantly reduced range within the region. To date however, there has been no comprehensive survey of fish or other aquatic fauna in the region.

Although remaining populations of some species (e.g. western galaxid, hardyhead and cobbler) in river pools of the Avon River may be further threatened by sedimentation and salinity, it is thought that there may still be healthy populations of freshwater fish in some waterways (e.g. the Dale River and Toodyay Brook).

Other aquatic fauna considered significantly at risk but not threatened include the oblong tortoise, the water rat (Rakali), and macro-invertebrates such as the freshwater crayfish (gilgies and koonacs).

4.4.4.2 Asset Class 2: Natural Ecological Communities

The natural ecological communities asset class is defined as 'groups of native species co-existing in characteristic assemblages.' The region contains a wide variety of distinctive ecological communities. Even within a particular type of ecosystem, there can be striking contrasts in the typically occurring ecological communities. For example, some salmon gum woodlands contain communities mainly comprising saltbush, samphire and pigface, while others consist of a range of grasses and herbaceous plants.

Condition of the region's ecological communities

Threatened ecological communities

There are 10 threatened ecological communities (TECs) In the Avon River Basin. One of these, the *Muehlenbeckia horrida* dominant community in Lake Bryde and associated wetlands, is 'critically endangered.' Five others are 'endangered' and four are designated as 'vulnerable'.

4.4.4.3 Asset Class 3: Ecosystems

The Ecosystem Asset Class is defined as 'discrete sets of ecological communities and their interaction with the distinctive physical environments they inhabit.' These include aquatic and terrestrial ecosystems as well as granite outcrops and laterite breakaways.

Aquatic ecosystems

The aquatic ecosystems of the region comprise fresh and saline wetlands and salt lakes. Although most of the freshwater wetlands of the region are located in the Avon Arc zone there are also several significant fresh wetlands in the Wheatbelt and Rangelands areas.

Among the region's fresh and saline wetland ecosystems are a number that are of national or sub-regional significance as designated by *The Directory of Important Wetlands in Australia* (Environment Australia, 2001) (see the Water Resources Supporting Document for further details). These wetlands include:

- Cowcowing Lakes
- Lake Bryde – East Lake Bryde
- Yealering Lakes
- Yorkrakine Rock Pools
- Lake Cronin
- Lake Grace System
- Avon River Valley (from Walyunga to Toodyay).

In addition to those listed above, a large number of other wetlands throughout the region have been identified as important (see listings in the Water Resources Supporting Document). It is expected that in the future, some of these will be added to the list of national and state priority assets as being of regional significance (Department of Environment, 2003).

There are extensive 'chains' of salt lakes in the Avon River Basin, one of which, the Lake Grace system, is of national significance. Altogether, these lakes occupy an area of

Map 9 Major salt lake and associated natural drainage systems of the Avon River Basin

264 825 hectares (2.24 per cent of the region) and although they are a very familiar feature of the region, particularly in the Yilgarn and Lockhart catchments, their hydrological and ecological processes are not well understood.

These processes are currently being investigated through a number of ecological and landform surveys of Lake Ardath, Lakelands Nature Reserve (including Lake Bryde and East Lake Bryde), Lake Campion, Lake Hinds, Lake Mears, Lake Ninan, Wallambin North nature reserve and some of the Yenyenning Lakes system.

Current knowledge indicates that the lakes are of varying sizes and depths and, although most are highly saline, some of the smaller lakes are formed by freshwater soaks, springs and streams usually associated with extensive sandplain soils (e.g. Maitlands Swamp).

Because in most years evaporation exceeds inflow, they are mostly internally draining with no flow between the lakes occurring. However, in wet years or above-average rainfall periods, the lakes will fill and overflow. Some lakes have been altered by road crossings or drains into the lakes, or by re-routing natural drainage channels. Map 9 shows the major salt lakes and associated natural drainage systems of the Avon River Basin.

Condition of the region's aquatic ecosystems

There are eleven wetlands in the Avon River Basin monitored for water quality and with ecological indices (Halse et al., 1993). Of these, the Lake Bryde wetlands are identified as state priority freshwater assets and are included in the State Salinity Strategy (2000) as a natural diversity recovery catchment due to the threat from salinity and inundation caused by high water tables.

Because so little is known of the natural ecology of the region's salt lakes, it is difficult to know if, and by how much, these processes may have been affected by major threats such as salinity and raised water tables. This in turn makes it difficult to state, with any degree of certainty, the current condition of the region's salt lakes. There is however, a significant research project planned (J. Davis, Murdoch Univ., pers. comm.) that will provide some of the answers. Specifically, the research aims to determine:

- The current ecological state (i.e. macrophytes and benthic microbes of playas, wetlands and channels);
- Seasonal impacts of high and low water, and other environmental parameters (salinity, pH, metals and nutrients);
- The impact on receiving waters of inflows of low pH and/or high iron groundwater;
- Nutrient retention capacity;
- Thresholds of salinity, nutrients and pH.

Work by Keighery and Lyons (2001) has identified 64 priority or threatened taxa in the naturally saline ecosystems of the region. It was also noted in this particular study that, although aquatic invertebrates in the freshwater ecosystems have a higher salinity tolerance than the same species in other locations, they are at serious risk with increasing levels of salinity, such that a species richness of 50 at less than 3000 mg/L is halved at 20 000 mg/L and halved again at 50 000 mg/L.

There are no wetlands listed under the international Convention on Wetlands (known as the Ramsar Convention) or other agreements in the Avon River Basin.

Terrestrial ecosystems

Although not ecosystems in the strict ecological sense of the term, the two most striking landform features that characterise the region, granite outcrops and laterite breakaways, have been included in this class in recognition of the unique biodiversity and flora-fauna interactions they support. Further information on these ecosystems is included in the study by Safstrom et al. *(*2000).

Hopkins et al. (1996) have determined that 99 of the vegetation association ecosystems that existed in Western Australia prior to European settlement are located in the Avon River Basin. Of these, 34 occur exclusively in the Avon region while 47 have approximately 75 per cent of their state-wide occurrences in the region. Some of the most characteristic of these ecosystems in the region are salmon gum, wandoo and York gum woodlands.

Condition of the region's terrestrial ecosystems

Table 35 shows the condition of the Avon region's vegetation association ecosystems within each IBRA region in terms of how much of the original extent of each remains. Only 3 of the 73 vegetation association ecosystems in the Avon Wheatbelt IBRA region have more that 75 per cent of their original extent remaining. Forty-one have less than 15 per cent and 29 have less than 10 per cent of their extent remaining. As would be expected, the Coolgardie IBRA region (which includes most of the Crown/Pastoral zone not cleared for agriculture) has 41 of its 43 association ecosystems with more than 75 per cent of their original extent remaining.

In addition to the destructive impacts of past land clearing on the region's ecosystems, there is concern about the accelerating spread of dieback (*Phytophthora* spp.). Also of concern is the declining health of wandoo woodlands (*Eucalyptus wandoo* and *E. accedens*), the causes of which are as yet unknown. The Wandoo Decline Reference Group has been formed to address community concern about the latter issues.

Table 35 The extent to which vegetation associations are currently represented within IBRA regions of the Avon River Basin

IBRA region (total number of vegetation associations)[1]	Number of vegetation associations with current extent > 75% in the IBRA region	Number of vegetation associations with current extent < 10% in the IBRA region	Number of vegetation associations with current extent < 15% in the IBRA region
AW (73)	3	29	41
COO (43)	41	1	1
ESP (3)	1	0	0
MAL (45)	6	13	18
JF (16)	5	1	1

1. Note: some vegetation associations occur in more than one IBRA region.

4.4.4.4 Asset Class 4: Ecoscapes/Landscapes

The ecoscape asset class is defined as 'the mosaic of ecosystems that span the topography from one ridge in the landscape to the next.' Although the term 'landscape' is often used to define this biodiversity entity, the term ecoscape is preferred as it avoids confusion with the general meaning of landscape which relates more to landform than to the plant and animal life that interacts with it. In general terms, the scale of a given ecoscape is a function of the size necessary to carry out the unique interactive processes between a specific natural environment and the native species that typically inhabit it. However, local research suggests that many of the interactive patterns that constitute the most characteristic terrestrial ecoscapes of the Avon region occur over a scale of about 10 000 hectares (i.e. the typical ridge-to-ridge catenary sequence). Aquatic ecoscapes include the major waterways and natural drainage systems of the region.

Terrestrial ecoscapes

As a part of the Salinity Investment Framework (SIF), a range of characteristic regional ecoscapes (referred to in the SIF as 'representative landscapes') have been identified and mapped using spatial criteria (Wallace et al., 2002b). Although these areas range widely in size and condition, they all share the potential for the type of high level ecological functioning that justifies their inclusion as ecoscapes as defined in this Strategy.

Condition of the region's terrestrial ecoscapes

Other than in the Crown/Pastoral zone, the majority of terrestrial ecoscapes in the region are severely compromised; most with little of their original representative diversity remaining intact. This level of degradation does not allow for the high level of ecological processes required for optimal functioning such as local migration routes or corridors for birds and other animals.

The Lake Bryde Wetlands Complex and Drummonds Reserve (referred to in other conservation initiatives as Natural Diversity Recovery Catchments) are two such ecoscapes whose condition is very poor. The condition of a further eight ecoscape recovery catchments has been identified as critical.

Aquatic ecoscapes

While the extent and condition of the vegetation component of the Avon River ecoscape and a number of its tributaries is well documented (see list below), there is little known about the ecological functioning of some of its major tributaries, for example the Lockhart and Yilgarn rivers, or the very extensive smaller-order creeks. However, two aquatic ecoscapes, the North Mortlock River and the Avon River from the town of Toodyay to Walynga, are identified as being of national significance.

North Mortlock (to Lake Ninan)
Mortlock East
Mortlock South
Toodyay Brook
Spencers Brook (to Clackline)
Talbot Brook
Mackie River

Condition of the region's aquatic ecoscapes

A systematic survey of the channel and foreshore of the Avon River from Yenyenning Lakes to the Avon Valley National Park, a distance of 191 km, together with other surveys of the extensive river pools, provides detailed information about the condition of the riverine ecoscape, threatening processes and management needs (Jim Davies and Ecoscape Pty Ltd, 1997).

The Avon River originally had twenty-six major pools, some being over 10 m deep. However, survey findings indicate that only one pool, Wilberforce, is still in near pristine condition with only limited sediment infill. Six pools are almost filled with sediment and a further seven are totally filled with sediment (see list below). All pools are subject to eutrophication due to nutrient enrichment.

Mile Pool
Egoline Pool
Muresk Pool
Deepdale Pool
Cold Harbour Pool
Mt Hardy Pool
Burlong Pool

There are six pools that are almost filled with sediment:

Speldhurst Pool
Tipperary Pool
Yangedine Pool
Katrine Pool
Oakover Pool
Jimperding Pool

Because river pools are such significant wildlife refuges during summer and drought, their deterioration has major negative consequences for fauna species in the region.

4.4.4.5 Asset Class 5: Whole of Basin

It is noted that from an ecological perspective, this asset class is less rigorous than the previous four. However, its inclusion is based on the understanding that the variations in biodiversity patterns that occur within the region are, in general, smaller than the patterns between this region and other surrounding regions. Moreover, in terms of conservation needs and options arising from widespread threatening processes such as salinity, it constitutes a discrete and homogeneous biodiversity entity.

The asset classes and their definitions as outlined above, represent our best current knowledge of the region's biodiversity. However, it is important to recognise that many of the biological and ecologic processes that underpin the classes and their definitions are highly sophisticated and not yet well understood. It is therefore expected that as our knowledge evolves, refinements will need to be made. In addition, as knowledge increases about the condition and threatening processes impacting the region's biodiversity, so too will the quality of information used to determine conservation needs and priorities of the different asset classes.

4.4.5 Continuing threats to the region's biodiversity

An analysis of threats to biodiversity in the broader Wheatbelt region of Western Australia, of which the Avon region is the major part, has been undertaken primarily for terrestrial assets within a 50-year timeframe (Wallace et al., 2003b). Their analysis suggests that the most serious threats, in terms of species extinction, to the region's biodiversity are related to altered biogeochemical processes (as a result of high water tables, salinity and altered hydro-periods), insufficient ecological resources to maintain viable populations (due primarily to habitat loss and fragmentation) and detrimental regimes of physical disturbance. These factors, together with other serious issues such as declining water quality and sedimentation, pests and diseases and competing land use, have the most detrimental impacts across all biodiversity asset classes.

Table 36 Estimated mean annual data for Avon Basin

River	Area (km^2)	Clearing (%)	Flow[2] (ML/a)	Salinity[3] (mg/L TDS)	Salt Load[4] (kt TDS)
Lockhart River	32 400	85	7 900	29 700	230
Yilgarn River	55 900	85	6 400	20 500	130
Outflow Yenyenning Lakes	91 500	70	11 300	***Unknown***	
Mortlock Rivers	16 800	85	42 000	12 000	500
Avon River (Northam)	99 600	85	145 000	5 900	850
Swan River (GNH1)	120 700	65	360 000	5 200	1 900

Notes: 1 – Great Northern Highway.
2 – Mean annual flow.
3 – Mean flow weighted stream salinity.
4 – Mean annual salt load.

Department of Environment (2004)

High water tables

High water tables, with their resulting problems of dry land salinity and associated waterlogging and inundation, are major threats to biodiversity in the Avon River Basin. Although the extent of current high water table impacts has been estimated for the South West Land Division of WA, including estimates of the potential full extent of impact (the Land Monitor Project using satellite imagery and aerial photography), this spatial information is yet to be applied to all biodiversity assets in the Avon region to assess those at greatest risk.

We do however know that the effects of high water tables are continuing to increase in the Avon River Basin. Some local landscapes are already very extensively affected by salinity and waterlogging. Not surprisingly, the impact is greatest in the valley floors but some low and mid-slope landscape positions have also become seriously affected. It is predicted that this increase in impact will continue for 50-100 years before a new catchment water balance is achieved, however this predicted timing could vary considerably depending on other landscape factors.

Estimates show that of the 7.4 million hectares used for agriculture in the Avon River Basin, 388 000 hectares (5.3%) is presently saline, and a further 2 million hectares (27.4%) is at risk of salinity in the future (Land Monitor, 2002). Long-term trends indicate that groundwater rise in the Central Wheatbelt is expected to be at a rate of 15 to 25 mm per year, although it needs to be remembered that shallow groundwater rises and falls to some extent with the seasonal rainfall patterns.

Table 36 shows the stream flows and salt loads contributing to the Avon River. It is evident from these data that the Lockhart and Yilgarn rivers contribute only 230 000 and 130 000 tonnes respectively of the average salt load discharged to the Swan River, whereas the average annual salt load discharged from the Avon River is 1 900 000 tonnes.

While it is recognised that rising saline water tables are a threat to the Avon River and major tributaries, the tolerance of salt lake ecosystems and river pools to increasing levels of salinity is not well known. Increasing salinity does however appear to be a cause of significant ecological community simplification in riparian vegetation of the Avon River channel. The salt-tolerant she-oak (*Casuarina obesa*) has begun to dominate the less tolerant flooded gum (*Eucalyptus rudis*) and swamp paperbark (*Melaleuca raphiophylla*). The extent to which this is occurring is not well established.

Altered hydro-period

Altered catchment hydrology, primarily as a result of increased surface water runoff, affects the hydro-period of wetlands and waterways (i.e. the length of time they remain inundated). Surface water runoff from catchments with high agricultural land use has increased significantly since clearing. Some estimates suggest that in certain locations the rate has doubled. The rate is expected to increase further in some areas as rising water tables saturate surface soils. However, local information suggests that the rates of runoff in some areas have reduced with adoption of minimum tillage cropping practices.

Discharge water from drainage and groundwater pumping for salinity control also has the potential to alter the hydro-period of receiving water bodies. Large engineering works that discharge to small water bodies are likely to be the greatest risk. There is however, only limited information about the extent to which these works will discharge additional water and about the physical capacity of water bodies to receive such additional discharge. Current research projects, including a regional assessment of drainage opportunities (undertaken by CSIRO Land & Water) and assessment of some salt lakes (undertaken by CALM) will provide useful information.

In terms of impact on the condition of the region's biodiversity, it is suggested that longer or shorter periods of inundation may affect the structure and function of aquatic ecosystems. Similarly, increased depths of inundation may also have an impact. The tolerance and resilience of aquatic ecosystems in the Avon River Basin to altered hydro-periods is not well understood and is an area where further significant research is required. Information from studies of Lake Bryde, where a threatened ecological community is at risk due to altered catchment hydrology, will provide direction for the research required.

Habitat loss and fragmentation

The clearing of native vegetation has caused significant habitat loss and fragmentation of the landscape. The extent of remaining vegetation cover on public and private land, including the Crown/Pastoral zone, is 39.3 per cent of the region. Of the 8.3 million hectares of land allocated for agricultural use, only 13.2 per cent has retained its original natural vegetation cover; 7.5 per cent is in reserves and 5.7 per cent is in mostly small patches on private land.

As was noted earlier, the amount of native vegetation remaining, and consequently the extent of habitat loss, varies considerably from Shire to Shire. The main destructive impact of habitat fragmentation is that it leads to sub-viable species populations and ecological communities as the result of diminishing survival resources. This, in turn, leads to loss of species diversity or vegetation structural diversity.

Although the rate of clearing has been substantially reduced, further fragmentation and vegetation condition decline is occurring due to a range of other causes including

overgrazing (both domestic and native species), salinity, waterlogging, fire, fertiliser and pesticide use. Firewood harvesting is not a significant cause of habitat loss within the region.

Spatial analysis of the Avon River Basin has been undertaken as a part of the Salinity Investment Framework (SIF) developed by the State NRM Council (Wallace et al., 2003a) to identify areas of least habitat loss and fragmentation. This assessment has identified a number of areas in the region greater than 10 000 hectares in size (the most characteristic size for ecoscapes in the Avon region) that still have 25 per cent habitat remaining. Although these areas have not been examined, it is expected that they will contain a high number of rare species and ecological communities.

Declining water quality

Increasing salinity is the primary cause of reduced water quality in the region. The extent to which this affects aquatic and other biodiversity assets is uncertain. As noted earlier, it is understood that the species-richness of fresh wetland ecosystems (with a salt concentration of < 3000 mg/L) is likely to be seriously impacted by increasing levels of salinity.

Water quality decline due to nutrient enrichment is another threat to biodiversity. High levels of nutrients, particularly phosphates, cause increased biological activity in water bodies commonly leading to substantial algal growth. Algal blooms de-oxygenate water bodies and may cause eutrophication. These processes are significant in pools of the Avon River.

While the most significant sources of nutrients are diffuse, there are some potential point source contributors, including wastewater treatment plants and intensive animal industries. These have been identified in the Avon River Basin by Ryan and Cobb (1999). The total annual point source contribution from four sites (wastewater treatment plants) of nitrogen (N) and phosphorus (P) are 12.7 and 1.2 tonnes per year, respectively (D.A. Lord & Associates, 2001).

Increasing acidity is a further potential water quality threat to aquatic biodiversity assets. However, the extent to which acidic groundwater occurs within the region and the potential for impact on aquatic ecosystems is not well known. Groundwater discharging from regional aquifers is generally highly acidic (pH may be less than 3) and it is therefore suggested that discharge from rising groundwater is likely to have an increasingly negative impact on wetlands and waterways, with the proportion of acidic groundwater discharged into water bodies expected to increase over time. In addition, there is concern that drainage for salinity control may discharge additional acidic groundwater into receiving water bodies.

Another cause of declining water quality in the region is that of suspended sediments (i.e. turbidity) in stream flows and ponded water. The amount of suspended sediment has increased due to increased surface runoff and associated erosion processes, and also because of the reduced filtering capacity of waterways and wetlands. Increased turbidity of water in lakes, wetlands and river pools has damaging impacts on benthic organisms due to reduced light availability. Fine sediments are also a major pathway for nutrient transport which has an additional destructive impact on aquatic organisms.

Sedimentation

The repeated flooding of riverside towns in the region (Beverley, York, Northam and Toodyay) and of agricultural land along the river during the 1950s was the principal concern that led to the River Training Scheme, a major engineering initiative that increased stream flow velocity in the river channel. The higher velocity eroded the river bed channel and transported coarse sediments into river pools. The damaging results of this erosion and sediment transport on the many river pools of the Avon were highlighted earlier. These processes of sedimentation within the river channel are continuing.

Weeds, animal pests and diseases

Introduced and native animal and weed species threaten all biodiversity assets in the region. Altered soil nutrient levels as a result of fertilisation of surrounding agricultural land or domestic stock access provide the conditions for weeds to out-compete native flora species in terrestrial and aquatic ecosystems. For example, spiny rush (*Juncus acutus*) is an introduced plant that has become dominant in many small waterways in the Avon Arc and is increasing significantly in the Avon River channel.

Foxes and cats are introduced predatory animal pests that can have a significant destructive impact on native fauna, while the explosion in native parrot numbers, primarily as a result of improved food resources from agricultural crops, can be damaging to trees and shrubs.

As noted earlier, the effect of disease on terrestrial ecosystems is of increasing concern. The significant decline in the health of wandoo woodlands noted in recent years may be the result of a specific disease affecting only wandoos or may be attributable to other broader health factors of ecosystem as a whole. The other major disease concern for the region's flora, the soil-borne dieback fungus (*Phytophthora* spp.), may be more prevalent than is currently understood.

Table 37 lists some of the weeds, animals and diseases that are considered to threaten biodiversity assets within the Avon River Basin. The extent to which these are a threat is not well known.

Table 37 Regional weeds, animal and disease threats to biodiversity

Weeds	Animal pest	Disease
Bridal creeper	Cats	Jarrah dieback (*Phytophthora* spp.)
Saffron thistle	Foxes	*Armillaria* spp.
Cape tulip	Dogs	
Introduced grasses	Rabbits	
Spiny rush	Native parrots	
Olives, boxthorn	Exotic birds	

Competing land use

Historically, the clearing of natural vegetation for agricultural use, urban growth or industrial development was the most significant competing land use to negatively impact on the region's biodiversity. However, while land clearing is no longer occurring in a significant way within the region, there are other impacts due to competing land use practices of adjacent landholders. One that is of increasing concern is spray and fertiliser drift to areas of native vegetation from chemically dependent neighbouring farming enterprises.

Fire impact due to escape from high-yielding cereal crop stubble burns is common. This affects paddock trees, remnant bush, reserves, riparian vegetation and tree-plantings. The occurrence of damaging fire is also relatively high in the recreational farming areas of the Avon Arc.

Roadside vegetation clearing continues to be a contentious issue with local government removing natural vegetation in some areas for improved access, road works and road safety.

4.4.6 Managing fire in the Avon

Fire in the Avon is a complex phenomenon that presents ongoing management challenges to protect life and property as well as maintaining ecosystem function and biodiversity. If fire is to be controlled and used to meet natural diversity management objectives it needs to be approached and understood within an asset protection and ecological framework.

Fire in the Avon pre-dates the arrival of humans by millions of years (Churchill, 1968; Singh et al., 1981; Kershaw et al., 2002). The relatively recent arrival of Aboriginal people (probably within the last 60 000 years) would undoubtedly have led to dramatic changes in fire patterns and fire environment (Hallam, 1975; Kershaw, 1986; Pyne, 1991; Hassell and Dodson, 2003). Fire regimes in areas frequented by Aboriginals had a controlling effect on vegetation composition and structure, presumably evolving with the economic and ecological needs of the people (Hassell and Dodson, 2003). Some consider that fire intervals varied from 3-10 year intervals in forested areas with fire in drier inland country relatively rare, so that large areas were typically unburnt for many years (Abbott, 2003; Ward *et al*., 2001). For example in Tutanning Nature Reserve it appears that fires occurred every 40-50 years in the century prior to 1829, and were rarer before then (Hopkins, 1985).

With the clearing of land for agriculture fire frequency, fire intensity, scale of fire, season of burning and source of ignition have all changed. This has caused loss of plant and animal species due to fires too frequently (before fertile seeds are produced) or too infrequently (after plants have died). Small bushland areas make it hard to achieve mosaic burns and unplanned fires often burn the entire area. Large edge to area ratios make bushland patches prone to weed invasion, feral animals and nutrient enrichment. Isolation of bushland areas does not readily allow for recolonisation after fire and ecosystem processes are already disrupted.

Community expectations have meant that most effort in fire management has focused on protection of any area or asset from wildfire. Recently, however, people's attitudes to fire and approaches to fire management have started to change. In the fragmented landscape of the Avon the challenge is to devise and implement fire management that conserves biodiversity and affords an acceptable level of protection to human life and property values.

4.4.7 Determining conservation priorities

The issue of prioritising biodiversity assets for intervention and investment is potentially the most difficult and contentious part of developing any conservation strategy. The ACC has therefore expended particular effort on this part of the Strategy development process to ensure that the views of all stakeholders have been considered.

Extensive consultation with the general regional community and partnering organisations, together with reference to the raft of national and state conservation investment frameworks (see Appendix 1 for details), has produced a prioritisation process that contains the critical features of **transparency** and **reliability**. A range of criteria have been identified as pivotal to the determination of conservation priorities. These criteria and their associated descriptors (shown below) create a relatively objective priority assessment process that can be widely understood and applied by all stakeholders.

Priority Criteria	Descriptors
Endemism	regional or local
Iconic Value	international, national, state, regional, or local
Scarcity	abundant to rare
Distribution	widespread to confined

Integrity	fully integrated to highly fragmented
Condition	pristine to severely compromised
Level of Threat	none to severe

Endemism – The endemism criterion refers to the uniqueness of particular biodiversity assets at either a regional or local level.

Iconic Value – This criterion refers to the perceived value of certain biodiversity assets as enduring representational images of a given area. This value may be purely at a local level or may be more widely shared at a regional, state or even international level.

Scarcity – This criterion relates to the relative natural occurrence of particular assets within each asset class, irrespective of the impact of threatening processes.

Distribution – This refers to the spread of particular assets within each class across the region on a continuum from widespread to confined only to limited areas.

Integrity – This criterion refers to the degree and patterns of clearing and other man induced changes to the landscape in comparison to the original distribution of native vegetation.

Condition – This criterion refers to the current state of particular assets as a result of threatening processes on a continuum from being essentially in their original condition to very severely affected.

Level of Threat – This criterion refers to the relative degree of danger from identified threatening processes.

When the prioritisation criteria are applied to the region's biodiversity assets, some fairly clear patterns emerge both within and between the asset classes. Level of Threat is unquestionably the most compelling criterion on which to base conservation priorities for all biodiversity assets across the entire region. However, the degree to which threatening processes, whatever their level of severity, are likely to hamper achievement of the region's overall biodiversity conservation goal will be significantly mediated by the other factors included in the prioritisation criteria, and these factors are differentially related to the various asset classes.

Native Species

For native species, it is apparent that conservation priorities are primarily related to scarcity and distribution, while other applicable criteria assume a more subordinate role. Thus, while endemism and iconic value are important, these factors need to be considered within the more critical issues of the relative abundance of particular species and how widespread or confined is their current distribution.

Ecological Communities

For ecological communities, the issue of Condition becomes more pivotal to determining conservation priorities, as the degree to which the vital relationships that constitute ecological communities are compromised, significantly impacts on the viability of assets within this class.

Ecosystems

Determination of conservation priorities for the ecosystems of the region centres mostly on issues of Integrity and Condition as these are the primary criteria for optimal survival of these assets. Iconic Value is also of particular importance for this asset class in view of the importance placed on some of the most regionally distinctive ecosystems such as granite outcrops and laterite breakaways.

Ecoscapes

Major criteria for determining conservation priorities for the region's ecoscapes are also Integrity and Condition. However, given the massive degradation of the region's landscape and the scale of typical ecoscapes, the issue of Scarcity is also a key priority criterion.

Whole of Basin

When considered as a unique biodiversity entity as well as a geographical location, Level of Threat is the single most distinctive and significant criterion for determining conservation priorities for the Avon River Basin.

Developing a range of criteria to guide determination of conservation priorities in the region is not sufficient, on its own, to identify where and on what financial investment should be made. The information needed to assess investment priorities, whilst based on conservation priorities, also includes other factors such as the financial resources available, feasibility and the cost-return benefits of potential intervention actions. In addition, investment priorities for biodiversity conservation must be assessed in relation to the priorities of the three other themes of the overall Strategy for natural resource management in the Avon region.

4.4.7.1 Delivery mechanisms for the region's biodiversity conservation strategy

Almost as sensitive as the issue of prioritisation, is determination of the most appropriate and effective mechanisms to deliver the key conservation elements of retention, restoration and enhancement. Read (2003) has identified a range of 'critical success factors' in developing delivery mechanisms for biodiversity conservation. They include:

- Identifying measurable biodiversity conservation outcomes that recognise:
  - Priorities according to international, national, state/territory, regional and local values
  - Response times for biodiversity recovery
  - The uncertainty of perpetual threat avoidance outcomes;
- The importance of ecosystem service values (see below);
- Planning at a landscape/ecoscape scale irrespective of land tenure;
- Appropriate application of information and knowledge, including:
  - National and Commonwealth information
  - State and regional information
  - Local information, skills and capacity;
- Adoption of a mix of market and non-market mechanisms for new practices related to biodiversity conservation;
- Recognising enterprising opportunities that may assist with regions achieving self-sufficiency for biodiversity conservation.

As well as these factors, there is widespread agreement on the part of major stakeholders that delivery mechanisms need to be based on the core values and sustainability goals of the regional community. The importance of these two underpinning principles is recognised by their inclusion in the overall aspirational goal for biodiversity conservation in the region.

Core values

As noted, the core values identified for the regional community centre around the physical, lifestyle and people attributes of the region. Physical attributes take in the entire landscape including land, water, biodiversity and built infrastructure (roads, rail, towns etc.), as well as the spiritual/cultural 'sense of place' that these particular physical attributes engender. Lifestyle attributes are those elements of regional living that provide a sense of the uniqueness of rural life such as social networking and cooperative effort, community recreation and celebration and profitable, sustainable agricultural enterprises. People attributes refer to the wealth of skills and qualities perceived to exist within the regional community such as innovation, resilience, knowledge, wisdom and indigenous heritage.

Sustainability goals

The sustainability goals of the region are not as well defined as the core values. They are however primarily linked to the agricultural heritage of the Avon River Basin and the growing recognition that successful future regional development must focus on the simultaneous pursuit of economic, social and environmental goals.

4.4.7.2 The region's biodiversity delivery model

The question of how the driving motivational forces of core values and sustainability goals, together with the success factors identified by Read (2003), can contribute to delivery of the conservation outcomes needed in the region lies in the unified regional approach outlined briefly earlier. Central to this approach is the amalgamation of the scientific and operational management expertise of relevant professional organisations with the wealth of experiential knowledge and wisdom of the broader regional community. These critical relationships, along with the strategic leadership and resourcing capabilities of the ACC, create a robust and effective delivery model that comprises two major interlinked components:

- Community/agency knowledge partnering
- Private landholder involvement

Community/agency knowledge partnering

The ACC recognises the enormous contribution that the knowledge and skills of various specialist biodiversity conservation organisations make to biodiversity conservation in the region. It also recognises the vast store of experiential knowledge and practical wisdom accumulated by the regional community through interaction with their unique natural environment since European settlement. The current Strategy seeks to continue to benefit from this wide range of expertise by including 'community/agency knowledge partnering' as one of the primary mechanisms for delivery of effective biodiversity conservation outcomes in the Avon region. There are many examples of effective partnerships between a variety of specialist organisations and regional community groups in successful conservation initiatives in the region to date. Some of these include:

Protection through the National Reserve System

The Comprehensive and Representative (CAR) analysis of vegetation associations in the region undertaken by Hopkins et al. (1996) provides valuable information to the National Reserve System planning process for the region.

Rangelands and Crown Land management

Land condition surveys documenting pastoral resources and their management have been carried out over 70 per cent of the land allocated for pastoral use in Western Australia. A survey for the rangelands area of the Avon River Basin is scheduled to occur within the next 3 years. Targets and management actions being developed for the Rangelands NRM Strategy over the next 3 years are expected to also be appropriate for the Crown/Pastoral zone of the Avon River Basin.

Recovery catchments and representative landscapes

Two recovery catchments have been identified within the region (Lake Bryde Wetlands Complex and the Drummond Reserve Catchment) and a further six are suggested according to identified selection criteria (Wallace et al., 2002a). Representative Landscapes (i.e. areas greater than 10 000 ha with 25 per cent habitat remaining) have been identified that might serve as the basis for conserving comprehensive representative samples of the region's biodiversity.

In addition, there are five local catchments where linkages between science and community knowledge are directed towards integrating biodiversity conservation into agricultural landscapes through the Living Landscapes program.

Recovery plans for threatened species and ecological communities

There are currently three Recovery Plans for Declared Rare Flora (DRF) in the region and Interim Recovery Plans for a further 33 species. Faunal recovery programs, for example Western Shield, are being undertaken for threatened species.

Road and rail surveys and management

Surveys of roadside vegetation are undertaken on a LGA basis. An assessment of vegetation 'value' (high, medium and low categories) is based on criteria for vegetation structure, native species composition, weed invasion, corridor or connectedness value and vegetated roadside reserve width. Vegetation surveys are complete for 13 LGAs within the Avon River Basin, and a further seven are near completion.

An audit of rare flora within rail reserves is complete and an environmental management plan that provides for their protection is being implemented.

Remnant vegetation on private and leasehold land

The State Remnant Vegetation Protection Scheme (1989-2000) has coordinated the fencing of over 20 000 hectares of private natural vegetation in 836 remnants.

The Land for Wildlife program has assessed 37 968 ha of remnant vegetation on 231 properties and has enhanced the reserves system by purchase of 5228 ha of private remnant vegetation (14 private properties).

The Woodland Watch program has negotiated Conservation Agreements for 100 landholders with over 14 000 hectares of remnant vegetation including:

- 3300 hectares protected under Land for Wildlife agreements,
- 3600 hectares under nature conservation covenants,
- 1700 hectares under voluntary management agreements, and
- 2500 hectares under Shire and/or community group control.

There are also LGA initiatives for remnant vegetation protection, for example, the Shire of York which has a rate relief scheme for 1180 hectares.

Riverine systems and wetlands

A systematic survey of the channel and foreshore of the Avon River from Yenyenning Lakes to the Avon Valley National Park (a distance of 191 km) provides detailed information about the condition of the riverine ecoscape, threatening processes and management needs. Recovery plans have been prepared in association with local communities for all sections of the Avon River, a part of which has included the fencing of over 85 per cent of the river that runs through agricultural land. Foreshore surveys are also complete for the following major tributaries of the Avon River:

- North Mortlock (to Lake Ninan), Mortlock East and Mortlock South river systems
- Toodyay Brook
- Spencers Brook (to Clackline)
- Talbot Brook
- Mackie River

A survey of the 26 major river pools of the Avon River provides detailed information about the depth, sediment infill, water quality and foreshore condition. Management plans are prepared for five of these pools. Priority for management of the river pools is identified in recovery plans for each section of the river. Gwambygine Pool is now one of the longest and deepest river pools downstream from the confluence with the Dale River. There is a management plan for this pool based on considerable information about the aquatic ecosystem collated through local community interests. This pool is significant as an indicator of river health especially in relation to artificial release of saline or acidic water from the Yenyenning Lakes. Other management plans have been prepared for river pools within towns.

Management plans for the Yenyenning Lakes and Lake Meares have been prepared in consultation with local communities and 11 wetlands in the region are monitored.

The future of community/agency knowledge partnering

The current biodiversity section of the NRM Strategy seeks to strengthen the partnership between specialist

organisations and the regional community exemplified in the above initiatives. One of the best opportunities to further develop these partnerships within the context of the unified regional conservation model outlined earlier is through the Local Area planning process that is part of the Natural Resource Management Strategy for the Avon River Basin.

The biodiversity aspect of Local Area Plans is designed as one of the major vehicles by which agency expertise and community knowledge and skills come together, and are transformed into effective on-ground biodiversity conservation actions that are science based and community owned. Partnerships will be formed involving multi-skilled advisory and delivery teams whose roles will include strategic guidance and review, public awareness and participation, on-ground work and mentoring. This mentoring function is critical to ensure effective establishment and maintenance of the second component of the delivery model, private landholder involvement.

Private landholder involvement

The other major delivery mechanism necessary for achieving the Strategy's biodiversity conservation goal is to engage private landholders as an integral part of the region's conservation efforts. The ACC acknowledges that, in a region largely dominated by agriculture, this is a challenge. However, given the large proportion of the region's biodiversity assets that are privately owned or managed and the sheer magnitude of the people resources needed to achieve the Strategy's aspirational goal, there is no doubt about the need to engage private landholders in delivering the required outcomes.

Although it is clear from the work done on the core values of people in the Avon River Basin that the regional community places a high value on many aspects of their unique physical environment, including its biodiversity, it is equally apparent that historically there has been less value placed on conserving that biodiversity. This apparent paradox almost certainly has its roots in the agricultural heritage of the region, and biodiversity conservation has been seen by many as somewhat at odds with the agricultural process upon which the majority of the community depend for their livelihood.

However, work by the ACC and others (Wallace, 2003; Burgman et al., 1999) suggests that the most successful way to resolve this seeming paradox lies in addressing the underlying components of the community's expressed core value for biodiversity. Wallace (2003) has suggested that the primary reasons the regional community values biodiversity are:

Consumptive use values – these include the values of natural products that are harvested for domestic use, e.g. food;

Productive use values – the values of natural products that are commercially harvested, e.g. wildflower harvesting;

Opportunity values – these include commercial opportunities based on unique biodiversity resources such as eco-tourism or the potential future use of genetic resources;

Ecosystem service values – these include values related to maintenance of the environment particularly life-sustaining functions such as oxygen production;

Amenity values – the values of biodiversity that make life more comfortable and pleasant such as native vegetation for shade and shelter;

Scientific and educational values – the values of natural biodiversity as a source of knowledge and learning;

Recreational values – the value of natural bushlands, lakes etc. for recreational activities such as picnics and bushwalks;

Spiritual/philosophical values – relate to emotional attachments to particular natural environments; a spiritual connection to nature and also to a recognition of the intrinsic rights of species beyond our human needs.

Of these biodiversity conservation values it is those that provide a direct financial return that have been recognised as having the greatest potential to engage the private landholder community in biodiversity conservation. Although the economic potential of the region's biodiversity is very promising, development of potential market-drivers is still in the early stages of exploration. However, Read (2003) has identified a range of other financial incentives that have proved successful as mechanisms to engage private landholder involvement in biodiversity conservation projects throughout Australia.

Motivational and Regulatory	Financial Incentives
• local champions • local facilitators • awards • information • access to resources or qualified people • planning/technical support and skills development • biodiversity monitoring • 'learning set'/adult learning processes • community / government partnership agreements • icon or focal species • rare or endangered classification (species/communities) • conservation covenants • legislation	• devolved grants • cost/profit sharing • auction-based funding systems • philanthropic funding • private ownership/investment schemes • land purchase (public investment) • commercial development options • non-production subsidies • compensation for lost opportunities • tax incentives • municipal (or other) rate relief

In addition to direct financial incentives there are a range of indirect financial benefits and non-financial values that have the potential to form the basis of community involvement mechanisms. For example, environmental service values such as the erosion control, shelter belting and flood mitigation functions of biodiversity in the region are very high. Recognition of the scientific and educational values evidenced by the global focus on the region, especially on species richness and endemism, is also of growing importance to the community. Clearly, the effectiveness of mechanisms based on biodiversity values will be enhanced by ensuring that involvement processes also incorporate the core values already expressed by the regional community.

4.4.8 Implementation framework

The Implementation Framework developed for the region's biodiversity conservation Strategy has been designed to ensure the most effective on-ground outcomes for the conservation priorities of all biodiversity asset classes using the delivery mechanisms outlined above.

The major features of the framework include:

A goal statement

An outcome objective/vision for each of the five asset classes to act as a long-term guiding reference for what is to be achieved in terms of biodiversity conservation in the region with respect to each asset class at the end of a 50-year timeframe commencing in 2005.

Resource Condition Targets (RCTs) and Management Action Targets (MATs)

Mid-term (20 year) and short-term (3-5 year) targets, aligned with the asset class objectives and the overall aspirational goal, to address the conservation priorities of each asset class.

Management Actions

A set of specific actions for each asset class that will most effectively achieve the short, medium and long-term conservation objectives in ways that are consistent with the strategic context and delivery mechanisms set for the region's conservation Strategy.

To further improve implementation effectiveness, Management Action Targets and Management Actions are grouped according to an Eight Stage Sequence (The Sequence of Eight), which ensures that the eight key elements necessary for successful on-ground outcomes are addressed for each Resource Condition Target. The Sequence of Eight is as follows:

I Asset identification
II Threat identification and risk assessment
III Assessing the feasibility and cost benefits of management options
IV Setting and reviewing targets (RCTs and MATs)
V Planning for key management actions
VI Building capacity for implementation
VII Investment in implementation
VIII Monitoring, evaluation and review

It is important to clarify that the Implementation Plan outlined in the tables to follow pertains exclusively to the biodiversity conservation component of the overall Strategy. Its integration with the remaining themes (land, water and infrastructure assets), together with issues related to relative investment between themes, are contained in the Investment Plan that accompanies the Strategy document.

The overall structure of the tables details the specific targets and actions needed to achieve the long-term (50-year aspirational goals) for the asset classes and the overall biodiversity goal for the whole region. However, because each asset class refers to a unique biodiversity entity, targets and actions are grouped according to the distinct considerations relevant to each. The particular considerations for each asset class are as follows:

Native Species – the Resource Condition Target (RCTs) for this asset class is divided into three parts to reflect important differences in conservation considerations for strategy implementation with viable, declining and threatened species. It will be noted that the key priority mediating factors (discussed in Section 4.4.7) are also embedded within the conservation targets and the associated management actions for native species.

Natural Ecological Communities (NECs) – the Resource Condition Target for NECs is also divided into sub-targets for viable, declining and threatened communities in recognition of their differing implementation focus. Once again, priority-mediating factors, in this case condition and integrity, are also taken into account in the articulation of targets and actions.

Ecosystems – the descriptor titles of the two sub-targets for the ecosystem asset class, 'vulnerable' and 'threatened,' highlight the current poor state of the region's terrestrial and aquatic ecosystems in that there are none considered to be in a viable condition. 'Integrity' and 'extent' are the two priority mediators for the ecosystems asset class.

Ecoscapes – the primary intent of the Resource Condition Target for this asset class is that the preservation of two representative ecoscapes within each IBRA bioregion will maintain the essential biodiversity character of the Avon

River Basin. The most influential factor for prioritisation beside 'extent' and 'integrity' is the extent to which particular landscapes represent the natural diversity of the region.

Whole of the Avon River Basin – it will be noted that there is no specific Resource Condition Target set for the whole of the basin. Rather, the intent of designating the entire region as a distinct asset class is to capture its critical role, in biodiversity terms, of supporting regional-scale ecological functions such as networks of connected populations, migratory and dispersal capability and movements of pollinators and seed dispersers. The discrete patterns that constitute the IBRA bioregions are considered to be useful in the regional context for organisation of implementation actions.

Considering the Targets and Management Actions as a whole, it will be noted that there is considerable emphasis for this first 3-5 year period on asset identification data gathering and planning. This emphasis reflects the recognised need for a sound knowledge-based foundation to achieve effective conservation outcomes. However, it is important to clarify that there are a wide range of on-ground actions, based on already existing knowledge, information and plans that can be implemented immediately.

Additionally, it is understood that at a project level, on-ground actions identified for species, communities and ecosystems will be addressed at the broadest scale possible to achieve the desired outcomes and considering the other major landscape elements of land, water and infrastructure.

Table 38 Native Species Management Action Targets and actions

Asset Class 1: **Native Species** (all naturally occurring flora and fauna species of the region)

Goal Statement: All native species that naturally occur in the Avon region persist in viable populations.

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 1a: All species that are viable in 2005 persist in viable populations across their current distribution in 2025.	Resource Condition Target 1b: All species showing declining population trends (but likely to still exist in 20 years) will have stable populations across their current distribution by 2025.	Resource Condition Target 1c: All species likely to become extinct within the region in the next 20 years (threatened species) have stable or increased distribution and abundance by 2025.
I.	Asset Identification	**B_1MAT I.1abc**	An inventory (including estimates of current distribution and abundance) of species in the region known to be viable, declining and threatened established by Dec 2009 for viable species, by Dec 2007 for declining species, and by Dec 2006 for threatened species.		
		MA	Review current information and assess conservation status for each taxa and identify knowledge gaps.		
		MA	Establish an information management system to provide ready access to existing biophysical datasets relevant to the region.		
		MA	Design and initiate an ongoing biodiversity survey program for viable, declining and threatened species by Dec 2005.		
		B_1MAT I.2 bc		Priority declining and threatened species and priority locations (areas containing high numbers or unique occurrences of declining or threatened species) identified by Dec 2006 for threatened species and by Dec 2007 for declining species.	
		MA		Review and adapt/adopt existing criteria (e.g. extinction risk, urgency, feasibility, prior investment, additional environmental benefit, community recognition (icon species)) for selecting priority species and locations.	
II.	Threat identification and risk assessment	**B_1MAT II.1 abc**	A threat assessment for viable, declining and threatened species in the region completed and results included in 30 LAPs by June 2006 for threatened species, by June 2007 for declining species and by June 2008 for currently viable species.		
		MA	Develop and apply threat assessment process.		
III.	Assessing the feasibility and cost benefits of management options	**B_1MAT III.1 abc**	Conservation options for viable, declining and threatened species are assessed for feasibility and cost benefit by June 2006 for declining and threatened species and by June 2007 for viable species.		
		MA	Develop and apply a process and criteria for determining and evaluating options for retaining viable species, stabilising declining species, and stabilising or increasing threatened species.		
IV.	Setting and reviewing targets (RCTs and MATs)	**B_1MAT IV.1 abc**	MATs reviewed for threatened species by Dec 2006, for declining species by Dec 2007 and for viable species by Dec 2009, following completion of threat assessments and assessment of management options.		
		MA	Develop framework for refining targets which would ensure that all resource condition targets for the asset class Native Species will be met.		
		MA	Review and refine targets following assessment of priorities and threats.		

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 1a: All species that are viable in 2005 persist in viable populations across their current distribution in 2025.	Resource Condition Target 1b: All species showing declining population trends (but likely to still exist in 20 years) will have stable populations across their current distribution by 2025.	Resource Condition Target 1c: All species likely to become extinct within the region in the next 20 years (threatened species) have stable or increased distribution and abundance by 2025.
V.	Planning for key management actions	**B_1MAT V.1 abc**	General biodiversity conservation guidelines developed and incorporated into 30 Local Area Plans by June 2006 and conservation plans for the five remnants with highest biodiversity values in each local area developed by Dec 2006.	Conservation plans for priority locations which contain high numbers, or unique occurrences, of known declining species completed by Dec 2007.	
		MA	Develop general planning guidelines for retention of viable species.	Prepare conservation plans for selected locations containing priority declining species.	
		MA	Develop conservation plan for 5 priority remnants in each local area.		
VI.	Building capacity for implementation	**B_1MAT VI.1 abc**	Information packages containing conservation guidelines for remnant vegetation provided to each LGA by June 2008.	Action-based training provided to individuals undertaking restoration programs for priority declining species by June 2008.	
		MA	Prepare information packages.	Design action learning skills development program for restoration of declining species.	
		MA	Design and implement value-based public awareness programs for viable, declining and threatened species.		
VII.	Investment in implementation	**B_1MAT VII.1abc**	Priority biodiversity conservation actions based on guidelines in the 30 Local Area Plans implemented by 2010.	Conservation actions for locations containing 10 highest priority declining species, commenced by Dec 2006.	
		MA	Implement on-ground works and other priority actions identified in relevant conservation plans above.		
		B_1MAT VII.2abc	Conservation actions for the five highest-value remnants in each local area that currently do not have a threat management plan, commenced by Dec 2006.		
		MA	Implement on-ground works and other priority actions identified in relevant conservation plans above.		
		B_1MAT VII.3 abc	Implement public awareness and participation programs for viable, declining and threatened species by June 2006.		
		MA	Design public awareness program and integrate with LAPs.		
VIII.	Monitoring, evaluation and review	**B1MAT VIII.1 abc**	Long-term monitoring sites and protocols for assessing status of currently viable species designed and established by June 2006.	Long-term monitoring sites and protocols for assessing status of declining species designed and established by June 2006.	
		MA	Review conservation status of all species for which information is available.		
		MA	Design and establish long-term monitoring sites.		
		B_1MAT VIII.2 abc	Status of selected viable and declining species and all threatened species reviewed at 3-year intervals..		
		MA	Review and adapt/adopt existing monitoring and evaluation procedures for viable, declining and threatened species.		

Avon Catchment Council community workshop

Table 39 Natural Ecological Communities Management Action Targets and actions

Asset Class 2: **Natural Ecological Communities** (groups of native species co-existing in characteristic assemblages)

Goal Statement: Maintain the extent and integrity (structure and composition) of all natural ecological communities that occur in the Avon region.

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 2a: All NECs that are viable in 2005 retain their current extent and integrity across their current distribution in 2025.	Resource Condition Target 2b: All NECs declining in extent and integrity (but are likely to still exist in 20 years) retain/increase their current extent and integrity.	Resource Condition Target 2c: NECs likely to become extinct (threatened ecological communities) within the region in the next 20 years retain or increase their extent and integrity.
I.	Asset Identification	**B_2MAT I.1 abc**	An inventory of the current extent and integrity of all natural ecological communities (terrestrial and aquatic) completed by Dec 2007.		
		MA	Review and adapt/adopt existing classifications of NECs (e.g. EPBC Act 1999) to develop an agreed nomenclature, mapping system and measures of integrity for terrestrial and aquatic NECs in the Avon Basin (develop in consultation with other regions to ensure cross-regional consistency).		
		MA	Design and implement an ongoing biodiversity survey program for NECs by Dec 2005.		
II.	Threat identification and risk assessment	**B_1MAT II.1 abc**	A threat assessment for currently viable, declining and threatened NECs designed and applied and results incorporated into 30 LAPs by Dec 2006.		
		MA	Develop and apply threat assessment process.		
III.	Assessing the feasibility and cost benefits of management options	**B_2MAT III.1 abc**	Priority viable, declining, threatened NECs (terrestrial and aquatic) and priority locations (areas containing multiple NECs or unique occurrences of uncommon NECs) identified by Dec 2006.		
		MA	Determine priority NECs and locations.		
		B_2MAT III.2 abc	Conservation options for viable, declining and threatened NECs are assessed for feasibility and cost benefit by Dec 2005.		
		MA	Establish and apply a process and criteria for determining and evaluating conservation options.		
IV.	Setting and reviewing targets (RCTs and MATs)	**B_2MAT IV.1 abc**	MATs for currently viable NECs reviewed and updated by Dec 2007.	MATs for currently declining NECs reviewed and updated by Dec 2006.	MATs for currently threatened NECs reviewed and updated by Dec 2006.
		MA	Review and refine targets by June 2007 following assessment of priorities and threats.		
V.	Planning for key management actions	**B_2MAT V.1 abc**	Biodiversity conservation guidelines for viable NECs incorporated into 30 Local Area Plans by Dec 2006 and conservation plans for threatened and declining NECs incorporated into LAPs by Dec 2006 and Dec 2007 respectively.		
		MA	Develop general conservation guidelines for NECs that are not at immediate risk.	Prepare conservation plans for selected priority declining NECs.	Prepare conservation plans for all 'critically endangered' and 'endangered' NECs.
		MA	Identify areas where the greatest diversity or unique occurrences of currently viable or declining NECs occur.		Prepare conservation plans for five additional priority NECs.
VI.	Building capacity for implementation	**B_2MAT VI.1 abc**	Training in conservation of viable NECs provided for all private landholders engaged in covenanting and other incentive schemes by Dec 2006.	Action-based training in retention and restoration of declining NECs for all private landholders engaged in covenanting and other incentive schemes by June 2006.	Biodiversity implementation teams established and trained to undertake restoration work for all threatened NECs by June 2006.
		MA	Design training program for conservation of viable NECs.	Design action-learning skills development programs for restoration of declining NECs.	Select training model NECs from among threatened NECs and design training framework.
VII.	Investment in implementation	**B_2MAT VII.1 abc**	Priority conservation actions for viable NECs (based on guidelines in the 30 Local Area Plans) implemented by 2009.	Priority conservation actions for declining and threatened NECs from LAPs (above) implemented by Dec 2007.	
		MA	Implement on-ground works and other priority actions for NECs identified in Local Area Plans.		
		B2MAT VII.2 abc	The area of priority viable NECs under conservation agreements is increased by 500 ha annually for 5 years	The area of priority declining NECs with conservation agreements is increased by 500 ha annually for 5 years.	All threatened NECs have conservation agreements.
		MA	Establish covenanting and other incentive schemes for priority viable and declining NECs.		Determine most appropriate conservation agreements for threatened NECs.

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 2a: All NECs that are viable in 2005 retain their current extent and integrity across their current distribution in 2025.	Resource Condition Target 2b: All NECs declining in extent and integrity (but are likely to still exist in 20 years) retain/increase their current extent and integrity.	Resource Condition Target 2c: NECs likely to become extinct (threatened ecological communities) within the region in the next 20 years retain or increase their extent and integrity.
VIII.	Monitoring, evaluation and review	**B2MAT VIII.1 abc**	Long-term monitoring sites and protocols for assessing status (extent and integrity) of currently viable, declining and threatened NECs designed and established by June 2006.		
		MA	Identify and establish long-term monitoring sites.		
		B2MAT VIII.2 abc	Status of selected viable, declining, threatened NECs reviewed at 3-year intervals.		
		MA	Review the conservation status of all NECs against 2005 benchmarks and RCTs.		

Avon Catchment Council community workshop

Table 40 Ecosystems Management Action Targets and actions

Asset Class 3: **Ecosystems** (discrete sets of natural ecological communities and their interaction with the distinctive physical environment they inhabit)

Goal Statement: Maintain or increase the extent and integrity of all terrestrial and aquatic ecosystems.

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 3a: Vulnerable ecosystems (ecosystems whose current extent in good condition exceeds 15% of their pre-European extent and their current extent exceeds 2000 ha) retain their current extent and integrity and have at least 15% of their pre-European extent formally protected for conservation (reserve system or legally binding management agreement).	Resource Condition Target 3b: Threatened ecosystems (ecosystems whose current extent in good condition is less than 15% of their pre-European extent, or have < 2000 ha total extent remaining, retain their current extent and retain/improve their integrity, and have at least 60% of their remaining extent formally protected for conservation (reserve system or legally binding management agreement).
I.	Asset Identification	**B_3MAT I.1 abc**	An agreed classification of Avon ecosystems, and an inventory and map of the distribution, extent / condition / integrity of vulnerable and threatened ecosystems completed by Dec 2007.	
		MA	Review and adapt/ adopt existing classifications to develop an agreed nomenclature, mapping system and measures of integrity for terrestrial (including outcropping granite, doleritic dykes, greenstone ranges etc.) and aquatic (saline and freshwater wetlands) ecosystems of the Avon River Basin (developed in consultation with other regions to ensure cross-regional consistency and undertaken in conjunction with mapping of NECs).	
		MA	Establish an information management system to provide ready access to existing biophysical datasets relevant to the region.	
		MA	Design and implement an ongoing biodiversity survey program.	
II.	Threat identification and risk assessment	**B_3MAT II.1 ab**	A threat assessment for ecosystems completed and results incorporated into 30 LAPs by Dec 2006.	
		MA	Develop an assessment framework for all ecosystems of the Avon River Basin utilising existing ecosystem classification, inventory, assessment and mapping (e.g. Beard-Hopkins) to identify the CAR status of all ecosystems within the Avon region.	
		B_3MAT II.2 ab	The threat to major low-lying ecosystems due to rising groundwater and potential discharge from drainage schemes is predicted by Dec 2006.	
		MA	Develop a classification and assessment process for wetlands to determine their current condition and capacity for receiving drainage.	
III.	Assessing the feasibility and cost benefits of management options	**B_3MAT III.1 ab**	Review and adapt/adopt existing criteria to identify priority terrestrial and aquatic ecosystems by 2007.	
		MA	Gain agreement on criteria for selecting priority ecosystems from key stakeholders and undertake assessment using those criteria.	
		B_3MAT III.2 ab	Options for retaining and improving the integrity of vulnerable and threatened ecosystems are assessed for feasibility and cost benefit by Dec 2005.	
		MA	Establish and apply a process and criteria for determining and evaluating cost effectiveness of alternative options for conserving ecosystems.	
IV.	Setting and reviewing targets (RCTs and MATs)	**B_3MAT IV.1 ab**	MATs for vulnerable ecosystems reviewed and updated by Dec 2007.	MATs for threatened ecosystems reviewed and updated by Dec 2006.
		MA	Review and refine targets following assessment of threats and priorities.	
		MA	Develop conservation framework for refining targets which ensure that vulnerable and threatened ecosystems retain their extent and increase their integrity.	
		MA	Develop partnership arrangements with Rangelands NRM organisation for targets relevant to the Crown/Pastoral zone.	

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 3a: Vulnerable ecosystems (ecosystems whose current extent in good condition exceeds 15% of their pre-European extent and their current extent exceeds 2000 ha) retain their current extent and integrity and have at least 15% of their pre-European extent formally protected for conservation (reserve system or legally binding management agreement).	Resource Condition Target 3b: Threatened ecosystems (ecosystems whose current extent in good condition is less than 15% of their pre-European extent, or have < 2000 ha total extent remaining, retain their current extent and retain/improve their integrity, and have at least 60% of their remaining extent formally protected for conservation (reserve system or legally binding management agreement).
V.	Planning for key management actions	**B_3MAT V.1 bc**	Biodiversity conservation plans for vulnerable and threatened terrestrial and aquatic ecosystems developed and incorporated into 30 Local Areas Plans by 2009.	
		MA	Commence preparation of conservation plans for initial 10 ecosystems (terrestrial and aquatic) at significant risk.	
		B_3MAT V.2 ab	Priority ecosystems and priority locations that should be added to the conservation reserve system or secured through legally binding means identified by Dec 2006.	
		MA	Identify priority ecosystems and locations that should be protected for conservation and the most appropriate protection mechanisms (reserve system or management agreement) available.	
VI.	Building capacity for implementation	**B_3MAT VI.1 ab**	LGA-based biodiversity implementation teams established and trained to undertake and mentor retention/improvement of priority vulnerable and threatened ecosystems within each LGA by June 2008.	
		MA	Design training programs for on-ground and mentoring skills development for the teams working with vulnerable and threatened ecosystems.	
VII.	Investment in implementation	**B_3MAT VII.1 abc**	Conservation programs implemented in priority vulnerable and threatened ecosystems in each local area by Dec 2009.	
		MA	Identify priority ecosystems and implement conservation plans.	
		B_3MAT V.2 abc	95% of the Avon River that is adjacent to agricultural land is fenced both sides of the bank by 2009.	
		MA	Provide incentives to landholders adjoining Avon River to undertake fencing.	
		B_3MAT VII.3 abc	The area of priority threatened ecosystems formally protected (reserve system or management agreement) has increased by 20% PA for 5 years.	
		MA	Implement targeted covenanting programs.	
		MA	Apply for National Reserve System funds for securing highest value areas that represent the range of ecosystems in the Avon River Basin.	
VIII.	Monitoring, evaluation and review	**B_3MAT VIII.1 abc**	Long-term monitoring sites and protocols for assessing status (extent and integrity) of vulnerable and threatened ecosystems designed and established by June 2006.	
		MA	Design and establish long-term monitoring sites.	
		MA	Monitoring program initiated for nationally and regionally significant wetlands.	
		B_3MAT VIII.2 abc	Status of selected ecosystems reviewed at 3-year intervals.	
		MA	Biennial report on extent and integrity of all priority ecosystems within the Avon River Basin.	
		MA	Review conservation status of all ecosystems.	

Avon Catchment Council community workshop

Table 41 Landscapes/Ecoscapes Management Action Targets and actions

Asset Class 4: **Landscapes/Ecoscapes** (A mosaic of ecosystems that spans the topography from one ridge in the landscape to the next)

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 4: Conserve the extent and integrity of the natural diversity (species, NECs and ecosystems) within 12 landscapes /ecoscapes which best represent the natural diversity of the Avon River Basin.
I.	Asset Identification	**B_4MAT I.1**	Two ecoscapes that best represent the natural diversity (ecosystems, NECs and species) and are best able to retain that diversity identified in each bioregion by June 2005.
		MA	Review and adapt/adopt existing criteria or develop novel approaches and criteria to identify and select ecoscapes best representing natural diversity in the Avon River Basin (developed in consultation with other regions to ensure cross-regional consistency).
II.	Threat identification and risk assessment	**B_4MAT II.1**	A threat assessment for selected ecoscapes completed and results incorporated into 30 LAPs by Dec 2006.
		MA	Develop threat assessment framework and undertake assessment.
III.	Assessing the feasibility and cost benefits of management options	**B_4MAT III.1**	Options for conservation of representative ecoscapes assessed for feasibility and cost benefit by Dec 2005.
		MA	Establish and apply a process and criteria for determining and evaluating options for retaining the natural diversity of representative ecoscapes.
IV.	Setting and reviewing targets (RCTs and MATs)	**B_4MAT IV.1**	MATs for representative ecoscapes developed by June 2006. These will include ability to detect measured increase in the integrity of the natural diversity and processes for: • retaining viable populations and communities, • restoring threatened populations and communities, • conserving regionally significant biodiversity assets (e.g. granite outcrops), and • enhancing landscape-scale connectivity.
		MA	Develop a framework for refining targets which ensure that natural diversity of representative ecoscapes is viable, retains its current extent and has greater integrity.
		MA	Review and refine targets following assessment of priorities and development of conservation strategy and methodology.
V.	Planning for key management actions	**B4MAT V.1**	Biodiversity conservation plans developed for representative ecoscapes (1 per IBRA region) by June 2006 with an additional 1 per IBRA region developed by June 2008.
		MA	Prepare priority conservation plans.
VI.	Building capacity for implementation	**B4MAT VI.1**	Bioregional biodiversity teams established and trained to undertake mentoring and project management skills to conserve representative landscapes by June 2008.
		MA	Design skills development programs in mentoring and project management for bioregional teams.
VII.	Investment in implementation	**B4MAT VII.1**	Actions identified in conservation plans for representative ecoscapes (including fencing, regeneration, revegetation, weed and animal pest management, and other actions) implemented by 2009.
		MA	Initiate on-ground works according to priorities identified in conservation plans.
VIII.	Monitoring, evaluation and review	**B4MAT VIII.1**	Long-term ecological reference and monitoring sites designed and established to provide baseline data and enable assessment of trends in extent and integrity of natural diversity within representative ecoscapes.
		MA	Review and adapt/adopt existing monitoring and evaluation procedures.
		B4MAT VIII.2	Status of selected natural diversity within representative ecoscapes reviewed at 3-year intervals.
		MA	Design and establish long-term monitoring sites.
		MA	Review conservation status of natural diversity in representative ecoscapes.

Avon Catchment Council community workshop

Table 42 Whole of Avon River Basin Management Action Targets and actions

Asset Class 5: **Whole of Avon River Basin**

Goal Statement: The Avon River Basin contains a connected and functional network of vegetation that represents the natural diversity of the region (landscapes, ecosystems, communities and species) and supports regional-scale ecological functions (networks of connected populations, migratory and dispersal capability, movements and re-colonisation in response to extreme events, movements of pollinators and seed dispersers, options for changes in distribution and abundance in response to climate change, maintenance of evolutionary potential etc.)

Implementation Framework (Sequence of Eight)		Targets	Resource Condition Target 5a: The Avon River Basin community is contributing to and participating in biodiversity conservation goals, targets and actions at state, national and international scales by 2025
I.	Asset Identification	**B_5MAT I.1**	Classification of distinct regions within the Avon River Basin that have similar biophysical and human land-use patterns completed by Dec 2005.
		MA	Review and adapt/adopt existing classifications.
		B_5MAT I.2	Biodiversity survey program for all asset classes implemented by Dec 2005.
		MA	Design and initiate biodiversity survey program.
II.	Threat identification and risk assessment	**B_5MAT II.1**	Threats that need to be addressed at bioregional scales, such as high water tables, altered hydro-periods, habitat loss and fragmentation, declining water quality, sedimentation, weeds, pests and diseases are quantified by Dec 2005.
		MA	To map the extent and severity of impact of known threats.
		MA	Impact and severity of various threats for each bioregion are prioritised by Dec 2005.
III.	Assessing the feasibility and cost benefits of management options	**B_5MAT III.2**	Options for management of bioregional-scale issues assessed for feasibility and cost benefit.
		MA	Establish and apply a process and criteria for determining and evaluating cost effectiveness of alternative threat management options for addressing bioregional-scale issues.
IV.	Setting and reviewing targets (RCTs and MATs)	**B_5MAT IV.1**	Basin-wide RCTs and MATs quantified by Dec 2006.
		MA	Review and adapt/adopt targets from other asset classes and combine to establish new bioregional targets.
V.	Planning for key management actions	**B_5MAT V.1**	Sub-regional conservation plans that consider ecological function at regional scales (e.g. macro corridors) developed by Dec 2007.
		MA	Identify functions that need to be addressed at a regional scale. Develop design principles for regional-scale conservation plans.
		B_5MAT V.2	Seed resource management plans developed for each bioregion by Dec 2005.
		MA	Undertake seed resource audit and needs analysis and develop a seed management plan for the Avon River Basin.
		B_5MAT V.3	Guidelines for use of perennial plant-based enterprises to contribute to protection of priority assets developed by Dec 2005.
		MA	Develop design criteria for optimal use of perennial plant-based enterprises to enhance biodiversity outcomes.
		B_5MAT V.4	An integrated suite of incentive schemes for biodiversity conservation will be developed by June 2006.
		MA	Review and adapt/adopt existing incentive schemes with higher levels of incentives for activities that protect higher priority assets.
		B_5MAT V.5	An industry development program based on native perennial plant species developed by 2008.
		MA	Assess (in partnership with existing programs) current enterprise options with respect to their potential contribution to biodiversity outcomes based on perennial native plant species.
		B_5MAT V.6	Weed management strategy developed by June 2006.
		MA	Develop a weed survey and weed management plan for the Avon River Basin.
		B_5MAT V.7	Fire management plans developed for each bioregion by Dec 2007.
		MA	Assess risk and options for effective fire regimes.
VI.	Building capacity for implementation	**B_5MAT VI.1**	Regional biodiversity conservation steering committee to lead biodiversity conservation at a regional level established and fully operational by June 2005.
		MA	Commission professional program in leadership and team formation for regional steering committee.

Implementation Framework (Sequence of Eight)	Targets	Resource Condition Target 5a: The Avon River Basin community is contributing to and participating in biodiversity conservation goals, targets and actions at state, national and international scales by 2025
VII. Investment in implementation	**B_5MAT VII.1**	Implement priority actions identified in sub-regional plans by 2009.
	MA	Initiate priority on-ground works identified in subregional plans. Establish seed production areas across each bioregion to ensure availability of provenance seed at a scale sufficient to meet vegetation management needs.
	B_5MAT VII.2	Review investment priorities annually and the Strategy after 5 years.
	MA	Undertake review.
	B_5MAT VII.3	By 2009, the currently mapped area of priority environmental weeds is reduced by 20%.
	MA	Implement a weed survey and weed management plan for the Avon River Basin.
VIII. Monitoring, evaluation and review	**B_5MAT VIII.1**	Regional biodiversity monitoring program for high water tables, altered hydro-periods, habitat loss and fragmentation, declining water quality (nutrient, acidity, salinity and sediments), sedimentation, weeds, pests and diseases developed and initiated by 2005.
	MA	Review statewide monitoring and evaluation guidelines and adopt/adapt to meet regional needs.

Avon Catchment Council community workshop

4.5 Infrastructure

The built infrastructure within the Avon River Basin is fundamentally important to community development and management of natural resources within the region. This includes both private and public investment in infrastructure. In addition there are major transport linkages from Perth to the north and south of the state, and to Kalgoorlie-Boulder and the Eastern States that pass through the region.

Public infrastructure provides services for water supply, energy, transport (road, rail and aviation), communications, education, industry parks and health within the region as identified in *Shaping the Future 1997-2010: An Economic Development Vision and Strategy for the Wheatbelt Region* (Wheatbelt Development Commission, 1997). These services enable people to live and work in decentralised communities. The transport infrastructure also provides opportunities for biodiversity conservation through the network of road and rail reserves.

Most rural infrastructure is associated with towns and transport corridors, both of which are located in the landscape where the risk of salinity and flooding is increasing due to rising regional groundwater tables. There is also further risk due to actions that may be taken to combat the effects of salinity and flooding on land, water or biodiversity assets.

Aviation is becoming a significant industry in the region with Merredin hosting the first regionally based, commercial pilot training school. Cunderdin has a large, sealed and fully lit runway which has previously provided an alternative to Perth Airport. The risk to aviation facilities due to high water tables has not been assessed.

While regional infrastructure is not a natural resource, the benefits of integrating management of infrastructure assets with management of natural resource assets are recognised.

Efficient infrastructure is fundamental to the effectiveness of local communities and economies within the region. Decline in infrastructure services will deter community development and detract from new enterprise initiation. Built cultural and heritage values are also at risk from the processes of environmental change.

4.5.1 Infrastructure asset classes

Infrastructure assets within the Avon River Basin are identified in three asset classes:

1. **Transport Infrastructure**
   a. Roads – a total of 25 200 km of roads in the region including almost 500 km of main roads, including the Great Eastern Highway
   b. Rail – over 1900 km of railways within the region
   c. Aviation – including private and public airstrips
2. **Industry Support Infrastructure**
   a. Power lines
   b. Telecommunications
   c. Water infrastructure – there are almost 8 000 km of pipelines within the region
3. **Community Infrastructure**
   a. Towns and buildings – 21 towns are identified at risk to salinity within the region
   b. Industry and commerce
   c. Farm building and facilities

d. Education, recreation and tourism
e. Heritage – including both Aboriginal and non-Aboriginal

The region has a comprehensive network of roads and rail including major linkages from Perth to the Goldfields and the Eastern States. The rail network is fundamental to the grain industry of the region and the Prospector (Kalgoorlie to Perth) and AvonLink (Northam to Perth) trains provide passenger services.

The total length of roads in the Avon River Basin is 25 203 km which is 30.4% of all roads in the Southwest Land Division (82 844 km). The lengths of three classes of roads are shown in Table 44. The total length of rail in the region is 1918 km.

The provision of reliable and adequate water supplies to rural consumers is a high priority for communities and economic development in the Avon River Basin. The eastern portion of the Avon River Basin is supplied by the Goldfields and Agricultural Water Supply Scheme. The south-western portion is supplied by the Great Southern Towns Water Supply Scheme, and the western area closer to Perth is supplied by a network of local schemes. There are almost 8 000 km of water supply pipelines within the region. This includes 456 km in the Avon Arc zone, 7 058 km in the Wheatbelt and 171 km on the Crown/ Pastoral zone. In addition, there are 272 km of other pipelines managed by local government.

Electricity for the Avon River Basin is provided through the South West Interconnected System (SWIS). The settlement pattern within the region causes the distribution of power to be relatively inefficient and expensive.

The inadequate power supply, transmission system and high connection fees act as a barrier to diversification of land use and processing industries in some locations in the region (Wheatbelt Development Commission, 2002).

Table 43 Threat assessment for infrastructure in the Avon River Basin

ASSET CLASS	NRM Threats		Other Threats	
	Salinity	Flooding	Ageing Infrastructure	Pop. Change
Transport				
Road				
– Main	H	H	H	H
– Local	H	H	H	H
Rail	M	H	M	H
Aviation	M	L	M	H
Service Provision				
Power				
– Transmission/grid	?	L	H	H
Telecommunications				
– Cables	?	L	H	H
Water				
– Pipeline	?	L	?	H
– Water reserves	?	L	L	L
– Dams	?	L	L	L
– Wells	?	L	L	L
– Rock catchments	?	L	L	L
– Sealed/roaded catchments	?	L	L	M
Rural Towns				
Public buildings	H	H	M	L
Heritage buildings/sites	H	H	M	L
Commercial buildings	H	H	L	L
Industrial infrastructure	H	H	L	L
Grain facilities	M	L	L	M
Recreational sites	M	L	L	L

Avon Catchment Council community workshop

Table 44 Potential impact of high water tables on roads in the Avon River Basin

	Total length (km)	Current risk (km)	Potential risk (km)
Avon Arc			
Main roads	379	17	100
Shire roads – Class 1	896	21	177
Shire roads – Class 2	1 574	48	314
Wheatbelt			
Main roads	1 598	117	390
Shire roads – Class 1	5 061	252	1 290
Shire roads – Class 2	14 694	1 508	3 357
Crown/Pastoral			
Main roads	128		
Shire roads – Class 1	150		
Shire roads – Class 2	723		
Total Avon River Basin			
Main roads	2 105	134	489
Shire roads – Class 1	6 107	273	1 466
Shire roads – Class 2	16 991	1 556	3 671

Note: Class 1 roads have a bituminous seal surface
Class 2 roads have a gravel surface.

Derived from Land Monitor project
Department of Agriculture WA and Main Roads (2003)

The communications infrastructure includes post offices and agencies, telephone systems, radio and television services.

There is considerable investment within the region in housing, sheds and other built assets of farms.

Community social assets for NRM include many Landcare Centres and related facilities that have been developed in local towns to support NRM initiatives and facilitate local capacity with skills, knowledge and information to deliver on-ground actions. While not necessarily threatened physically, their continued functions are considered to be an important community asset.

Local assets are being identified and assessed according to their value and risk through local NRM and other planning processes. This includes an assessment of significant Aboriginal sites based on the advice of Noongars, Ballardong and other Aboriginal Elders within the region. The ACC is developing partnership arrangements with relevant Aboriginal cultural groups within the region through appropriate facilitated processes. While this may not produce an inventory of significant sites, it will build the processes for integration of heritage and cultural values within local area planning processes. An Aboriginal Heritage and Cultural Values Supporting Document is being prepared concurrent with this strategy.

The most significant built heritage asset within the region is the Golden Pipeline built by C. Y. O'Connor to provide water to the Goldfields, and Ballardong Farm near York is the first farm developed in WA away from the coast. Most towns in the region have heritage buildings or sites that are valued and protected. Municipal inventories of heritage buildings have also been prepared for at least six LGAs within the region.

4.5.2 Threats to infrastructure

The value of infrastructure to communities within the region is threatened by physical impacts as well as by social and economic change. The major physical threats are due to increasing potential for salinity and flooding. However, the decreasing population in some areas and deterioration of some infrastructure with age are reasons for asset values to not be maintained. Table 43 provides an assessment of the level of these threats to infrastructure assets within the region.

Transport infrastructure

The major threat to roads in the Avon River Basin is from rising water tables and the associated risk of salinity damage. Table 44 shows the extent of roads within the region that currently are at risk from high water tables and also the extent at future risk. This shows that the most extensive impact is on LGA Class 2 (gravel) roads. The extent to which roads within each LGA are currently and potentially at risk is shown in Appendix 3. This shows for example that 21 LGAs within the region have approximately 100 km or more of Class 2 roads with potential risk

A state assessment of the impact of salinity on roads shows there are:

- 252 km of highways and main roads currently affected
- 1 194 km of highways and main roads at risk
- 3 853 km of local and unclassified roads currently affected
- 22 960 km of local and unclassified roads at risk.

When compared with the regional information shown in Table 43, it can be seen that a high proportion of the state's roads at risk are in the Avon River Basin.

The major impacts of high water tables on roads are:

- Waterlogging causing delamination of pavement base and bituminous surface, and
- Salt impact on concrete structures.

The over-all total cost of repairs and maintenance for State roads due to high water tables is estimated to be $1 355m (not including unclassified roads) of which 80% is for local

roads. The extent of rail currently affected is 214 km and 1 047 km are at risk. The long-term annual cost for state rail repair is estimated to be $176m.

The long-term repair costs for roads currently at risk in the Avon River Basin are estimated to be:

134 km of MRWA roads @ $416 000/km	$55.7m
273 km of Shire Class 1 roads @ $67 600/km	$18.4m
1 556 km of Shire Class 2 roads @ $16 000/km	$24.9m
Total 20-year regional cost estimate	**$99m**

(Note: costs based on the *Revised South Australia Estimate, Austroads 2004*)

While roads and other transport infrastructure are extensively threatened by rising water tables, these facilities are often considered to be a significant cause of threatening processes. Many roads were constructed with culverts and flood ways that are now of inadequate capacity considering the increased surface water runoff from catchments cleared for agriculture. Some are blocked by sediments and require frequent maintenance. Where culverts are inadequate, there is often localised flooding and an extended period of water ponding causing *in situ* recharge to groundwater causing salinity.

Railways generally have culverts of greater capacity than culverts used for roads however the alignment of rail and road culvert are sometimes not well coordinated, causing local flooding.

Acidic stream flow is a significant cause of damage to concrete culvert structures. The cause is related discharge of acidic groundwater and is not related to soil acidity. Drainage and groundwater pumping may increase acidic stream flow however the extent to which this will make a difference is not well understood.

Major flooding is a significant cause of damage to road and rail assets. It is expected that damaging flood flows will increase in magnitude and frequency as a result of rising water tables and climate change.

Aviation facilities will be affected where airstrips deteriorate due to high water tables.

Industry support infrastructure

The major threat to industry support infrastructure is through the impact of rising saline groundwater and flooding. The potential extent and cost of these impacts have not been estimated for the region, however most pipelines and communications transmission facilities are co-located in road and rail corridors so the extent to which they are at risk would be similar to the risk to roads.

Community infrastructure

There are 38 towns that are affected or threatened by salinity and high water tables in Western Australia, 21 of which are in the Avon River Basin (Table 45). Sixteen towns are identified as being of high priority under the Salinity Investment Framework (SIF) and 7 of these priority towns occur in the Avon River Basin.

An economic assessment of six towns at risk to salinity in the Avon River Basin identifies the potential impacts, reviews management options and provides an analysis of the costs involved (WA Department of Agriculture, 2001). This shows that a significant proportion of the costs are associated with damage to roads within the town area. The analysis estimated the cost to be $8.936 million over the next 30 years (net present values, 7% discount rate). At an average total cost of $1.2 million per town, the control programs over the next 30 years across the 21 towns will require $25 million (discounted at 7%) for full implementation.

Many farm homesteads and associated buildings were located in valley floors but now are affected by salinity. Some have serious structural damage. Salinity has also affected farm fencing, dams and other facilities.

Threats to other community infrastructure, including the built heritage, is not well documented within the region.

4.5.3 Current management strategies and actions

Roads and rail infrastructure within the region are managed by state and local government instrumentalities according to statutory requirements and local community priorities. There is currently no coordinated approach for management of these assets within a landscape context. The current response to threatening processes, including rising water tables, is to repair damage caused. Preventative action for landscape threats to transport facilities does not currently occur on an integrated catchment basis.

Salinity and other NRM issues relating to transport infrastructure are proposed for consideration in transport planning in the Avon River Basin region. The *Wheatbelt Regional Transport Strategy* (Department for Planning and Infrastructure, 2003) focuses on the efficiency of the transport network for industries in the region, the impact of heavy vehicles on roads and communities and the coordination of planning and decision making roles. It should also consider the potential impact of salinity.

The Rural Towns – Liquid Assets Program (RTLA) is a key component of the State Salinity Strategy coordinated by the WA Department of Agriculture. This program

Table 45 Prioritisation of towns at risk from salinity in the Avon River Basin

Rural Town (Priority towns shown in bold)	***Pop.**	**Years to Impact** (i.e. water table < 1.5 m)	**Risk Index** (population/ number of years to impact)	**Ranking within Region**	**Ranking within State** (from 38)	**Priority** (high/medium/ low)
Bakers Hill	455	1	455	1	5	high
Merredin	3 630	9	403	2	6	high
Pingelly	800	2	400	3	7	high
Wongan Hills	800	3	267	4	8	high
Lake Grace	1 034	4	259	5	9	high
Narembeen	950	5	190	6	10	high
Dowerin	400	6	67	8	17	high
Kellerberrin	855	15	57	10	20	medium
York	2 000	31	65	9	18	high
Quairading	680	24	28	11	24	medium
Corrigin	750	27	28	12	25	medium
Bruce Rock	700	31	23	13	26	medium
Goomalling	600	31	19	14	27	medium
Mukinbudin	400	26	15	15	29	medium
Koorda	315	22	14	16	30	low
Bencubbin	170	15	11	17	31	low
Beacon	120	16	8	18	34	low
Bullaring	10	2	5	19	35	low
Trayning	118	30	4	20	36	low
Pingrup	80	24	3	21	37	low
21 Towns	**15 567**			**21**	**38**	

Derived from Rural Towns – Liquid Assets, Department of Agriculture, WA (2004)

aims to protect townsite infrastructure at risk due to high water tables and salinity by implementing strategies for residential areas, public and commercial buildings, water supplies, roads, railways, parks, gardens, sporting facilities and other assets within towns. A recent revision and new investment in this program has provided further focus on towns within the Avon River Basin.

Of the 21 towns at risk in the Avon River Basin, almost half are implementing actions of their local townsite salinity management programs (assessed June 2003). For example, the Corrigin Shire and local community have successfully lowered water tables and have almost completed salinity control work. The management focus is on water control and reduction of groundwater levels, including drainage and groundwater pumping schemes.

4.5.4 Options for management

Integrated natural resource management undertaken at a landscape scale with local and regional planning processes provides a significant opportunity for management of the processes that threaten both natural and infrastructure assets.

Local and regional road management could benefit from preventative actions through integrated management. The options include:

- Reduced peak stream flow events by implementation of integrated catchments water management;
- Design of culverts and flood ways that are of adequate capacity for stream flow and are coordinated with local water management plans;
- Ensure minimal flooding and ponding (caused by local groundwater recharge);
- Roadside revegetation to lower groundwater tables (maintain separation of groundwater from the road pavement);
- Drainage and groundwater pumping to control groundwater.

The options and costs for salinity control have been assessed for the RTLA program (Department of Agriculture,

2001). This assessment shows the importance of localised groundwater recharge so actions for local water use efficiency and storm water management are considered. The options for management include:

- Improved stormwater drainage within towns;
- Tree establishment within townsites;
- Reducing the amount of imported water available to enter the groundwater table;
- Recycling of waste water and excess stormwater to public areas;
- Reducing the groundwater table below areas most at risk (groundwater pumping generally considered).

Disposal of the pumped water for infrastructure asset management can provide opportunities for productive use. If it is of suitable quality, it can be used to replace more expensive imported water. If saline it can be evaporated, however this is expensive and additional work to develop economic uses for the saline water is required – including recovery of potable water through desalination, and use of the water for aquaculture, salt harvesting or to generate electricity.

Management options for other infrastructure assets are similar to those described for roads and towns.

4.5.5 Goals, targets and actions

Goals and targets have been developed for each of the infrastructure asset classes as outlined in Section 4.1. Consideration of trade-off criteria and target indicators for the 20-year Targets is also provided in the tables below.

I1 Transport Infrastructure (Roads, Rail, Aviation)

Goal Statements: *Public transport infrastructure is maintained or enhanced to support existing industries and facilitate regional diversification.*

Issue Statement: There are a total of 25 203 km of roads and 1918 km of rail within the Avon River Basin. This extensive regional transport network is essential for commerce and social cohesion. The networks are also significant as landscape corridors that enhance environmental values. Most road and rail infrastructure have been located in low gradient landscape positions and as a result are now at risk of impact from rising water tables. Modelling shows that 7.8% of the road network may be affected now and that this could rise to over 20%. The high cost of repair may result in some lower-use roads being neglected however these are locally significant. The repair costs need to be pre-empted by preventative action through catchment management.

Railways are less threatened by rising water tables, however inadequate capacity and coordination of culverts cause sedimentation and ponding.

Table 46 Transport infrastructure targets, trade-off criteria and indicators

20-year Target		Trade-off Criteria[1]	Target Indicators
$I_1T_{20}1$	By 2025, the percentage of roads at risk due to high water tables and flooding is reduced to 10% (2 520 km) or less of the total road network in the Avon River Basin. Note: The estimated long-term impact without preventative intervention is for over 7 500 km.	**PI:** Considerable public investment in regional transport assets that are threatened.	• Percentage of road, rail and aviation assets at risk.
Strategic Response: **Prevention** of flooding and high water table impact. **Recovery** of roads currently affected by high water tables. **Adaptation** of culvert design to appropriate capacity and materials for ongoing threatening processes. **New opportunities** for multiple benefit outcomes from an integrated and co-operative approach to infrastructure and natural resource management.			

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence.

Avon Catchment Council community workshop

I2 Industry Support Infrastructure (Power, Telecommunications, Water)

Goal Statements: *Long-term industry development and diversification within the region is supported by reliable and adequate power, telecommunication and water supply facilities. Suitable opportunities to generate power or source water within the region are utilised.*

Issue Statement: Viable industry development and diversification in the region is often limited by reliable and high quality electricity supply. There are opportunities to generate power within the region as an associated activity with other natural resource management.

Telecommunication and water supply infrastructure assets are at risk to threatening processes, but the extent of this risk is not known.

Table 47 Industry Support Infrastructure targets, trade-off criteria and indicators

20-year Target		Trade-off Criteria[1]	Target Indicators
$I_2T_{20}1$	Residential and industrial electricity demand is generated within the region at a level equivalent to 20% of current regional demand (500MW) by 2025.	**PI:** Considerable previous investment in industry infrastructure within the region.	
$I_2T_{20}2$	By 2025, 15% of water supplied through public infrastructure is sourced from within the region.	**S:** Opportunities for power generation and water supply within the region through natural resource management depend upon the feasibility of other management options.	
Strategic Response: **Prevention** of damage to water and telecommunication assets. **New opportunities** for electricity generation and water supply within the region.			

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence.

I3 Community Infrastructure Assets (Towns, Commercial and Farm Buildings, Recreational Facilities and Heritage)

Goal Statements: *Community assets in towns and on farms are protected from the threats of rising water tables and flooding.*

Local communities have the capacity to progressively develop opportunities for industry enhancement, and new and diversified industries, and provide and maintain recreational, cultural and community facilities that attract and retain people within the region.

Issue Statement: As with roads and rail, rural towns were established in valley floor landscape positions where they are now at increasing risk due to rising water tables and flooding. Of 38 towns at risk in Western Australia, 21 are within the Avon River Basin. Seven of these towns are considered to be of high priority for recovery actions.

Farm buildings in valley floor locations are also at risk to rising groundwater levels.

Heritage buildings and associated sites, including those of significance to Aboriginal people, are also at risk to salinity and flooding. Some LGAs have prepared inventories of heritage buildings but there are no specific risk assessments for these Aboriginal assets.

Local community groups have developed facilities in Landcare Centres, continuing support for these is required.

Avon Catchment Council community workshop

Table 48 Community infrastructure targets, trade-off criteria and indicators

20-year Target		Trade-off Criteria[1]	Target Indicators
$I_3T_{20}1$	By 2025, 10 rural towns in the Avon region have the risk of damage to infrastructure and heritage values due to salinity and flooding reduced by 50% compared with 2004 risk assessments.	**EP:** Priorities for threatened rural towns have been established through the RTLA program.	
$I_3T_{20}2$	The capacity of local communities to undertake NRM actions is supported by appropriate facilities, including those that have been developed by communities during the Decade of Landcare, by 2007.	**PI:** Considerable prior investment through the RTLA program.	
Strategic Response: Prevention of further impact to community assets. Recovery from impacts to rural town assets. New opportunities for recycling waste or storm water, and by desalinisation.			

1. EP = existing priorities, PI = prior investment, U = urgency, S = sequence.

Avon Catchment Council community workshop

Management Action Targets (MATs)

11. Transport Infrastructure (Roads, Rail, Aviation)

20-year Targets: $I_1T_{20}I$ By 2025, the percentage of roads at risk due to high water tables and flooding is reduced to 10% (2520 km) or less of the total road network in the Avon River Basin.

Note: Without preventative intervention over 7500 km of the road network will be affected.

Table 49 Transport infrastructure management action targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*	**I_1 MAT I.1**	An inventory of transport assets, including roads, rail, airstrips and associated assets (e.g. culverts, bridges) is prepared for LGAs within the region by 2005.	• Local area inventories of transport assets.
II.	*Threat identification and risk assessment*	**I_1 MAT II.1**	The risk of high water tables and flooding for transport infrastructure is known within each local government area by 2009.	• Risk assessment modelling and surveys (including geophysics) undertaken for roads at risk.
III.	*Assessing the feasibility and cost benefits of management options*	**I_1 MAT III.1**	Assessment of engineering and revegetation options for groundwater reduction beneath roads by 2025.	• Feasibility assessment of technical options for prevention, recovery and adaptation. • Review current information (MRWA) and evaluate options for road risk assessment.
		I_1 MAT III.2	Assess alternative culvert materials and designs to suit changed catchment hydrology by 2007.	
		I_1 MAT III.3	Methods of road risk assessment are evaluated by 2005.	
IV.	*Setting and reviewing targets (RCTs and MATs)*	**I_1 MAT IV.1**	Priority roads for preventative action identified through regional transport policy development processes by 2007.	• Regional transport policy development.
V.	*Planning for key management actions*	**I_1 MAT V.1**	Local transport asset planning included in 30 Local Area Plans by 2006.	
VI.	*Building capacity for implementation*	**I_1 MAT VI.1**	By end of 2005 an education package is developed for LGAs, Main Roads, catchment or conservation groups and land managers, to encourage an understanding of the links between catchment management and the protection of key infrastructure.	• Liaise with stakeholders (incuding land managers) to design and adopt integrated catchment management approaches to infrastructure developments and maintenance. • Provide employment and training for suitable technical support.
		I_1 MAT VI.1	More than one full-time employee (or equivalent) with technical skills for transport infrastructure management integrated with landscape management is working with LGAs within the region by 2005.	
VII.	*Investment in implementation*	**I_1 MAT VII.1**	Ten sites are implemented demonstrating preventative management options for transport assets by 2007.	• Identify suitable locations with Local Area Plans. • Prepare Works Plans for each site. • Develop cost-sharing arrangements for implementation.
VIII	*Monitoring, evaluation and review*	**I_1 MAT VIII.1**	Monitoring of road assets at risk is initiated and arranged by 2006.	• Undertake road risk assessment surveys.

Avon Catchment Council community workshop

I2. Industry Support Infrastructure (Power, Telecommunications, Water)

20-year Targets: **$I_2T_{20}1$** Residential and industrial electricity demand is generated within the region at a level equivalent to 20% of current regional demand (500 MW) by 2025.

$I_2T_{20}2$ By 2025, 15% of water supplied through public infrastructure is sourced from within the region.

Table 50 Industry support infrastructure management action targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*	**I_2 MAT I.1**	Audit the amount of energy supplied to the Avon River Basin via the South West Integrated Supply Scheme and water through regional reticulated schemes by 2005.	• Assess annual electricity use (South West Integrated Supply Scheme) for the region. • Assess annual scheme water use for the region.
II.	*Threat identification and risk assessment*	**I_2 MAT II.1**	Assess the risk to pipelines within the region due to rising water tables as a part of Local Area Plans by 2005.	• Local inventory of risk to pipeline assets.
III.	*Assessing the feasibility and cost benefits of management options*	**I_2 MAT III.1**	The feasibility of options for regional bio-energy generation and alternative water sources is assessed by 2006.	
		I_2 MAT III.2	Assess the feasibility of a gas-fired power station within the region by 2008.	
IV.	*Setting and reviewing targets (RCTs and MATs)*			
V.	*Planning for key management actions*			• Integrate management actions for prevention or recovery of pipeline assets with other infrastructure and natural resource management.
VI.	*Building capacity for implementation*		I2 MAT VI.1 An extension program is developed and being delivered by 2007 that is intended to gain wide acceptance of alternative energy production and water supply development in the region as a necessary requirement for long-term sustainability and self-sufficiency of the region by communities and government.	• Promote identified opportunities for alternative energy production and water supply development in the region to communities, government and the private sector, as a mechanism for continued economic growth utilising local natural resources.
VII.	*Investment in implementation*	**I_2 MAT VII.1**	Establish one bio-energy plant within the Avon River Basin by 2008.	• Facilitate public and private investment into sustainable industry and town water (e.g. desalinisation and surface catchment initiatives). • Facilitate public and private investment into alternative energy generation projects in the Avon River Basin.
		I_2 MAT VII.1	10 MW renewable energy generated within the Avon River Basin by 2008.	
		I_2 MAT VII.1	Establish one desalinisation plant in the Avon River Basin by 2008.	
VIII.	*Monitoring, evaluation and review*			

Avon Catchment Council community workshop

I3. Community Infrastructure (Towns, Commercial and Farm Buildings, Recreational Facilities and Heritage)

20-year Targets: **$I_3T_{20}1$** By 2025, 10 rural towns in the Avon region have the risk of damage to infrastructure and heritage values due to salinity and flooding reduced by 50% compared with 2004 risk assessments.

$I_3T_{20}2$ The capacity of local communities to undertake NRM actions is supported by appropriate facilities, including those that have been developed by communities during the Decade of Landcare, by 2007.

Table 51 Community infrastucture management action targets and actions

Sequence of Eight		MATs (3-5 years)		MAs
I.	*Asset Identification*	**I_3 MAT I.1**	Rural town assets at risk within the region are identified by 2006.	• Identify rural towns with assets at risk to rising water tables that are not currently a part of the RTLA program.
II.	*Threat identification and risk assessment*	**I_3 MAT II.1**	Threats to community assets are included in 30 Local Area Plans by 2006.	• Undertake asset inventory assessment including town and farm assets as a part of local area planning.
		I_3 MAT II.2	Geophysical surveys are completed for 5 priority rural towns (RTLA program) by 2006.	• Arrange ground-based geophysical surveys for the 15 priority rural towns (RTLA program).
III.	*Assessing the feasibility and cost benefits of management options*	**I_3 MAT III.1**	Complete a feasibility study for a waste/stormwater recycling process and for desalinisation of pumped groundwater in the region by 2006.	
IV.	*Setting and reviewing targets (RCTs and MATs)*			
V.	*Planning for key management actions*	**I_3 MAT V.1**	Prepare Implementation Plans for 5 priority rural towns (RTLA program) by 2009.	• Identify the five priority rural towns.
VI.	*Building capacity for implementation*	**I_3 MAT VI.1**	Complete 5 Waterwise education and training programs as a part of implementation planning for the 5 priority rural towns by 2009.	• Develop appropriate Waterwise information and training. • Develop appropriate Water Sensitive Urban Design information. • Commercially based pilot/case studies are developed based on water use patterns to demonstrate alternative water supply technologies and encourage adoption of efficient water utilisation practices. • Develop communication packages targeted to key stakeholders and the general community on the role and function of the ARB NRM Strategy implementation. • Facilitate the development of knowledge and understanding of heritage and cultural values within the ARB and their role and benefit to the region's communities and NRM.
		I_3 MAT VI.2	Prepare a Water Sensitive Urban Design manual suitable for rural towns in the region by 2006.	
		I_3 MAT VI.3	A report and extension material is produced by 2006 for use by local government that identifies commercial 'drivers' of alternative water sources and water use patterns.	
		I_3 MAT VI.4	Inventories of heritage and cultural values are identified and assessed for 30 Local Government Authorities as a part of Local Area Plans for natural resource management by 2006.	
VII.	*Investment in implementation*	**I_3 MAT VII.1**	Implement Integrated Water Management Systems demonstration projects in two towns by 2006.	• Identify two towns most suitable for demonstration. • Prepare Works Plans for the water management demonstrations. • Develop cost-sharing arrangements with appropriate partners for the demonstration projects.
VIII.	*Monitoring, evaluation and review*	**I_3 MAT VIII.1**	Groundwater monitoring to show salinity risk in 10 priority rural towns (RTLA program) is established and providing biannual reports to ACC by 2006.	• Establish comprehensive monitoring at the 5 priority rural towns as a part of implementation planning. • Identify 5 other priority rural towns for monitoring. • Establish groundwater monitoring based on hydrological assessment. • Arrange coordinated monitoring and reporting.

Avon Catchment Council community workshop

5. Priorities and Trade-offs for Strategic Actions

5.1 Trade-off assessment

The preceding sections provide information in a logical sequence that leads towards targets for resource condition and the management actions required to meet these targets. It is recognised that not all actions can be prioritised due to the limitations of resources, time and information or knowledge. The Avon NRM Strategy is structured to address the differing priorities and the trade-off of benefits by investment in one action ahead of another.

The ACC has developed a set of criteria for recognising and managing the relative trade-offs that could occur. They are:

- The value of the assets (including national or state importance);
- Relative contribution towards the 'preferred future' for the Avon River Basin;
- The urgency for management (the level of threats);
- The feasibility or effectiveness of proposed actions;
- Prior investments (so that new investment adds substantial value);
- Existing priorities (including statutory obligations).

These criteria were considered for each of the 20-year Targets within asset classes during open workshop processes (May, 2004) attended by community people and agency representatives who expressed interest during the formal review period. The outcomes are based on the consequences of not investing in a long-term target. Table 52 provides an assessment of the trade-offs that could be expected by prioritised investment.

5.2 Priorities for investment

The ACC considers that all 20-Year Targets are a high priority and expects full achievement of these targets within the 20-year period. However, it is also recognised that not all long-term targets required immediate investment, and that investment in other targets is contingent upon other prior investment or achievement of a set of management action outcomes.

Priorities for investment are based on current information. They are derived from the trade-off assessment and by consideration of priority setting criteria:

1. Current high regional concern,
2. High value assets,
3. High threat level, and
4. Technically feasible options are available.

These criteria are assessed in Table 52. From these criteria assessments, priorites for investment in the 20-Year Targets have been identified into three categories:

A – Urgent, and important first step (18 targets)
B – Important but not time-critical (11 targets)
C – Important but linked to other targets (5 targets).

Priorities for investment in Management Action Targets are identified according to the Sequence of Eight, i.e. the highest priorities are for actions first on the sequenced list.

Table 52 Trade-off assessment for investment in the 20-Year Targets of the Avon NRM Strategy

Matters for Targets in the Avon River Basin	T_{20}	Trade-Off Assessment	Priority Criteria[1]				Investment Priority[2]
			1	2	3	4	
Avon River and Floodplains	$W_1T_{20}1$	The Swan-Canning Estuary is an iconic asset and important to the character of Perth. Targets for nutrient contribution from the Avon River have been set under the *Environmental Protection Policy – Swan-Canning*. These targets are currently not exceeded. Integrated catchment management actions for water and land assets as well as actions for riparian zone management will ensure that the probability of exceeding the target is reduced within 20 years. There is no requirement for direct investment in this target. This target provides a useful measure of the 'health' of the Avon River Basin.	√	√√√	√√	√	**C**
	$W_1T_{20}2$	The major pools of the Avon River have filled significantly over the past 30-40 years due mostly to engineering works for flood reduction. Channel erosion and sedimentation processes are continuing. Most pools will be completely filled, and there will be increasing sediment transport to the upper reaches of the Swan River without preventative and recovery actions. This is an urgent issue that must be dealt with as a high priority. There are commercial opportunities for excavated coarse sediments.	√√	√√	√√√	√√	**A**
Major and Minor Tributaries	$W_2T_{20}1$	The channel and riparian zone of most major and minor tributaries in the Avon River Basin have reduced capacity to strip nutrients and sediments from stream flow, and contain groundwater rise. Rehabilitation of these functions is a long-term process. The benefits from major investment may be relatively low in the short-term, however the long-term cumulated benefits of healthy functioning riparian systems should be high. Rehabilitation of waterways should be a part of many landscape-scale projects.	√	√√	√√	√√	**A**
		Riparian ecosystems provide important habitat value and other ecosystem services within the region although they have been generally degraded and are further threatened. Based on foreshore survey results, areas of high value riparian ecosystems can be identified. Relatively low investment in fencing to control livestock in these areas will deliver medium to long-term multiple benefits. Actions for this target are considered to be a high priority.	√√	√√√	√√√	√√√	**A**
Salt Lakes and Wetlands	$B_4T_{20}1$	The aquatic ecosystems of salt lakes and river pools are poorly understood yet threats to them are increasing. There is an urgent need to better understand the values and function of aquatic ecosystems, and the impacts that may occur due to increasing salinity, nutrients or acidity. This knowledge should precede implementation of significant engineering options for salinity control so as to better understand the environmental trade-off that may result from protection or recovery of other assets or otherwise prevent or avoid a loss. This is a high priority for investment.	√√	√√	√√√	√	**A**
	$B_4T_{20}2$	Salt lake systems are a dominant landscape feature in the Avon River Basin with many hydrological, ecological and social values. However, their location in the valley floor suggests they are further threatened by groundwater rise. The use of lakes as receiving water bodies for regional drainage schemes is of increasing community interest. While this may have low impact in large lakes, others are probably vulnerable. There is an urgent requirement to better understand the salt lake systems prior to trial or full implementation of regional drainage schemes.	√√	√√	√√	√√	**A**

Matters for Targets in the Avon River Basin	T_{20}	Trade-Off Assessment	Priority Criteria[1] 1	2	3	4	Investment Priority[2]
Salt Lakes and Wetlands (continued)	**$B_4T_{20}3$**	The listed wetlands of national significance are currently not well recognised by communities within the region. The value of these assets is high by their national listing, however the threats to the wetlands are currently not well known. Threat assessment management planning and communications with local communities are a high priority for actions. The level of investment required for actions to protect these assets is currently not identified.	√	√√√	√√	√√	**A**
Stream Water Quality	**$W_3T_{20}1$**	Surface water is a significant asset for farm and domestic supply. Many farms have annual water deficits met by reticulated scheme water supply. While there is not an urgent need to reduce dependence on scheme water, incentives to do so will also achieve other land management benefits. The short-term return to investment in this target should be high.	√√	√√√	√√	√√√	**B**
	$W_3T_{20}2$	Although not generally recognised by community as a significant issue in the region, there is increasing demand to retain freshwater stream-flow in higher rainfall areas. The issue can be addressed with minimal investment by local government through Town Planning Schemes. The Avon Arc Sub-Regional Strategy should be amended for this purpose.	√	√√	√	√√√	**B**
Regional Groundwater	**$W_4T_{20}1$**	While there is some potential to identify additional groundwater aquifers for commercial and community benefit, there is no urgency to do so. Fresh unconfined aquifers used for supply are managed without conflict. Initiatives to further investigate groundwater supplies have been taken by local communities (e.g. near Brookton and Beverley). This is not a high priority for further investment.	√	√√	√	√√	**B**
	$W_4T_{20}2$	Rising regional groundwater levels are a major concern within the region affecting many land, water, biodiversity and infrastructure assets. However, the options to significantly reverse the rising trends in a cost-effective way are limited. Revegetation options to reduce groundwater recharge will displace profitable agriculture and have a long delay period before benefits are derived. Options to enhance discharge, including drainage and pumping, may have immediate localised benefits, but there are also potential off-site impacts and ongoing maintenance costs. The net benefit from significant investment in currently available options to contain or recover from regional groundwater rise is probably low. However, the community concern about the impacts of salinity and community interest in finding a cost-effective solution is high. Research and development investment in recharge control and engineering options remains a high priority.	√√√	√√√	√√√	√	**A**
	$W_4T_{20}3$ and 4	Environmental impacts from both mining and agricultural operations can effectively be managed through adoption of best management practices and, if required, under statutory licence conditions. These arrangements are considered urgent and require high priority actions, but may not require a high level of investment.	√√√	√√	√√√	√√√	**A**
Soil Condition	**$L_{1.1}T_{20}1$**	Increasing soil acidity is affecting agricultural productivity. The response for topsoil acidity by liming is effective and should be more widely adopted. Investment in this target should be primarily derived from within the agricultural industry. Additional industry investment is required to identify changes to farming systems that will reduce the causes of soil acidity. Public investment for information extension should be low but will derive significant benefits. There is limited impact on other assets if this target is not achieved.	√√	√√	√√√	√√√	**B**

Matters for Targets in the Avon River Basin	T_{20}	Trade-Off Assessment	Priority Criteria[1] 1	2	3	4	Investment Priority[2]
Soil Condition (continued)	$L_{1.2}T_{20}1$	Actions to improve soil structure and reduce soil compaction provide short and long-term production benefits. These are considered industry best practice components of sustainable farming systems. New technological developments should provide future options for reduction in soil compaction. Improvement to soil structure does improve rainfall infiltration and reduce surface water runoff and associate erosion and sedimentation processes. While there are industry benefits by adoption of best practice, there are also environmental and social benefits to be derived. A medium priority for investment, particularly for extension of best practice, is considered appropriate.	√√	√√	√√√	√√	**B**
	$L_{1.3}T_{20}1$	The control of soil erosion and reduced waterlogging is relatively easily achieved using well-established integrated water management practices. The short-term production benefits usually exceed the costs so should be considered as private investment. However, there are considerable environmental and social benefits to be derived from integrated water management. The priority for investment in planning and provision of technical advice is high.	√√	√√	√√√	√√√	**A**
	$L_{1.4}T_{20}1$	Practices to reduce wind erosion risk are well known but not widely adopted because of some practical inconvenience and crop disease risk by stubble retention. The effect of not adopting risk reduction practices is mostly on soil productivity, but also on degradation of important assets. Investment in communication of the importance of wind erosion risk reduction is a medium priority, however relatively low investment should result in a high return on investment.	√√	√√	√√√	√√√	**A**
	$L_{1.5}T_{20}1$	Improving soil fertility provides benefits to the agricultural industry, which is a national priority. Soils in the Wheatbelt are inherently infertile. On-farm investment to improve fertility needs to be maintained. While improved farm productivity provides economic and social benefits it does not necessarily provide direct environmental benefit.	√√	√√	√√	√√√	**B**
Dryland Salinity	$L_2T_{20}1$	Urgent need to manage areas with assets at risk to salinity due to rising local flow aquifer systems. The links to surface water management are important. Actions require a high level of investment over a long time period, however the benefits of managing salinity where aquifers are responsive to intervention are high. The loss of asset values by taking no action is unacceptable to regional communities. This target is a high priority for investment.	√√√	√√√	√√√	√√√	**A**
	$L_2T_{20}2$	Most valuable assets are located in valley floor positions where the risk of groundwater rise is greatest. Investment in actions to reduce the risk, recover asset values or adapt land use will provide multiple benefits, so achievement of this target is a high priority. Salt-affected land has production potential with adaptation to currently available options. Management of regional groundwater to reduce the risk to valley floor assets requires substantial landscape change. Profitable options to achieve this require further research and development. Investment in this area of research and development is a high priority.	√√√	√√√	√√√	√√	**A**

Matters for Targets in the Avon River Basin	T_{20}	Trade-Off Assessment	Priority Criteria[1]				Investment Priority[2]
			1	2	3	4	
Plant and Animal Pests and Diseases (Industry and Environment)	$L_3T_{20}1$	There are existing statutory responsibilities on landowners/managers to control plant and animal pests. Existing government structures administer and regulate these responsibilities. Further investment will add value to existing structures. The urgency for further action is high, particularly for biodiversity as the control of plant and animal pests is required for achievement of the other 20-Year Targets (e.g. reintroduction of native animals, rehabilitation of waterways). The priority for investment in coordinated community action for plant and animal pest control is high. Community investment in disease control for economic and environmental benefit is also a priority.	√√	√√√	√√	√√√	**A**
Native Vegetation (Avon Arc, Wheatbelt and Crown/Pastoral)	$B_1T_{20}1$	The high value of biodiversity and the ongoing threatening processes require a high priority response to achieve the target in the Wheatbelt and Avon Arc zones. The Crown/Pastoral zone should require only low investment but will provide high long-term benefits. The highly fragmented condition of reserves and remnants within the region underlies the high priority for developing community capacity, particularly through interest groups and local government, to manage for biodiversity values. Inadequate investment in this target would diminish the value of significant prior investment.	√√√	√√√	√√√	√√√	**A**
Threatened Species and Communities	$B_3T_{20}1$	Total extinction and regional extinction are considered unacceptable. With increasing threats, there is potential for more species and ecological communities to become critically endangered. It is a high priority to prevent this occurring. The cost of recovery of endangered species is normally very high. Preventative action by identifying vulnerable species or communities at further risk is a high priority.	√√√	√√√	√√√	√√	**C**
	$B_3T_{20}2$	The level of understanding by communities within the region about which species or ecological communities are vulnerable, endangered or critically endangered is not particularly high. Investment in increased community awareness and coordinated community action to reduce the risks or recover endangered species/communities is a high priority.	√√	√√√	√√√	√√	**A**
	$B_3T_{20}3$ and 4	Carnaby's black cockatoo is an iconic species that is significantly threatened by diminished habitat condition. Recovery of this species within the region will require coordinated community effort and support. Loss of this species to the region would be very significant, and would also indicate substantial habitat decline that will affect many other species dependent upon tree hollows for breeding.	√√√	√√√	√√√	√√	**A**
Natural Diversity	$B_2T_{20}1$	A landscape approach to managing species and ecological communities is not well understood but is considered important, particularly with highly fragmented and altered landscapes. Investment in developing this understanding by people in communities, agencies and other organisations is a high priority. Management for natural diversity outcomes at a landscape scale requires long-term investment, however the potential for multiple-benefit outcomes is high. There is considerable prior investment in existing landscape-scale projects.	√	√√√	√√√	√√	**A**

Matters for Targets in the Avon River Basin	T_{20}	Trade-Off Assessment	Priority Criteria[1]				Investment Priority[2]
			1	2	3	4	
Natural Diversity (continued)	$B_2T_{20}2$	Understanding the cause of declining health of wandoo woodlands is a high priority as this knowledge will assist with other landscape-scale management processes. In the short term, low investment is required to support an existing research and recovery program. Strong community interest in the condition of these woodlands suggests that not achieving the target would be unacceptable.	√√	√√√	√√√	√	**B**
	$B_2T_{20}3$	The extent of impacts due to dieback within the region is not well understood. If extensive, the impact on biodiversity values could be substantial. There is a high priority for actions to assess risks within the region due to this threat. Preventative actions for dieback control are a substantially better investment than recovery from impacts or ecosystem rehabilitation.	√	√√√	?	√√	**A**
Regional Water and Energy Supply	$I_2T_{20}1$	Reliable electricity supply within the region will facilitate local industry development and diversification which in turn will provide capacity for improved natural resource management. Opportunities for bio-energy production linked to revegetation (e.g. with oil mallees) will provide multiple benefits, including reducing greenhouse gas emissions by lower dependence on coal-fired power station energy sources. The priority for investment is moderate, although investment should be responsive to opportunities through new technology that may arise.	√√	√√	N/A	√	**C**
	$I_2T_{20}2$	Opportunities to supply additional water sourced from within the region is linked to opportunities for desalinisation of groundwater pumped to protect high-value assets, including towns. The feasibility of the options to provide water with suitable quality is to be further researched. The priority for significant investment is moderate, until the feasibility and economic benefits are better demonstrated.	√√	√√√	N/A	√√	**C**
Regional Infrastructure, Roads and Towns	$I_1T_{20}1$	The extent and value of roads at risk within the region suggests that investment in preventative actions are a high priority. There is currently a high cost in road repair and maintenance, particularly for local government, however there is very limited investment in preventative actions. There is considerable potential for multiple-asset benefits by co-investment in valley floor management and coordinated surface water management.	√√√	√√√	√√√	√√√	**C**
	$I_3T_{20}1$	Rural towns have high value assets, many at risk from rising water tables. There is considerable prior investment through the Rural Towns – Liquid Assets program. Ongoing investment in this program is considered to be a high priority to ensure the social and economic viability of rural towns and because they are central to development of community capacity for natural resource management.	√√√	√√√	√√√	√√√	**B**
Community Capacity for NRM	$B_5T_{20}1$	Biodiversity values transcend regional boundaries. There is a high priority requirement to initiate or support cross-boundary or larger-scale projects, programs or policy development. Relatively low investment in innovative cross-regional biodiversity projects has potential to attract further public and private investment. These opportunities are not well recognised within the region.	√	√√√	√√	√√√	**B**
	$I_3T_{20}2$	Capacity for natural resource management built over the past decade or more is a significant regional asset that should not be lost. Investment in community capacity is necessary to achieve local and regional targets, and is a high priority.	√√√	√√	N/A	√√√	**A**

Matters for Targets in the Avon River Basin	T_{20}	Trade-Off Assessment	Priority Criteria[1] 1	2	3	4	Investment Priority[2]
Social, Heritage and Cultural Values		Heritage and cultural values within the region are significant although the multiple values (Aboriginal and European) are not fully appreciated. The major investment required is in knowledge and understanding of these values as an integral part of natural resource management. The priority for investment is medium, with the assumption that understanding and protecting heritage and cultural values is integrated within natural resource management projects.	√√	√√√	√√	√√√	**B**

Note 1: **1** = Current high regional community concern. **2** = High value assets. **3** = High threat level. **4** = Technical feasibility.
Note 2: **A** = Urgent, important first step. **B** = Important, but not-time critical. **C** = Important, but linked to other targets.

Avon Catchment Council community workshop

6. Implementation Framework

Implementing the Avon NRM Strategy to achieve the aspirational goals and 20-Year Targets for the region requires tasks that range from local works to policy review and adjustment. The Avon NRM Implementation Framework provides the basis for this to occur with efficient and effective use of public and private resources.

The implementation framework also provides the structure for development of the Avon NRM Investment Plan and Avon NRM Partnership Arrangements.

6.1 Principles of the framework

The key principles of NRM underlying the Avon NRM Implementation Framework are:

1. Integration of management for the full range of NRM issues relevant at a local landscape scale and, where relevant, through sustainable industry development.

2. Public investment is based on strategic assessment of NRM assets and threatening processes (Investment Plan).

3. Priorities for management actions are based on regional goals and targets that are derived from international, national, state and local priorities, policies, frameworks and agreements.

4. Communities are engaged and empowered to take efficient and effective action through consultation and capacity building processes.

5. Partners are engaged and committed to make effective and efficient contributions to NRM management within the region according to the Avon NRM Strategy (Partnership Agreements).

6. Consideration of environmental, social, cultural, heritage and economic values when assessing the impact of threats to NRM assets, or of proposed management actions.

7. Compliance with national and state legislation and regulation frameworks.

8. Assessable and applicable regional information, knowledge and skills developed through integration of local, scientific and other experience.

9. Decisions for regional NRM that are:

    a. based on scientific, technical and economic analysis where feasible, or otherwise on precautionary judgements,
    b. addressing the causes of problems rather than the symptoms,
    c. transparent and understood by community and partners,
    d. adaptive to management performance measures.

10. Efficient and effective regional delivery through devolved organisational capacity and adoption of a range of policy and planning instruments.

11. Implementation is undertaken recognising the importance of planning and implementation at a range of scales within the region

12. Monitoring and evaluation undertaken within a systems-management context.

These principles are maintained through all stages of implementation.

6.2 Regional zones for planning and management

The Avon River Basin has three distinctly different zones for regional-scale planning and management; they provide for regional differentiation of investment for implementation based on social, economic and environmental factors. They are:

1. The Avon Arc

The Avon Arc zone is defined by the Shires of Toodyay, Northam, York, Beverley and Brookton and the Town of Northam in the Avon River Basin. This zone is geomorphologically distinct as a 'rejuvenated' landscape

dominated by the main channel and minor tributaries of the Avon River. The eastern boundary of this zone is approximately aligned with the geomorphic axis of landscape uplift (the Meckering Line).

It differs socially and economically to other zones in the Avon River Basin now and as may be expected into the future. There are increasing population trends for the LGAs of this zone and there are changes towards more intensive agriculture and recreational or lifestyle land uses.

Local government planning in this zone is guided by the Avon Arc Sub-regional Strategy. This is supported by an environmental audit and landscape analysis (WA Planning Commission, 2001). These documents are used to assist in the development of Town Planning Schemes for local government under the *Town Planning and Development Act 1928*. This approach provides a suitable basis for inclusion of priority actions of the Avon NRM Strategy within local government planning, policies and administration particularly because the LGAs are forming a regional association of Councils (the Avon Organisation of Councils – AROC).

The area of the Avon Arc zone is 6 996 km^2 (5.9% of the Avon River Basin). This zone occurs within the state electoral boundary of Avon, with the exception of the Shire of Toodyay that is within the electorate of Moore.

2. The Wheatbelt

The Wheatbelt zone extends inland from the Avon Arc and the Meckering Line. East of this, the 'ancient' landscapes have low relief and subdued natural drainage where the requirements for integrated landscape management differ. The landscape is dominated by the broad valley floors and salt lake chains of the major tributaries to the Avon River. Although rainfall decreases inland, extensive dryland farming is the predominant land use.

The increasing impacts of rising water tables, including salinity, waterlogging and flooding, are significant within this zone.

Not all LGAs in the Wheatbelt zone have Town Planning Schemes, however some are cooperating to form a Regional Organisation of Councils (e.g. the North East Wheatbelt ROC). These arrangements provide a substantial opportunity for regional-scale implementation of NRM actions.

The area of the Wheatbelt zone is 75 662 km^2 (64.3% of the Avon River Basin). This zone is predominately within the state electoral boundaries of Merredin and Roe although it also extends into the Moore, Avon, Wagin, and Murchison-Eyre electorates.

3. The Crown / Pastoral

East of the Wheatbelt zone is land not released for agricultural use. A relatively small proportion of this zone is under Pastoral Lease but the remaining area is unoccupied Crown Land with a limited area under mining leases. Groundwater allocation licences are issued for mining leases under the *Rights in Water and Irrigation Act 1914*.

Management of natural resources within the Crown/ Pastoral zone clearly differs from the other two zones. Although natural vegetation has been disturbed or degraded by grazing and mining (exploration lines and timber harvesting for energy), most areas now have increasing biodiversity values with limited management intervention required.

The area of the Crown / Pastoral zone is 35 047 km^2 (29.8% of the Avon River Basin). This zone lies within the state electoral boundary for Murchison-Eyre.

The location of the three regional management zones for the Avon River Basin is shown in Map 10.

Adoption of zones for implementation does not influence regional NRM priorities. The major benefit of a zone approach is in negotiating partnership arrangements and investment planning for implementation. For example, the Avon Arc zone with its higher population will have quite different requirements for capacity building. It is recognised that the zones are not directly relevant for biodiversity conservation.

6.3 Preparation of Local Area Plans (LAPs)

While it is recognised that some aspects of NRM are best considered at the regional or sub-regional scales, planning at a local landscape scale provides an effective format for integrated management for multiple private and public benefits within the Avon River Basin. Biophysical processes and many natural resource and infrastructure assets occur at a landscape scale. It is at this scale that local communities focus their common interest.

The ACC recognises the current local government areas as the local communities of the Avon River Basin. Implementation is based substantially on support through local community and local government initiative. To achieve this, the ACC will provide support for all LGAs that are significantly within the region to prepare a Local Area Plan. Some already have LAPs that are well advanced however most have only preliminary stage planning for NRM.

The intent is to have all LAPs of similar format and aligned with the Avon NRM Strategy. It is anticipated that each LAP

Map 10 Regional management zones in the Avon River Basin

will be a set of thematic layers, one for each of the Avon Matters for Targets that are relevant to the LGA.

The primary purpose of the LAPs is to guide local area actions according to local community priorities. However, these plans will also provide an important delivery framework for regional-scale implementation. In some situations, this will require linking and integration of several adjacent LAPs.

6.4 Collation of priority assets

The focus of the Avon NRM Strategy is on management of high value regional assets that are at risk. This requires identification of regional assets that are of local, state or national significance. The Strategy has identified assets of national significance, and the Salinity Investment Framework (SIF) has listed assets of state significance (Department of Environment, 2003). Assets from these information sets are proposed as regional priority assets. In addition, the ACC is supporting local communities to identify assets of local significance as a part of local area planning. All assets are grouped into the Asset Classes (Section 4).

The process for identifying regional priority assets from the inventories of local assets will be directed by Regional Delivery Program Implementation Teams (RDP IT) (Section 6.6) set up by the ACC. The criteria for priority assessment will differ for each Asset Class, however emphasis will be on the value of the asset and the level of threat to it.

6.5 Information management

Information for all assets and LAPs will be arranged in two formats:

1. **The Avon River Basin Database** – a spreadsheet format database that lists all assets, targets, actions and monitoring information according to the structure of the Strategy.

2. **The Avon Asset Spatial Analysis** – all regional priority assets will be located with a Geographic Information System (GIS) database with separate levels for each Asset Class. This will provide for spatial analysis by overlaying levels of priority asset information to identify areas where there is a common occurrence of regional priority assets from a range of Asset Classes. This will be undertaken initially for each LAP, then cumulatively at a regional scale.

Map 11 shows an example of initial asset analysis for the Shire of Corrigin and adjacent areas.

6.6 Integration through Regional Delivery Programs (RDPs)

The Regional Delivery Programs (RDPs) for the Avon NRM Strategy show how the 20-Year Targets (T_{20}s) and Management Action Targets (MATs) will be met through coordinated regional-scale actions. They will focus development of capacity and delivery of resources through linked and integrated Local Area Plans (LAPs) and other jointly funded projects to where targeted investment derives benefits for a range of priority NRM assets.

The significance of the RDPs is that they provide:

- The key mechanism for integrated management at a landscape scale to achieve targets for resource condition change;
- The basis for a stable, long-term delivery of programs that will attract a range of partners and funding options;
- The opportunity for people to work in partnership at a landscape scale;
- A basis for developing the regional capacity for delivery (the resources, skills, information and knowledge required to achieve the targets); and
- A key part of the basis for developing the Investment Plan (identifying the full cost for achieving the 20-Year Targets).

Each RDP will consist of:

- The Avon Matters for Targets that it addresses and the associated set of priority 20-Year Targets;
- The set of MATs to achieve the 20-Year Targets;
- The existing policies, strategies, agency programs and other initiatives that are included;
- A Business Plan for delivery of actions (the interface to the Investment Plan);
- Identification of the partners for delivery and the roles and responsibilities they have, including leadership;
- The capacity required for delivery, including funding and people;
- Social, economic and environmental benefit/impact assessment;
- Information and knowledge management;
- Community capacity and leadership;
- A Communications Plan;
- Indicators for program monitoring and evaluation.

There are four RDPs proposed (see Figure 9):

1. **Integrated Water Management**
2. **Sustainable Industry Development**
3. **Natural Diversity**
4. **Capacity Building.**

Map 11 Preliminary spatial asset collation for the Shire of Corrigin

Each RDP has a proposed set of Sub-programs within which projects will be developed for regional delivery of implementation actions. Some Sub-programs are currently well developed while others are yet to be initiated. It is expected that existing partner programs, including those of state and local government agencies and other partner organisations, will be aligned with the RDPs.

The ACC will ensure that appropriate capacity is built for regional delivery through the Capacity Building RDP. This will add substantially to existing local community capacity. It will also facilitate the appropriate policy, planning and statutory arrangements for effective and efficient implementation of the RDPs, through the Institutional Planning, and Policy Sub-program.

The processes for associating assets, targets and actions with the RDP are shown in Figure 9. Some targets are specifically identified for Capacity Building, however it is recognised that this RDP is required to achieve all targets.

6.6.1 Integrated Water Management (NRM Delivery)

The Integrated Water Management (IWM) RDP brings together management for all aspects of the water cycle, including water use and management of rivers and streams. It has strong links to biodiversity conservation and land use, particularly for agriculture. The proposed Sub-programs are:

6.6.1.1 Catchment Water Management Sub-program

Includes:

- Regional salinity risk and drainage assessment based on the existing the regional drainage framework (through the Engineering Evaluation Initiative – EEI);
- Regional groundwater management strategies;
- Demonstration of engineering options through the EEI;
- Linkage with the WA Channel Group initiatives;
- Assessment of off-site impacts of engineering options (including assessment of acid groundwater risk and other impacts on receiving water bodies);
- Integrated catchment water management planning and implementation;
- Increased technical capacity, including applied hydrologists.

6.6.1.2 Valley Floor Management Sub-program

Includes:

- Salinity risk assessment (sub-regional and local scales);
- Integrated surface and groundwater management (including assessment for drainage and groundwater pumping);
- Saltland shrubs and pastures for salt-affected land;
- Integrated management of biodiversity and infrastructure assets threatened by salinity;
- Review of options for land restoration through purchase and recovery programs.

6.6.1.3 River and Tributaries Restoration Sub-program

Includes:

- Avon Rivercare Program (existing program of riparian zone and channel restoration works);
- Avon River Recovery Plans (existing local implementation programs);
- Avon River pool recovery program (including sediment management);
- Mortlock River management program;
- Nutrient export reduction program;
- Priority tributaries management (including survey, assessment, restoration);
- Flood and floodplain management program;
- Saline lake management program;
- Reconstruction of priority creeks (within LAPs);
- Identification and management of heritage and cultural water assets, including Aboriginal interests.

6.6.2 Sustainable Industry Development (NRM Delivery)

The Sustainable Industry Development (SID) RDP brings together all aspects of industry development to support effective and efficient natural resource management, including dealing with salinity and rising water tables, and promoting new sustainable and profitable industries. It also includes the management of the adverse impacts on existing infrastructure and considers additional industry requirements for sustainable industry development. The proposed Sub-programs are:

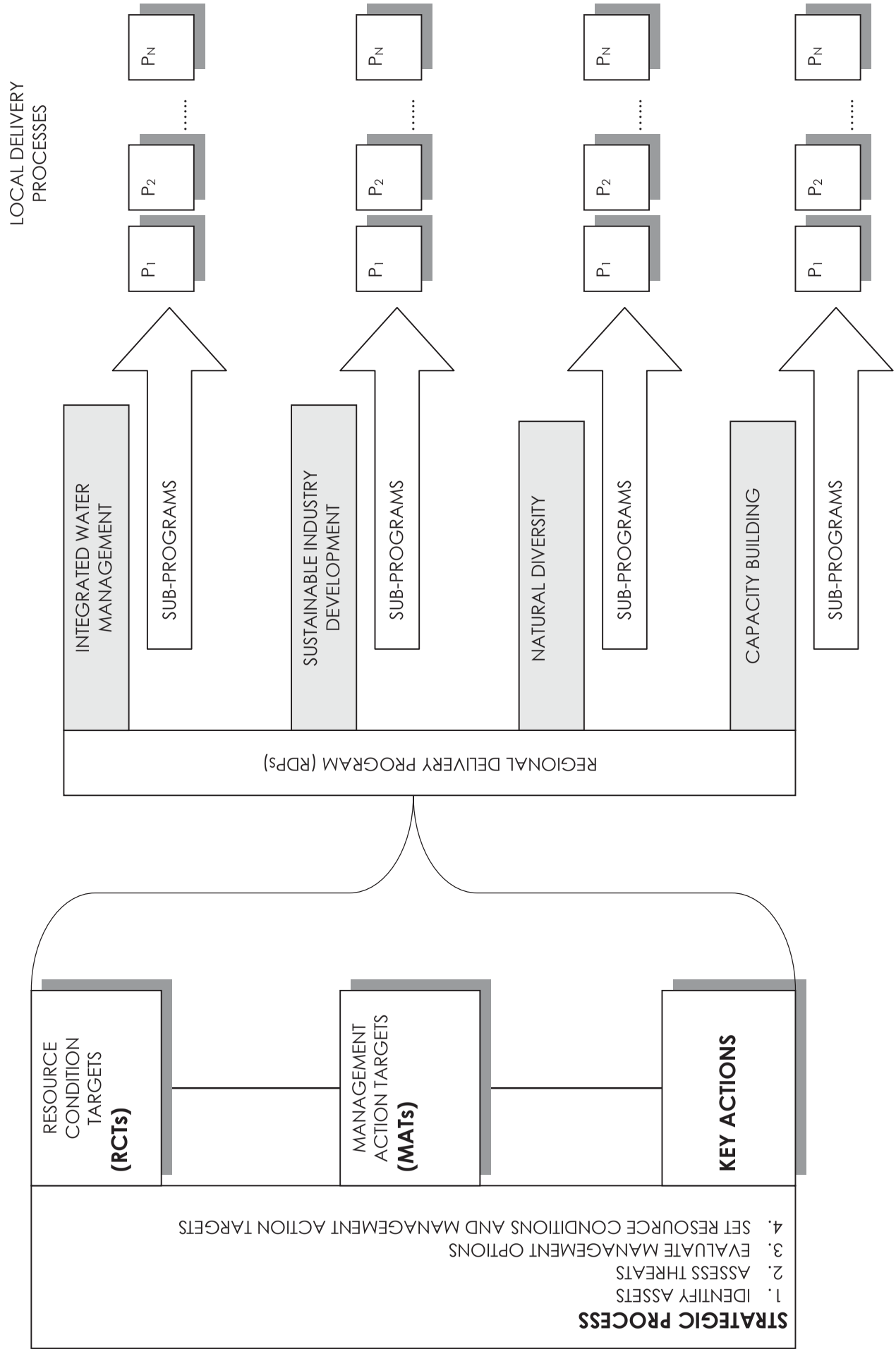


Figure 9 Process for associating Targets and Actions with RDPs

6.6.2.1 Sustainable Agricultural Industry Development Sub-program

Includes:

- Sustainable industry best practice development, recognition and adoption for:
  - Soil acidity
  - Soil structure decline
  - Soil compaction
  - Water erosion and waterlogging
  - Lower groundwater recharge
  - Wind erosion control
  - Soil fertility;
- Perennial pastures for groundwater control;
- Development of new plant-based solutions for groundwater control (linkage with CRC – Plant-base Solutions for Salinity);
- Support for local industry development groups;
- Biosecurity;
- Use of demonstration catchments to extend best practice information;
- Further industry engagement in NRM (including WANTFA, Grain and Graze, Land Water and Wool, Million Hectares programs and other programs);
- Development and support of networks for knowledge, information and learning;
- Information suited to small-scale landholders.

6.6.2.2 Tree Crops Sub-program

Includes:

- Avon River Basin Tree Crops Development Strategy (existing Avon Catchment Council/FPC partnership initiative) including a Coordinator (existing funding through NLP);
- Use of long-term tree crops for groundwater management;
- The SEARCH and related programs to identify potential commercial revegetation options;
- Forest Products Commission programs (commercial eucalypts, maritime pine and sandalwood);
- Oil Mallee Association and initiatives (including resource development and infrastructure required for processing);
- Carbon sequestration opportunities (including international initiatives);
- Support for grower groups (e.g. the Avon Sandalwood Network and the Australian Master Tree Grower Network).

6.6.2.3 Infrastructure Sub-program

Includes:

- Salinity risk assessment for roads and rural towns;
- Social, economic and environmental impact assessment of threats;
- Planning for integrated projects to prevent salinity, waterlogging and flood damage to roads as well as other adjacent NRM assets;
- Implementation of preventative and recovery works integrated within local landscapes;
- Review of infrastructure requirements for new NRM initiatives, including:
  - Avon renewable energy program,
  - Avon sustainable water use program,
  - Regional transport policy review;
- Partnership arrangements with key organisations for road and rail management.

6.6.2.4 Industry Water Use Sub-program

Includes:

- Rural water supply and drought-proof planning and implementation;
- Development of value-adding enterprises for use of discharge water from groundwater pumping or drainage;
- Integration of salinity management strategies with water resource development and industry enhancement;
- Survey and assessment of further groundwater resources suitable for use on a sustainable yield basis;
- Negotiated arrangements for maximum sustainable use of known groundwater resources;
- Evaluation of opportunities for use of saline water resources;
- Ongoing licence arrangements for water allocation to the mining industry, and for discharge of waste water.

6.6.3 Natural Diversity Program (NRM Delivery)

The Natural Diversity (ND) RDP considers all aspects of conserving and enhancing natural biodiversity within the

Avon River region at a range of scales across landscapes. It includes responses to the threatening processes, integrating with land use, linking to relevant aspects of water management and involving the community and landowners. The proposed Sub-programs are:

6.6.3.1 Native Vegetation Conservation Sub-program

Includes:

- Public reserve enhancement and management;
- Private remnant vegetation management for priority vegetation associations;
- Road and rail reserve management;
- Crown/Pastoral zone vegetation management.

6.6.3.2 Natural Diversity Sub-program

Includes:

- Identification of priority landscapes for biodiversity management, including Recovery Catchments and Representative Landscapes and considering specific hotspots and areas of high endemism;
- Developing opportunities for integrating biodiversity with agricultural land use and with other NRM practices;
- Management of areas or ecosystems with high public concern (e.g. wandoo woodlands);
- Coordinated management of plant and animal pests and diseases;
- Community engagement in landscape-scale biodiversity management.

6.6.3.3 Threatened Species and Ecological Communities Sub-program

Includes:

- Revised listing of threatened species and ecological communities based on new information;
- Recovery planning and implementation for critically endangered and endangered species and communities (landscape-scale approach adopted where appropriate);
- Understanding the processes and extent of threatening processes (e.g. for dieback *Phythopthora* spp.);
- Understanding aquatic ecosystems and recognising threatened species;
- Icon species recovery projects (e.g. for Carnaby's black cockatoo).

6.6.3.4 Salt Lakes and Wetlands Sub-program

Includes:

- Understanding the hydrological and ecological functions of regional salt lake systems;
- Identifying wetlands and lakes that are assets of regional significance;
- Assessing the potential impacts of substantially increased salt-affected areas or discharge from drainage options to control salinity in regional salt lake systems;
- Preparing management guidelines for priority wetland and lake assets;
- Enhancement of priority areas of riparian vegetation on the Avon River and its major and minor tributaries;
- Understanding and protection of aquatic fauna;
- Building community capacity for wetland and lake management.

6.6.3.5 Regional Biodiversity Sub-program

Includes:

- Identification and assessment of potential macro-corridors;
- Regional-scale assets of significance (e.g. granite outcrops);
- Cross-regional ecosystem management;
- Protection and enhancement of migratory routes and summer or drought refuge;
- Coordinated community approach to pest plan and animal control;
- Regional monitoring program for change processes (e.g. for abundance and extent of bird populations);
- Shared information, knowledge and skills.

6.6.4 Capacity Building Program (NRM Support)

The regional Capacity Building (CB) RDP covers all aspects of capacity building to support the effective and efficient delivery of NRM in the Avon region. It includes capacity building, training and support to local communities, landowners and land managers. Involvement by local government is a significant opportunity for regional NRM as

these organisations are highly experienced with governance, administration and project management, and have regulatory powers. The proposed Sub-programs are:

6.6.4.1 Capacity for RDP Implementation Sub-Program

Includes:

- Business and implementation planning;
- Development of four Regional Delivery Teams including the RDP Implementation Team (community and agency steering committee), Coordinators and Project Teams. This is to include:
  - Leadership
  - Governance and management
  - Roles and responsibilities
  - Succession staffing
  - Training and skills development
  - Monitoring and evaluation;
- Training and support for Regional Delivery Team members;
- Partnership support arrangements;
- Research and development;
- Integrating science with management practice;
- Developing a regional mind-set and dealing with big-picture decisions and regional-scale change mechanisms;
- Information, knowledge and communications;
- Project planning and management;
- Adaptive management processes according to the evolving preferred future for the Avon River Basin;
- Cost-sharing arrangements and other implementation mechanisms;
- Financial planning and accounting;
- Monitoring and evaluation (for programs and for resource condition).

6.6.4.2 Community Capacity Sub-program

Includes:

- Assessment of current community capacity;
- Local NRM asset assessment;
- Development of Local Area Plans;
- Integrated farm and catchment planning;
- Understanding and supporting volunteerism;
- Recognising local cultures and the capacity for change;
- Aboriginal community involvement;
- Hydrological/hydro-geological investigations and advice;
- Re-vegetation and remnant vegetation advice;
- Community group and leadership development and support.

6.6.4.3 Local Government Partnership Sub-program

Includes:

- Review of roles, responsibilities and opportunities for LGAs in NRM;
- Local Area Plan preparation (with linkage to regional 20-Year Targets);
- Support for project development and management through sub-regional organisations of LGAs.

6.6.4.4 Aboriginal Community Involvement Sub-program

Includes:

- Identification of cultural and heritage assets valued by Aboriginal communities that are threatened or can be enhanced through NRM efforts;
- Recognition of Aboriginal knowledge of the landscape and inclusion of this knowledge in planning processes;
- Development of opportunities for shared information and understanding between communities.

6.6.4.5 Institutional Planning and Policy Sub-program

Includes:

- Clarification of roles, responsibilities and leadership requirements within the region;
- Negotiated arrangements with state, Australian and local governments for alignment of appropriate agency programs with regional NRM requirements;
- Identification of non-government and sponsor involvement opportunities through the Avon RDPs;
- Development of formal partnership arrangements with identified commitments to roles, responsibilities and resource allocation;

- Review of existing legislation and policies in relation to efficient and effective delivery of NRM outcomes in the Avon region (undertaken in association with other NRM regions);
- Identification of opportunities to support NRM through local planning strategies and Town Planning Schemes and the Avon Arc regional planning strategy.

6.7 Building capacity

Investment is required in people and their organisations to achieve change in the condition of natural resources. This is particularly important in the absence of strong 'market-drivers' for change. Building the capacity for change through 'non-market' mechanisms requires development of strategic processes to address the most significant determinants of change. These include:

- Recognising and committing to achievement of a **shared 'preferred future'**;
- Recognition of **local core values and cultures** that need to be included in change processes;
- Providing **leadership** to develop common purpose and focus on the change that is required;
- **Decision-making** that ensures efficient and effective delivery of actions according to targets;
- Setting **priorities for NRM** by individuals and within organisations considering other social, economic or environmental goals or core business; and
- **Adaptive management** that is responsive to organisational monitoring and evaluation.

Building the capacity of individuals, communities, agencies and other organisations that influence NRM within the region is required to achieve the resource condition targets (RCTs) for the region. For each of these social categories, there is a requirement to:

- Increase the capability of individuals, and
- Develop social networks, relationships and processes.

The current capacity for NRM within the Avon River Basin has been developed significantly since the inception of the Swan-Avon ICM Program. This includes:

- A relatively high level of awareness and knowledge for management of natural resources through community and agency initiatives in partnership with many organisations (e.g. landcare, bushcare and rivercare support, Landcare Vision, Living Landscapes and many other programs),
- Cultures of agencies and research organisations have developed towards increased interaction and cooperative effort with the community; and
- Increased interest in NRM by local government and consideration of their capacity to contribute.

The regional Capacity Building RDP builds on current capacity by developing strategic decision-making processes and targeted actions for priority assets and threat management. This new focus for capacity building will be based on short-term targets (1-5 years) that identify the change that is required, where it is required to address regional management action priorities, and who are the key stakeholders to broker change management.

The key principles for building further capacity for strategic NRM in the Avon River Basin are:

- Recognition by key stakeholders of the regional NRM priorities and the requirement for targeted actions according to these priorities;
- Adding value to current information, knowledge and capacity through local, regional and organisational partnerships;
- Integrating science-based information with local knowledge;
- Shared learning experience through demonstration and networking;
- The community has access to capacity building opportunities;
- Capacity that is built is retained (sometimes identified as 'human and social capital').

Building capacity for regional delivery outcomes in the Avon River Basin will require changes to previous organisational and delivery arrangements where the focus was on building the capacity of communities and organisations according to their local or sectorial interest in NRM.

The preferred model for building further NRM capacity within the region is based on:

- **Adopting a regional team approach** to development of professional skills, information and support;
- **Engagement of community** through partnership arrangements, support and training as required according to regional priorities and targets;
- **Building community capacity in all areas** through sustainable industry development, self-initiating producer or catchment groups and organisations, and by sharing information, knowledge and experience.

The arrangements for building further capacity are through development and deployment of organisational arrangements for regional NRM delivery (see Section 6.6.4 RDP 4 – Capacity Building).

6.7.1 Capacity for delivery of regional NRM outcomes

The capacity for delivery of regional NRM outcomes is structured through the Capacity Building RDP (Section 6.6.4). The organisational and regional delivery capacity is based on three regional NRM Teams:

1. Avon Catchment Council

Members are democratically elected community representatives or appointed representatives of partner agencies or other organisations. The arrangements for this regional partnership team are according to the Avon Catchment Council Constitution. The primary role of this team is to set regional targets for NRM, attract investment according to priority targets and to make strategic adjustments according to program monitoring and evaluation.

2. Natural Resource Management Program

The Chairs and Coordinators of the RDP Implementation Teams form the NRM Program Committee. The key roles of this committee are to ensure integrated and efficient regional delivery of programs and to provide monitoring and evaluation of the performance of regional delivery processes against the targets of the Strategy.

3. Regional Delivery Program Implementation Teams

RDP Implementation Teams have been formed for the four RDPs with representation technical expertise and community wisdom. A Coordinator is to be appointed for each team. Project teams of employed staff are to deliver actions according to the annual RDP Business Plan. The trained employees will be devolved throughout the region within communities according to regional NRM priorities and identified local requirements. The experience and skills of these teams will be focused through the RDPs for the Avon River Basin that will be applied through regional projects and Local Area Plans (LAPs). Other specialist skills will be engaged as required according to RDPs.

Detailed organisational and delivery arrangements for NRM in the Avon River Basin will be developed through the Avon NRM Regional Capacity Model.

6.7.2 Information, knowledge and communication networks

The Avon River Basin is vast in area and sparsely populated so information, knowledge and communication networking for natural resource management is essential. This was recognised as important at the inception of the Swan-Avon ICM Program through development of the Avon Catchment Network (ACN) centred in Northam but with links throughout the region to provide the required networking framework.

The Avon Catchment Council Information Network Business Plan (2002-04) prepared by the Avon Catchment Council identifies the relationship between the community throughout the Avon River Basin, the partners of Avon Catchment Council and other supporting organisations through the network. The plan expects that all land managers in the Avon River Basin will be able to access the information and knowledge needed to undertake sustainable natural resource management.

The facilities of the Avon Catchment Council Information Network are supported by state government agencies. Linkage for information access by communities is through common usage of geographic information software. The capacity for spatial analysis of geographic information will be enhanced through options brokered by Avon Catchment Council for partnership arrangements.

Facilitation of social networking is a key role for:

- Avon Catchment Council through regional partnership development;
- The NRM Coordination Team through the processes of the Regional Delivery Programs; and
- The Regional Delivery Team through the processes of developing and implementing Local Area Plans.

Community consultation and engagement is particularly important for delivery of targeted NRM programs according to regional priorities. Consultation and engagement processes will empower community action through combination of local information, knowledge and communications systems with those of partner organisations in priority projects. These processes will follow the Avon Community Engagement Protocol.

6.7.3 Adopting a range of planning and policy instruments

It is recognised that most actions required for NRM within the Avon River Basin do not have strong market-based drivers. Their implementation depends upon a combination

Table 53 Planning and policy instruments for NRM in the Avon River Basin

Financial:	Motivational and Regulatory:
☐ Devolved grants	☐ Target-setting
☐ Cost/profit sharing	☐ Information and knowledge development
☐ Auction-based funding systems	☐ Community/government partnership agreements
☐ Philanthropic funding	☐ Local champions and facilitators
☐ Private ownership/investment schemes	☐ Access to resources or qualified people
☐ Commercial development options	☐ 'Learning set'/adult learning processes
☐ Tax or municipal rate adjustment	☐ Planning/technical support and skills development
	☐ Monitoring and evaluation
	☐ Icon or focal species
	☐ Legislation and regulatory controls

of both public and private investment in most areas. The options for market-based options are greater in the Avon Arc zone where rainfall is higher and the population is expected to increase. However, it is assumed that adoption of a mix of available planning and policy instruments will be required in all zones. The range of instruments suitable for adoption in the Avon River Basin is shown in Table 53. The options include financial and motivational incentives, and regulatory controls.

Investment according to each option is considered in the Avon NRM Investment Plan.

6.8 Cross-boundary planning and management

The Avon River Basin has shared boundaries with all other NRM regions in WA. Arrangements for common management of natural resources are made through:

- Integration of regional NRM strategies between the Avon and Swan regions according to arrangements under the Swan-Avon ICM Program and according to articles of a Memorandum of Understanding (MOU);
- Links with Rangelands NRM regions for Crown/Pastoral zone management;
- Involvement in the South West Eco-region project.

The Avon Catchment Council will continue to arrange other cross-boundary initiatives for effective and efficient natural resource management in Western Australia.

6.9 Linking with statutory planning and policies

The ACC is a non-statutory organisation however its key function of coordination for regional –scale natural resource management through partnership arrangements provides opportunities for effective linkage with statutory planning and related policies.

The opportunities for effective linkage are:

State, regional and local government planning

The State Planning Strategy (1997) and statutory planning processes through the *Town Planning and Development Act 1928* (including Regional Development Plans and Town Planning Schemes) provide significant opportunities to include natural resource management requirements. The five LGAs of the Avon Arc have Town Planning Schemes that are periodically revised according to the Avon Arc Sub-regional Strategy (2001). Other LGAs within the region have planning processes also able to incorporate natural resource management.

The WA Planning Commission's Statement of Planning Policy No. 2: Environment and Natural Resources Policy provides a robust framework for integrating the relevant range of national and state principles, policies and guidelines. It also provides linkage to the State Sustainability Strategy (2002).

Water resources

The State Water Quality Management Strategy for WA (2001) is linked to the National Water Quality Management

Strategy (1994). This provides guidelines for management that will assist in assessment of river pools, wetlands, salt lakes and groundwater especially in relation to proposed management actions.

The Wetlands Conservation Policy for WA (2001) and the Waterways WA: a Statewide Policy for Management of Waterways in Western Australia (2000) provide a framework to guide management of these resources.

Land resources

The WA Planning Commission's Statement of Planning Policy No. 11: Agriculture and Land Use Planning Policy provides principles and guidelines for planning zones, particularly in relation to land sub-division (linking with Policy No. DC 3.4: Sub-division of Rural Land). It also provides integrated planning for NRM outcomes and for floodplain management.

The Government Response to the Salinity Taskforce Report Salinity: a New Balance provides strategic direction that has strongly influenced the development of the Avon NRM Strategy through linkage with the Salinity Investment Framework (SIF).

The State Weed Strategy, linked with the National Weed Strategy, provides an important opportunity for a strategic response to weeds as a threat to production as well as other NRM values.

Recognition of the National Greenhouse Strategy (1998) provides significant opportunity for integration of tree crops within the options for landscape management.

Biodiversity conservation

The Avon NRM Strategy is significantly influenced by the National Strategy for the Conservation of Australian Biological Diversity (1996) and the National Objectives and Targets for Biodiversity Conservation (2001-05). The Directory of Important Wetlands in Australia (2001) provides the information required to identify the wetland assets of national significance. Schedules under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* identify endangered species and outline the requirements for their protection. The *Conservation and Land Management Act 1984*, the Wetland Conservation Policy for WA (1997) and the *State Wildlife Conservation Act 1950* also provide schedules for management of endangered species and ecological communities.

The ACC recognises these opportunities and seeks to develop appropriate partnership arrangements and cooperation with other NRM regions for a coordinated and effective approach to regional NRM governance and delivery of outcomes through linkage with existing statutory planning and policy instruments.

7. Monitoring, Evaluating, Reviewing and Reporting

7.1 Purpose and context for monitoring and evaluation

Monitoring, evaluation (M&E) and reporting are required for adaptive management processes that include learning from past actions. M&E is also important for the Avon Catchment Council to report on progress with its Resource Condition and Management Action Targets as required under the Bilateral Agreements for NHT2 and NAP.

The Avon Catchment Council will develop partnership arrangements with state government agencies with statutory responsibilities for NRM, which have associated long-term monitoring programs to measure and report on the natural resource condition. The Avon Catchment Council also expects to contribute to the longer term reporting through mechanisms such as national and WA State of the Environment reporting.

7.2 Overview of the approach to M&E

The framework for M&E in the Avon River Basin is based on national and state M&E Implementation Plans. In summary these provide:

- A collaborative and coordinated approach between the Avon Catchment Council and its partners using wherever possible existing state monitoring programs and systems;
- Development of an information management infrastructure using agreed Australian and state government processes and systems;
- Use of agreed protocols and templates for reporting to the Joint Steering Committee and the Australian and state governments;
- Development of agreed evaluation procedures in partnership with the Australian and state governments.

Table 54 shows the agreed processes for M&E that are relevant to the region.

The state government, its NRM agencies and the six NRM regions are to further develop a more detailed framework for the implementation of M&E.

Further detail on M&E in the Avon region will be provided in the Avon River Basin Investment Plan and the Regional Delivery Programs based on the detailed state framework when it has been developed.

Figure 10 shows the sequence of regional NRM planning processes ranging from the overarching objectives through the Resource Condition and Management Action Targets (RCTs and MATs) and indicators, to the MAT Output Categories and Output Units of Measure.

The long-term Program Logic Model for both the NAP and NHT is set out in a model in the national framework, which is shown in Figure 11. This model emphasises that attaining aspirational targets and resource condition targets is a long-term process with many steps and stages. The Avon Catchment Council understands both the length and importance of this journey based on strong partnership arrangements and building on existing long-term processes and monitoring programs.

The Indicators for the RCTs will show how the region is moving towards the targeted resource and priority asset conditions over a time period of 5 to 20 years. The indicators for the MATs and the Output Units of Measure will show how the region is achieving its shorter term (1 to 5 year) management targets. These measures are to be arranged with state government agencies and are to be built into an M&E database.

Evaluation of natural resource condition and program performance needs to occur at a range of scales based on:

- *Effectiveness* – how well the program delivers its goals;
- *Efficiency* – how efficiently and cost-effectively funding achieves its outcomes;
- *Appropriateness* – whether the Strategy and mechanisms (including regional planning and delivery) are the most appropriate means of achieving high-level objectives (National M&E Framework).

Table 54 Monitoring and evaluation process

	Natural Resource Condition	Program, Strategy and Policy Performance
Monitoring	• Natural resource condition monitoring at local, regional, state and national levels	• Monitoring of resource condition against standards and targets framework
Evaluation	• Evaluating progress towards improved natural resource condition at the national level	• Performance evaluation of programs and strategies.

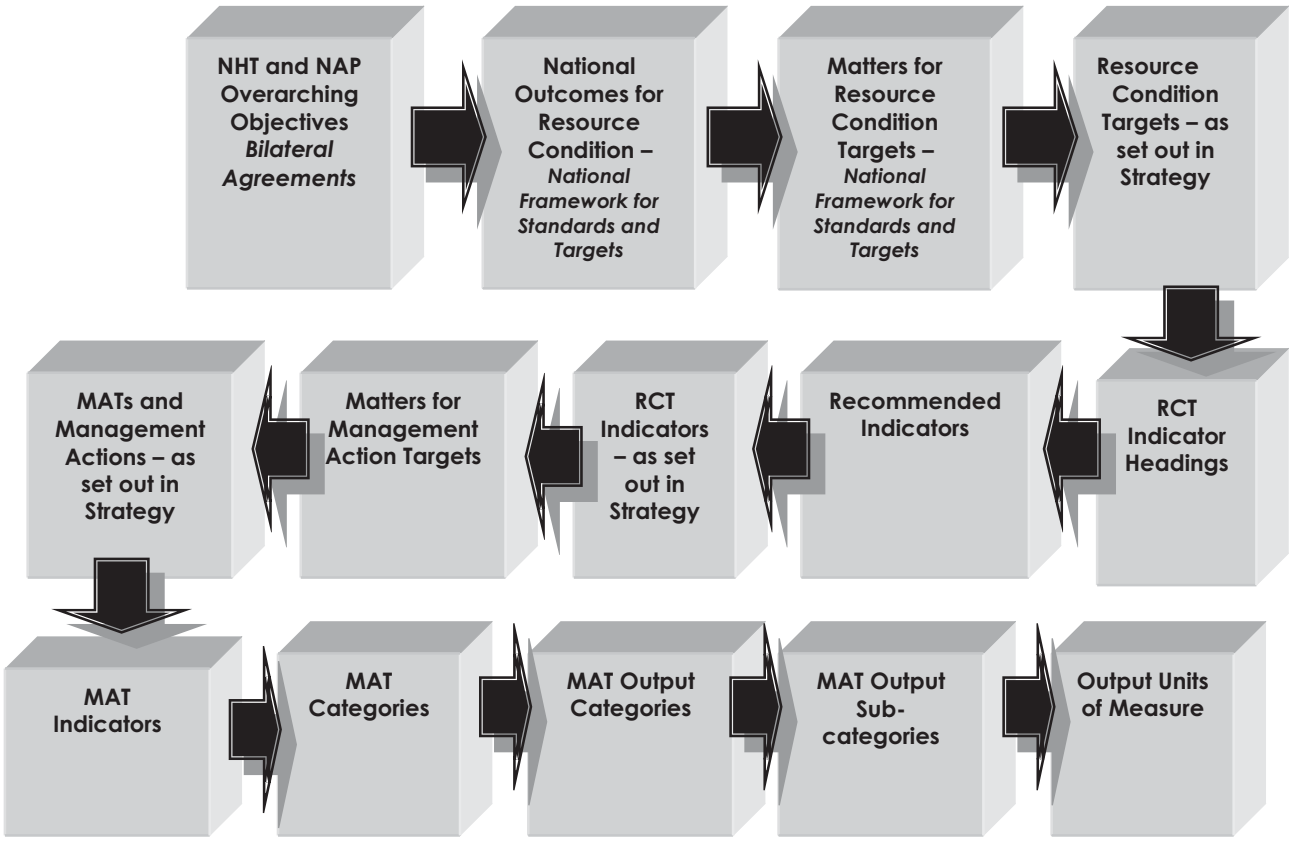


Figure 10 Sequence from national objectives to measuring the success of projects on the ground

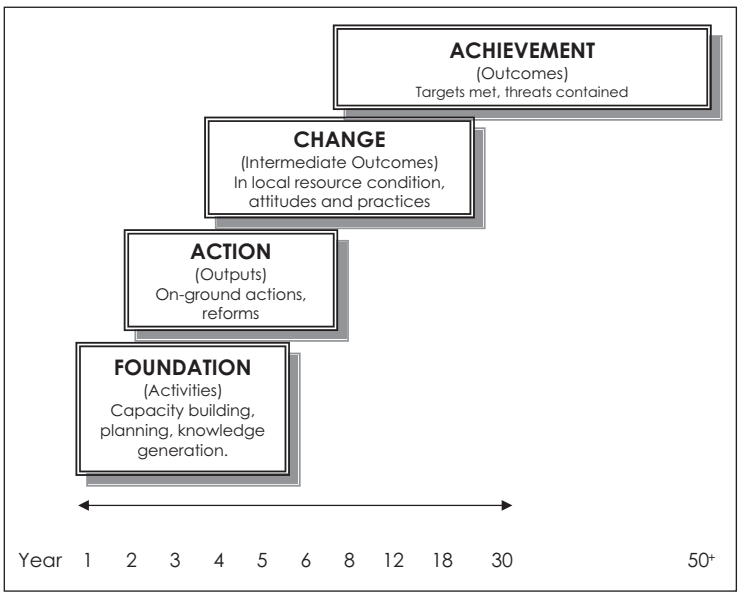


Figure 11 NAP and NHT Program Logic Model

7.3 Identifying M&E roles and responsibilities

The state government through its NRM agencies (DAWA, CALM and DOE) has an ongoing statutory responsibility in M&E for natural resources. These responsibilities require long-term monitoring for key natural resources and resource uses.

The Avon Catchment Council will partner with the State NRM agencies in a practical and cost-effective way to carry out its M&E role for the NAP and NHT.

Table 55 Focus areas in WA for monitoring and evaluation

Condition/Situation of the Resource Base (Pressure/State)	Performance of Programs, Policies and Strategies (Response)
Monitoring and Evaluation for: 1. Assessing progress towards improved resource condition 2. Priority setting and decision making	**Monitoring and Evaluation for:** 1. Clarifying the design of programs 2. Continuous improvement 3. Justification 4. Accountability

7.4 Avon Catchment Council response to the state M&E framework

The State Government's framework for M&E is based on the principles, data management protocols and structure of the National Monitoring and Evaluation Framework. Table 55 shows the key focus areas to be addressed by the WA framework, resource condition assessment and program evaluation.

7.4.1 M&E responsibilities for NAP and NHT2

The National Guidelines for Accreditation provide a clear outline of the requirements for the monitoring and evaluation component of regional NRM strategies. Where relevant, the current position in WA is set out and then the Avon Catchment Council's response to each M&E element is given.

Program logic

- An explanation of how the plan is intended to bring about long-term resource condition outcomes, including the core strategies to be employed, the stages in each process, the change mechanisms and the assumptions that underlie them;
- Processes to test these assumptions and revise the plan when necessary;
- A performance information and evaluation strategy that is consistent with, and relevant to, this rationale and these assumptions.

Avon Catchment Council response

The Avon Catchment Council has outlined its Implementation Framework and Regional Delivery Strategy in this document and this will be a strong and robust foundation for the detailed M&E Implementation Plan, including evaluation strategies. The foundation will also be used to provide for other reporting and evaluation requirements, such as State of the Environment reporting.

7.4.2 Existing monitoring

The State Government Monitoring and Evaluation Working group (MEWG) is currently identifying all relevant State NRM monitoring programs that will be necessary to support the NAP and NHT2 and develop a detailed M&E Implementation Framework for WA. An explanation of how these will be incorporated into an overall monitoring program for regional strategies will be developed.

Avon Catchment Council response

The existing state monitoring programs that relate to the recommended National Indicators are to be identified for the Avon region. Detailed monitoring requirements will be developed for the Regional Delivery Programs and Sub-programs and then for the related projects.

7.4.3 Performance indicators

- Indicators and measures consistent with the Monitoring and Evaluation Framework are to be used to measure and report on the minimum set of Matters for Targets established under the Standards and Targets Framework;
- Indicators and measures which will be used in measuring and reporting on Management Action Targets within 2 years of commencing activities and at the end of the program. There will be processes to review these targets periodically as required;
- Other indicators to be considered include measures of outputs or of institutional or behavioural change;
- Processes for data collection that ensure measurement of performance data is current and timely and for validation and quality control for performance data at the point of collection are to be developed.

Avon Catchment Council response

High-level RCT Indicators have been developed and linked to the agreed National Indicators. More detailed Management Action Target Indicators will be developed in the Investment Plan, as part of the process of prioritising the MATs and groups of

assets for funding through the Regional Delivery Programs and the Projects. Data collection protocols will be consistent with the State M&E database and information management system.

7.4.4 Baseline data and data gaps

- Details of all the available baseline data including useful and applicable measures of resource condition, attitude and behaviours are to be developed where it is relevant to regional NRM planning;
- Identification of data gaps or deficiencies in monitoring arrangements to meet performance information requirements are to be identified.

Avon Catchment Council response

Baseline data will be collected with the relevant government agencies for NRM assets in the Avon River Basin and entered in the regional database and information system. There are currently significant gaps for baseline information in the large Avon River Basin (nearly twice the size of Tasmania), so that the necessary baseline information may not be collected in the first three years, but the prioritisation process will ensure that the relevant baseline information will be systematically collected.

7.4.5 Data management

The State Government is currently building a data and information management system for all of the monitoring information that will need to be collected for the NAP and NHT2. This system will be linked to a new version of the existing NHT Programs and Projects database, which provides information on funding and a range of other reporting attributes. The proposed information management system will provide for the collection, storage, analysis and reporting of all performance information. The capability of the system will be developed to minimise duplication and maximise efficient use of data, and it will conform to established Data Management Agreements.

Avon Catchment Council response

The Avon Catchment Council will use the State long-term systems and where required, modify the regional database and information system to cater for M&E in the Avon River Basin.

7.4.6 Evaluation

An evaluation strategy that establishes processes for the review of the plan and its evaluation needs is to be developed at both regional and project levels based on the National M&E Framework.

Avon Catchment Council response

Avon Catchment Council recognises that evaluation at the regional level is a vital component of overall program evaluation and annual reporting, and will commit to ensuring such evaluations are carried out through its Partnership Agreements and by building them into the Regional Delivery Programs.

7.4.7 Communication and reporting

A comprehensive reporting structure tailored to the needs of all stakeholder groups is to be developed based on agreed institutional arrangements and responsibilities in WA. This will include:

- The collection, storage, analysis and reporting of performance information;
- The efficient and effective management of the performance information management system.

Avon Catchment Council response

The Avon Catchment Council has an effective Communication and Information Network for its stakeholders that will be extended as part of the process of implementing the Regional Strategy and Investment Plan. Reporting to the Joint Steering Committee, State and Australian Governments will be through agreed procedures and templates.

7.4.8 Adequate resources

An assessment of the adequacy of the resources allocated for ongoing maintenance of systems for the collection of monitoring data, including storage, analysis and reporting; the conduct of evaluations; and establishment of baseline information (Note that resources include dollars, capacity, institutions and structures).

Avon Catchment Council response

The Implementation Framework for the Avon NRM Strategy, including the Regional Delivery Programs and Sub-programs, will identify the resources (people, capacity building and dollars) needed for the region. These will be negotiated through Partnership and Service Agreements to establish working arrangements for data collection, data transfer, information systems and reporting as outlined in Table 56.

7.5 Reporting timeframes

The reporting timeframes for the Avon NRM Strategy are outlined in Table 56.

Table 56 Proposed reporting timeframes

Category	Monitoring Focus	Reporting timeframe
Resource condition targets	Resource condition	Annual
Management action targets	Management actions	Annual
Outputs	Capacity building Regional planning Specific on-ground activities/projects	Half yearly milestone reporting
Investments	Financial inputs and progress in activities/ projects against significant milestones	Quarterly financial reporting to NHT Secretariat by funding recipients

Note: NHT Secretariat provides quarterly financial reports to Regional NRM Groups and Joint Steering Committee. Audited financial reports also need to be provided to the Commonwealth on an annual basis.

The Avon Catchment Council understands all of the reporting timeframes and requirements and will comply with them in its role as the leader for integrated NRM in the Avon River Basin, and as part of its partnership with the state government agencies, through the detailed M&E Implementation Framework that is being developed.

8. Taking the Next Steps

8.1 Recognising organisational change

The transition from the arrangements for natural resource management during the Decade of Landcare to the current regional delivery model for strategic investment in priority assets to attain resource condition change provides significant challenges for NRM organisations and communities within the Avon River Basin. It requires a change away from practices in which local communities have been encouraged and to which they have become accustomed.

The change is also significant for state and local government agencies that have established policies and practices for effective and efficient expenditure of public resources according to their respective corporate plans and ministerial obligations.

The change for local government and many non-government organisations is also significant. Local government and associated communities have received support for local priorities and projects. With the emphasis changing to regional-scale priorities and projects, public funding for local projects may be reduced in some areas. Local government within the region has responded to the need for change by formation of regional organisations of Councils. While these arrangements serve other purposes, they are advantageous for NRM. Non-government organisations that have provided services for natural resource management based on their consideration of what is important for the region may find those services are no longer required under the regional strategy.

Many individuals employed and small enterprises engaged in natural resource management at the local or regional level are concerned about the effects of change. The uncertainty associated with allocation of funding to regional projects causes anxiety and limits service capacity.

While the change to a regional delivery model will affect many people and organisations, there are major benefits. Most who understand the purpose and direction of the change also understand the potential for benefit to the region. Most also appreciate that the previous approach was limited and not measurably efficient.

Most organisations and individuals who are involved in the planning processes now realise the significant challenges that the NRM regions have adopted. It is a challenge to set targets for resource condition change that are appropriate at national, state, regional and local scales. There are also challenges in getting government agencies working in effective partnerships with communities and with each other. There is the further major challenge of achieving genuine integration of management for multiple benefit outcomes at the landscape scale. These challenges have not previously been attempted in one strategic document for the region. None of these challenges have been effectively met in the past.

Organisational change requires transitional arrangements. The scale of change expected through the regional NRM strategy cannot instantly occur. The next steps required are based on the evolutionary nature of the Avon NRM Strategy and recognise the benefits of transitional arrangements for effective change to occur.

8.2 Developing the regional delivery framework

Section 6 of the Avon NRM Strategy provides a framework for implementing the regional strategy. This framework is based on the significant steps of identifying regional assets, preparing Local Area Plans and developing Regional Delivery Programs. Each of these steps requires staged development before full regional-scale implementation can occur. The next steps for this are outlined below.

8.2.1 Regional Asset Identification

Natural resource and infrastructure priority assets have been identified according to national and state criteria in Western Australia. Regional assessment processes are progressing but not complete for the Avon River Basin.

A process of identifying local assets in the region has commenced. It is expected that this can substantially occur within a 6-8 month period, however it is also recognised that this will be an ongoing process with continuous change based on new information.

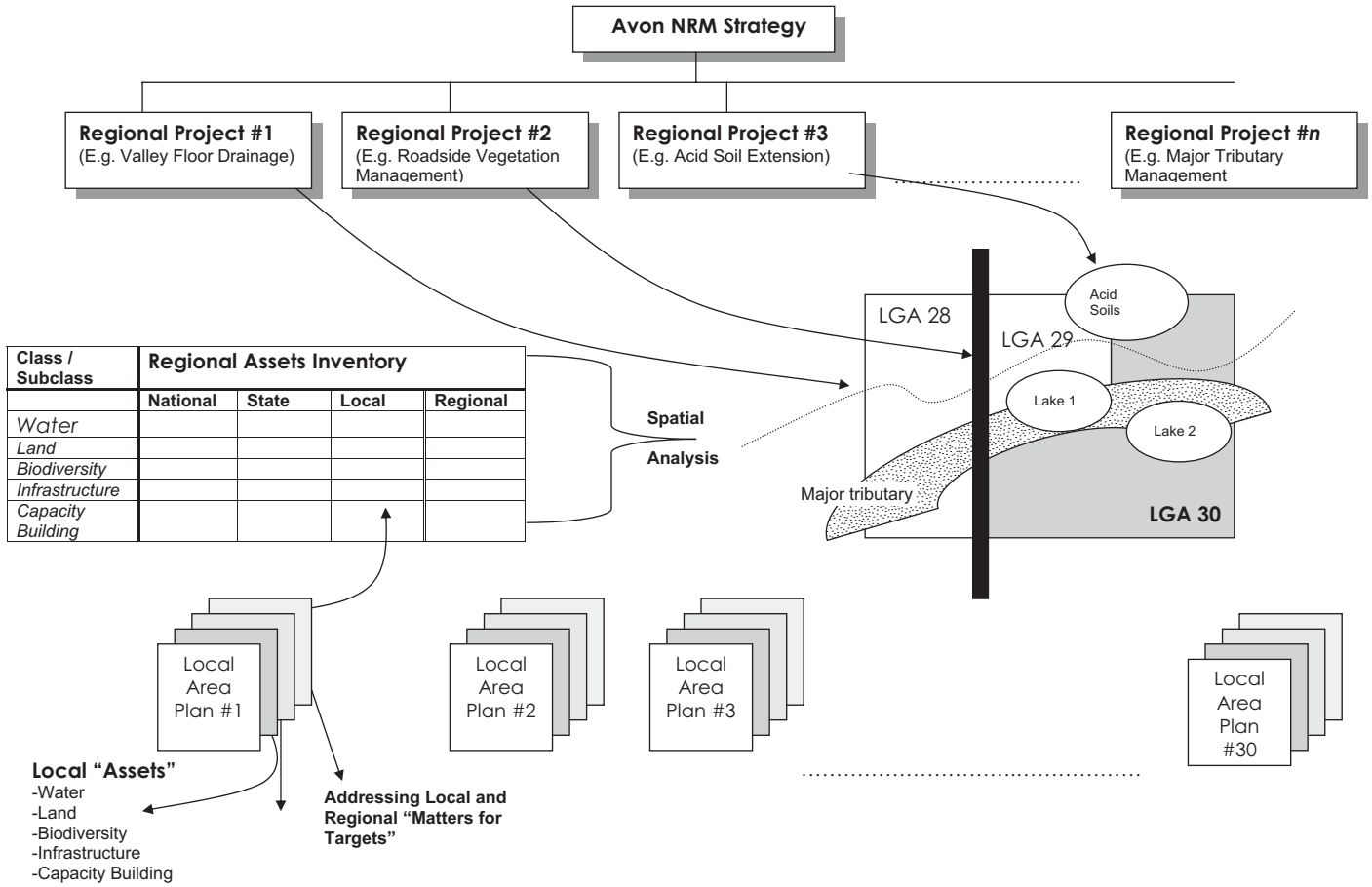


Figure 12 Delivering regional projects through Local Area Plans

8.2.2 Development of Local Area Plans

The Local Area Plans (LAPs) proposed in Section 6 will be based on spatial analysis of priority regional assets. It is anticipated that a LAP will be prepared for approximately 30 LGAs in the region.

GIS support to undertake the spatial analysis based on a regional database that includes natural resource and infrastructure asset information is being arranged. This will also include assessment of threatening processes, especially high water tables causing salinity.

Areas for priority regional investment may differ from LGA boundaries. Some may be surface water catchments, others could be valley floors or landscape sequences.

Figure 12 represents the planning processes for delivery of regional projects through Local Area Plans.

8.2.3 Development of Regional Delivery Programs

The four proposed Regional Delivery Programs (RDPs) and the respective sets of proposed Sub-programs will be developed as outlined in Section 6 of the Strategy. The basis for some of these programs is currently well developed however other components (e.g. salt lake management) require fundamental investigation.

The RDPs will be developed through Business Plans. These will be prepared in close association with relevant partner organisations and through substantial consultation with community groups. It is expected that the RDP Business Plans will be well developed within a 12-month period.

8.2.4 Building capacity for change

The level of capacity within the region for NRM is relatively high. This is an outcome of past investment for landcare, bushcare and rivercare in the region. The Avon Catchment Council is intending to maintain this capacity within communities in the short-term and further build capacity according to requirements of the Avon NRM Strategy.

The current range and levels of community capacity for NRM within the Avon River Basin is being documented. This includes assessment of community skills, knowledge and support, engagement by industry organisations, the functional roles of research institutions and non-government organisations and many others.

An assessment of current capacity will be compared with the requirements for implementation of the Avon NRM Strategy to identify where additional skills, knowledge, research, or technical and financial support may be required.

There will be a short-term requirement for capacity to develop the LAPs and RDPs. It is expected that the knowledge and skills developed during these processes will be appropriate to further implementation of the regional strategy.

8.3 Regional organisation and delivery structure

Implementation of the Avon NRM Strategy requires change in regional organisation and delivery structures within the region. It is expected this will provide new opportunities for employment for NRM within the region based on a team structure. It is anticipated that an appropriate structure will include:

- **Avon Catchment Council** – for strategic review and corporate governance of NRM within the Avon River basin;
- **RDP Coordinating Committee** – including the four RDP Coordinators, RDP Implementation Team Chairs and ACC representative members;
- **RDP Implementation Team** – members representing community interests and providing technical knowledge and support;
- **Project Delivery Teams** – coordinated by ACC and deployed as required throughout the region

The Avon Catchment Council will have responsibility for all outcomes of performance of the teams. Organisational re-structure of the regional NRM body will be required for implementation.

8.4 Advancing the Avon River Basin monitoring and evaluation framework

The requirements for monitoring and evaluation of resource condition and program performance are outlined in Section 7 of the Strategy. This includes building the state-level database for M&E based on regional information and on development of the State M&E Framework.

The Avon Catchment Council has developed the basis for the Avon M&E Framework for both resource condition change and evaluation of programs. This will be further developed consistent with the State Framework. It is anticipated that this will occur within a 12-month period.

8.5 Developing the Investment Plan

The Investment Plan for the Avon NRM Strategy will outline the priority for investment of partner funding within the region. The plan will identify the alignment of existing partner programs with the regional strategy and the opportunities for further investment.

The Investment Plan will be structured on the Avon NRM Implementation Framework and will show trade-offs made between programs, targets and assets. Investment for the priorities of the regional strategy will be sought through arrangements under the Bi-lateral Agreement but also through other partners and sources. The plan will show the range of partner and sponsor contributions along with public funding arrangements.

8.6 Developing partnership arrangements

The Avon NRM Strategy identifies substantial opportunities for partners to contribute to conservation and sustainable growth within the region through the Avon Catchment Council. Partnership arrangements will be with communities, local government, state and Australian government agencies, research institutions, non-government organisations and many others.

It is expected that many partners will enter into formal partnership arrangements with the Avon Catchment Council for their roles, responsibilities and shared investments. It is anticipated that substantial partnership arrangements will be developed within a 6-8 month period.

8.7 Evolutionary change process

Recognising the need for organisational change, the ACC has an evolutionary change process that will take management for natural resources and infrastructure within the region into the regional delivery model for targeted investment. This project will address each of the next steps for the regional strategy as outlined in the preceding sections.

APPENDICES

Appendix 1

National Natural Resource Outcomes, NRM Standing Committee (2002)

National Outcomes The national outcomes are aspirational statements about desired national natural resource outcomes
1. The impact of salinity on land and water resources is minimised, avoided or reduced.
2. Biodiversity and the extent, diversity and condition of native ecosystems are maintained or rehabilitated.
3. Populations of significant species and ecological communities are maintained or rehabilitated.
4. Ecosystem services and functions are maintained or rehabilitated.
5. Surface and groundwater quality is maintained or enhanced.
6. The impact of threatening processes on locations and systems which are critical for conservation of biodiversity, agricultural production, towns, infrastructure and cultural and social values, is avoided or minimised.
7. Surface water and groundwater is securely allocated for sustainable production purposes and to support human uses and the environment, within the sustainable capacity of the water resource.
8. Sustainable production systems are developed and management practices are in place, which maintain or rehabilitate biodiversity and ecosystem services, maintain or enhance resource quality, maintain productive capacity and prevent and manage degradation.

Matters for which Regional Targets must be set
Resource Condition Matters for Targets
• Land salinity.
• Soil condition.
• Native vegetation communities integrity.
• Inland aquatic ecosystems integrity (rivers and other wetlands).
• Estuarine, coastal and marine habitats integrity.
• Nutrients in aquatic environments.
• Turbidity/suspended particulate matter in aquatic environments.
• Surface water salinity in freshwater aquatic environments.
• Significant native species and ecological communities.
• Ecologically significant invasive species.
Management Action Matters for Targets
1. Critical assets identified and protected.
2. Water allocation plans developed and implemented.
3. Improved land and water management practices adopted.

Appendix 2

Stream Flow and Salinity Trends in the Avon River Basin

Long-term records from a network of gauging stations located within the Avon River Basin (Map 12) have been analysed to derive trends in stream flow and salt load.

The following graphs show the increasing trend of stream flow (Figure 13) and salinity (Figure 14) at the Brouns Farm gauging station (Ref: 615014) over a 25-year period (1975-2000). This station is located on the Avon River between York and Beverley downstream from the confluence with the Dale River. Although the Dale River is relatively fresh, the trend of increasing stream flow salinity at this station is expected to continue as the area land affected by salinity within the catchment increases.

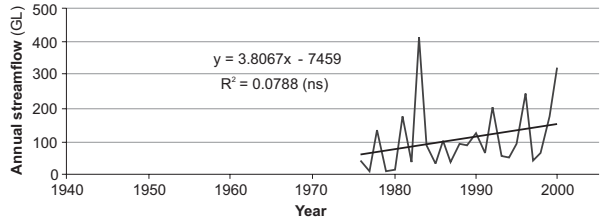
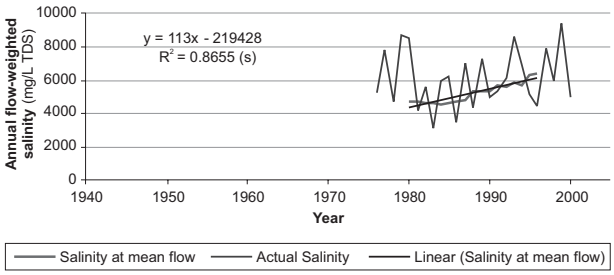


Figure 13 Stream flow at Brouns Farm gauging station



(Source: Department of Environment, 2004)

Figure 14 Salinity at the Brouns Farm gauging station

The stream flow at Northam (gauging station ref: 615062) has a slightly decreasing trend and for salinity there is a slightly increasing trend, as shown in the following graphs (Figures 15, Figure 16).

Streamflow and salinity at Walyunga (gauging station ref: 616011) located on the Avon River down slope of the Darling Scarp and downstream of the confluences of the Brockman River and Wooroloo Brook, show no significant long-term trend, as shown in the following graphs (Figure 17, Figure 18).

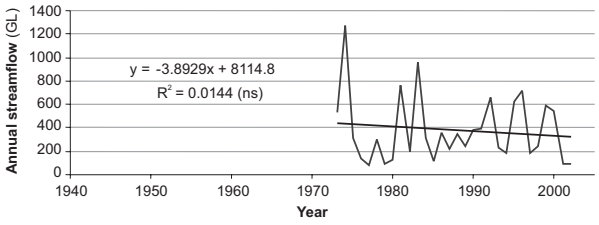
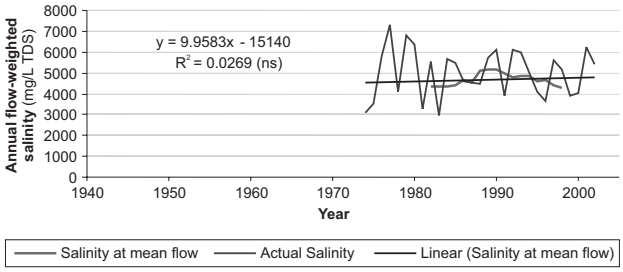


Figure 15 Stream flow at Northam



(Department of Environment, 2004)

Figure 16 Salinity at Northam

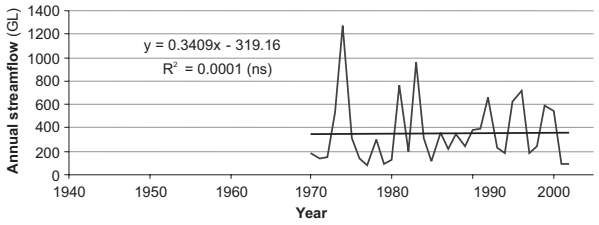
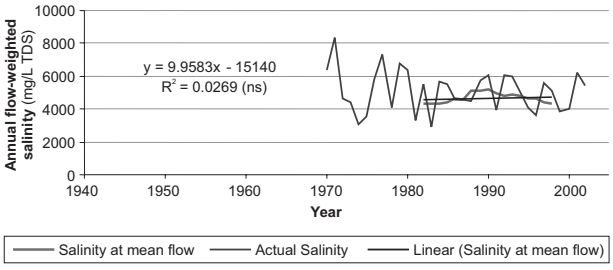


Figure 17 Stream flow at Walyunga



(Department of Environment, 2004)

Figure 18 Salinity at Walyunga

Map 12 Location of Gauging Stations within the Avon River Basin

Appendix 3

Total Length of Roads for each Local Government Authority within the Avon River Basin Threatened by Salinity

LGA	Road Class	Road Length (km)	Current Impact (km)	Potential Impact (km)	Pipeline Length (km)
Beverley	MRWA	59.47	2.47	15.25	52.2
	Shire Roads - Class 1	143.02	2.37	26.45	
	Shire Roads - Class 2	509.55	15.2	117.87	
Brookton	MRWA	88.90	6.6	29.1	21.4
	Shire Roads - Class 1	148.04	8.27	46.77	
	Shire Roads - Class 2	381.53	13.82	86.9	
Bruce Rock	MRWA	72.08	1.87	21.67	518.7
	Shire Roads – Class 1	401.06	22.82	127.42	
	Shire Roads – Class 2	713.95	30.7	203.4	
Coolgardie	MRWA	74.37	N/A	N/A	68.3
	Shire Roads – Class 1	0.00	N/A	N/A	
	Shire Roads – Class 2	56.26	N/A	N/A	
Corrigin	MRWA	80.42	2.37	16.47	116.8
	Shire Roads – Class 1	323.06	11.07	77.8	
	Shire Roads – Class 2	702.12	32.8	136.35	
Cuballing	MRWA	0.00	0	0	0
	Shire Roads - Class 1	0.00	0	0	
	Shire Roads - Class 2	30.49	0.07	2.34	
Cunderdin	MRWA	42.85	8.87	16.22	406
	Shire Roads – Class 1	194.27	9.77	38.35	
	Shire Roads – Class 2	571.87	27.05	129.72	
Dalwallinu	MRWA	42.35	3.77	12.5	202.9
	Shire Roads – Class 1	96.41	2.15	26.85	
	Shire Roads – Class 2	419.20	25.32	115.62	

LGA	Road Class	Road Length (km)	Current Impact (km)	Potential Impact (km)	Pipeline Length (km)
Dowerin	MRWA	37.70	1.72	8.95	407.9
	Shire Roads – Class 1	124.43	4.72	30.87	
	Shire Roads – Class 2	767.52	35.25	219.37	
Dumbleyung	MRWA	12.69	2.67	0.32	0
	Shire Roads – Class 1	6.11	0	0.7	
	Shire Roads – Class 2	152.89	0	13.05	
Gnowangerup	MRWA	10.84	2.85	0	0
	Shire Roads – Class 1	19.24	2.67	13.27	
	Shire Roads – Class 2	70.58	2.5	18.05	
Goomalling	MRWA	105.92	3.32	19.7	271
	Shire Roads – Class 1	97.40	4.25	22.85	
	Shire Roads – Class 2	471.48	39.72	127.72	
Kellerberin	MRWA	43.56	6.47	16.32	498.6
	Shire Roads – Class 1	189.05	10.17	66.7	
	Shire Roads – Class 2	691.27	35.97	192.95	
Kent	MRWA	36.98	2.93	5.82	28.6
	Shire Roads – Class 1	49.78	7.02	14.6	
	Shire Roads – Class 2	561.49	25	103.25	
Kondinin	MRWA	151.67	16.67	42.45	241.8
	Shire Roads – Class 1	112.97	9.85	34.95	
	Shire Roads – Class 2	1 097.29	50.45	233.65	
Koorda	MRWA	0.73	0	0	224.2
	Shire Roads – Class 1	156.91	6.1	35.65	
	Shire Roads – Class 2	400.72	23.77	121.07	
Kulin	MRWA	150.09	5.1	19.5	342.7
	Shire Roads - Class 1	80.30	5.72	15.25	
	Shire Roads – Class 2	1,222.68	47.12	195.27	
Lake Grace	MRWA	272.70	24.32	59.72	62.8
	Shire Roads – Class 1	109.15	12.57	31.9	
	Shire Roads – Class 2	1 585.03	62.8	285.97	
Merredin	MRWA	102.97	6.45	31.97	665.2
	Shire Roads – Class 1	308.24	22.7	109.82	
	Shire Roads – Class 2	931.84	35.35	249.5	
Moora	MRWA	0.00	0	0	48.3
	Shire Roads – Class 1	34.75	2.77	6.42	
	Shire Roads – Class 2	84.84	7.5	18.27	

LGA	Road Class	Road Length (km)	Current Impact (km)	Potential Impact (km)	Pipeline Length (km)
Mount Marshall	MRWA	0.00	N/A	N/A	440.6
	Shire Roads – Class 1	257.00	N/A	N/A	
	Shire Roads – Class 2	926.60	N/A	N/A	
Muckinbudin	MRWA	0.00	N/A	N/A	248.6
	Shire Roads – Class 1	208.56	N/A	N/A	
	Shire Roads – Class 2	660.67	N/A	N/A	
Narambeen	MRWA	0.37	0	0	228.1
	Shire Roads – Class 1	319.60	20.12	98.8	
	Shire Roads – Class 2	1 012.80	45.7	284.25	
Northam (Shire)	MRWA	87.74	4.27	22.37	278.1
	Shire Roads - Class 1	224.43	3.4	36.22	
	Shire Roads - Class 2	181.73	4.72	26.17	
Northam (Town)	MRWA	14.45	0	2.77	16.8
	Shire Roads - Class 1	77.04	0.17	10.2	
	Shire Roads - Class 2	7.26	0.1	1.35	
Nungarin	MRWA	25.75	1.35	8.77	235.3
	Shire Roads – Class 1	117.61	6.72	50.3	
	Shire Roads – Class 2	381.18	2.1	126.5	
Pingelly	MRWA	11.14	0	2	4.7
	Shire Roads - Class 1	142.07	0.67	19.7	
	Shire Roads - Class 2	248.90	6.2	35.37	
Quairading	MRWA	62.52	2.1	19.35	277.2
	Shire Roads – Class 1	259.45	12.97	69.42	
	Shire Roads – Class 2	568.44	33.65	166.27	
Ravensthorpe	MRWA	0.00	0	0	
	Shire Roads – Class 1	0.00	0	0	
	Shire Roads – Class 2	47.42	4	7.85	
Tammin	MRWA	23.49	7.17	12.7	221
	Shire Roads – Class 1	133.93	7.07	37.22	
	Shire Roads – Class 2	326.00	27.7	99.02	
Toodyay	MRWA	29.19	0.27	5	10.9
	Shire Roads - Class 1	91.85	2.5	13.25	
	Shire Roads - Class 2	176.47	3.25	25.85	
Trayning	MRWA	39.13	1.85	13.85	348.2
	Shire Roads – Class 1	133.81	7.67	49.67	
	Shire Roads – Class 2	596.52	36.3	173.6	

Total length of roads for each Local Government Authority within the Avon River Basin threatened by salinity

LGA	Road Class	Road Length (km)	Current Impact (km)	Potential Impact (km)	Pipeline Length (km)
Victoria Plains	MRWA	14.21	0.62	1.75	2.3
	Shire Roads – Class 1	51.11	3.77	11.55	
	Shire Roads – Class 2	227.24	8.72	40.27	
Westonia	MRWA	23.43	2.72	6.87	0
	Shire Roads – Class 1	158.23	7.1	61.42	
	Shire Roads – Class 2	655.72	9.42	171.52	
Wickepin	MRWA	42.61	0.35	6.17	216.2
	Shire Roads - Class 1	101.22	2.02	21.32	
	Shire Roads - Class 2	345.92	17.52	72.17	
Wongan-Ballidu	MRWA	69.83	5.2	19.55	500.5
	Shire Roads – Class 1	301.84	33.72	78.55	
	Shire Roads – Class 2	845.64	69.17	193.47	
Wyalkatchem	MRWA	37.82	0.62	4.65	284.1
	Shire Roads – Class 1	166.79	7.7	37.5	
	Shire Roads – Class 2	525.90	19.8	148.17	
Yilgarn	MRWA	84.22	5.57	22.25	118.8
	Shire Roads – Class 1	406.44	7.97	100.9	
	Shire Roads – Class 2	1 507.56	34.07	369.4	
York	MRWA	99.02	3.45	25.2	77
	Shire Roads - Class 1	211.48	4.02	43.7	
	Shire Roads - Class 2	317.08	10.9	55.87	
Miscellaneous					272.4

Note 1: Boxed values are for roads in Shires (n = 15) which have 100% of their area within the Avon River Basin and more than 100 km of roads potentially affected by salinity.

Information derived from Land Monitor project information, Department of Agriculture, WA.

Appendix 4

Vegetation Associations in the Avon River Basin (Hopkins et al., 1996)

Vegetation Association	Vegetation Description
3	Medium forest; jarrah-marri
4	Medium woodland; marri and wandoo
5	Medium woodland; wandoo and powderbark (*E. accedens*)
7	Medium woodland; York gum (*E. loxophleba*) and wandoo
8	Medium woodland; salmon gum and gimlet
13	Medium open woodland; wandoo
25	Low woodland; *Allocasuarina huegeliana* and York gum
36	Shrublands; thicket, acacia-casuarina alliance
37	Shrublands; teatree thicket
47	Shrublands; tallerack mallee-heath
125	Bare areas; salt lakes
128	Bare areas; rock outcrops
131	Mosaic: Medium woodland; salmon gum and gimlet / Shrublands; mallee scrub, redwood and black marlock
141	Medium woodland; York gum, salmon gum and gimlet
142	Medium woodland; York gum and salmon gum
144	Medium woodland; wandoo, salmon gum, morrel, gimlet and rough fruited mallee
145	Mosaic: Medium woodland; York gum and salmon gum / Shrublands; thicket, acacia-casuarina-melaleuca alliance
147	Succulent steppe with scrub; acacia species over saltbush
214	Mosaic: Medium woodland; goldfield eucalypts / Succulent steppe with open low woodland; myoporum over saltbush
352	Medium woodland; York gum
356	Succulent steppe with open woodland; eucalypts over saltbush
380	Shrublands; scrub-heath on sandplain
392	Shrublands; *Melaleuca thyioides* thicket
413	Shrublands; *Acacia neurophylla* and *A.* species thicket
435	Shrublands; *Acacia neurophylla*, *A. beauverdiana* and *A. resinomarginea* thicket
436	Shrublands; mixed acacia thickets in thickets of acacia-casuarina-melaleuca alliance

Vegetation Association	Vegetation Description
437	Shrubalnds; mixed acacia thicket on sandplain
511	Medium woodland; salmon gum and morrel
519	Shrublands; mallee scrub, *Eucalyptus eremophila*
520	Shrublands; *Acacia quadrimarginea* thicket
522	Medium woodland; redwood (*Eucalyptus transcontinentalis*) and merrit (*E. floctoniae*)
535	Medium woodland; rough fruited mallee on greenstone hills
536	Medium woodland; morrell and rough fruited mallee (*Eucalyptus corrugata*)
537	Medium woodland; morrel (*Eucalyptus longicornis*)
538	Shrublands; *Acacia brachystachya* scrub
551	Shrublands; *Allocasuarina campestris* thicket
552	Shrublands; *Casuarina acutivalvus* and calothamnus (also melalueca) thicket on greenstone hills
555	Hummock grasslands, mallee steppe; red mallee over spinifex, *Triodia scariosa*
631	Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire
694	Shrublands; scrub-heath on yellow sandplain banksia-xylomelum alliance in the Geraldton Sandplain and Avon-Wheatbelt regions
929	Low forest; moort (*E. platypus*)
931	Medium woodland; yate
936	Medium woodland; salmon gum
941	Mosaic: Medium woodland; salmon gum and morrel / Shrublands; mallee scrub, redwood
945	Mosaic: Medium woodland; salmon gum / Shrublands; mallee scrub, redwood and black marlock
946	Medium woodland; wandoo
947	Medium woodland; powderbark and mallet
948	Medium woodland; York gum and river gum
949	Low woodland; banksia
950	Medium woodland; *Casuarina obesa*
951	Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over teatree thicket and samphire
953	Succulent steppe with thicket; teatree over samphire
954	Shrublands; thicket, jam and *Allocasuarina huegeliana*
955	Mosaic: Shrublands; scrub-heath (SE Avon)/ Shrublands; *Allocasuarina campestris* thicket
956	Shrublands; *Allocasuarina campestris* thicket with scattered wandoo
959	Succulent steppe with sparse woodland and thicket; yorrell and Kondinin blackbutt over teatree and samphire
960	Shrublands; mallee scrub, redwood and black marlock
961	Mosaic: Shrublands; scrub-heath (SE Avon)/ Shrublands; *Allocasuarina acutivalvis* thicket
962	Medium woodland; mallet (*E. astringens*)
966	Succulent steppe with sparse woodland and thicket; salmon gum and morrell over teatree and samphire

Vegetation Association	Vegetation Description
968	Medium woodland; jarrah, marri and wandoo
988	Succulent steppe with thicket; *Melaleuca thyoides* over samphire
1003	Medium forest; jarrah, marri and wandoo
1004	Mosaic: Medium open woodland; wandoo / Shrublands; mixed heath
1005	Low woodland; *Allocasuarina huegeliana*
1006	Medium woodland; jarrah, wandoo and powderbark
1023	Medium woodland; York gum, wandoo and salmon gum (*E. salmonophloia*)
1024	Shrublands; mallee and casuarina thicket
1025	Mosaic: Medium woodland; York gum, salmon gum and morrel / Succulent steppe; saltbush and samphire
1041	Low woodland; *Allocasuarina huegeliana* and jam
1048	Mosaic: Shrublands; melaleuca patchy scrub / Succulent steppe; samphire
1049	Medium woodland; wandoo, York gum, salmon gum, morrel and gimlet
1053	Shrublands; *Melaleuca uncinata* thicket with scattered York gum
1055	Shrublands; York gum and *Eucalyptus sheathiana* mallee scrub
1056	Shrublands; thicket, acacia and *Allocasuarina campestris*
1057	Mosaic: Shrublands; medium woodland; salmon gum and gimlet / York gum and *Eucalyptus sheathiana* mallee scrub
1058	Shrublands; York gum and *Eucalyptus gonglocarpa* mallee scrub
1059	Mosaic: Medium woodland; salmon gum and gimlet / Shrublands; mallee *Eucalyptus longicornis* and *E. sheathiana* scrub
1061	Mosaic: Medium sparse woodland; salmon gum and yorrell / Succulent steppe; saltbush and samphire
1062	Succulent steppe with open woodland and thicket; York gum over *Melaleuca thyiodes* and samphire
1065	Mosaic: Shrublands; medium woodland; wandoo and gimlet / York gum and *Eucalyptus sheathiana* mallee scrub
1067	Medium woodland; salmon gum, morrel, gimlet and rough fruited mallee
1068	Medium woodland; salmon gum, morrel, gimlet and *Eucalyptus sheathiana*
1071	Succulent steppe with scrub; acacia species over saltbush and bluebush
1075	Shrublands; mallee scrub, *Eucalyptus eremophila* and black marlock (*E. redunca*)
1076	Mosaic: Medium woodland; salmon gum and morrel / Shrublands; mallee scrub *Eucalyptus eremophila* and bloodwood (*E. dichromophloia*)
1078	Medium woodland; salmon gum, redwood, merrit, gimlet and *Eucalyptus sheathiana*
1079	Mosaic: Medium open woodland; salmon gum and morrel / Succulent steppe; saltbush
1080	Succulent steppe with mallee and thickets; mallee and *Melaleuca uncinata* thickets on salt flats
1081	Shrublands; mallee scrub, *Eucalyptus longicornis* and *E. sheathiana*

Vegetation Association	Vegetation Description
1098	Mosaic: Medium sparse woodland; salmon gum and morrel / Succulent steppe; samphire
1147	Shrublands; scrub-heath in the south-east Avon-Wheatbelt region
1148	Shrublands; scrub-heath in the Coolgardie region
1200	Mosaic: Medium woodland; salmon gum and morrel / Shrublands; mallee scrub *Eucalyptus eremophila* and black marlock (*E. redunca*)
1271	Bare areas; claypans
1413	Shrublands; acacia, casuarina and melaleuca thicket
2047	Shrublands; tamma and dryandra thicket
2048	Shrublands; scrub-heath in the Mallee region
3041	Mosaic: Low woodland; Allocasuarina huegeliana and jam around granite rocks

Appendix 5

Extent of Vegetation Associations and IBRA Regions in ARB

IBRA Region Code	IBRA Region Name	Vegetation Association	Pre-European Extent	Current Extent	% Remaining
AW	Avon Wheatbelt	4	5753.776	725.976	12.62%
AW	Avon Wheatbelt	5	9704.162	5838.066	60.16%
AW	Avon Wheatbelt	7	22005.297	1268.829	5.77%
AW	Avon Wheatbelt	8	356648.341	33523.328	9.40%
AW	Avon Wheatbelt	13	238.824	61.821	25.89%
AW	Avon Wheatbelt	25	8318.089	949.934	11.42%
AW	Avon Wheatbelt	36	299159.212	60631.484	20.27%
AW	Avon Wheatbelt	37	3575.942	493.108	13.79%
AW	Avon Wheatbelt	49	192.394	61.384	31.91%
AW	Avon Wheatbelt	125	38798.787	1559.659	4.02%
AW	Avon Wheatbelt	128	37153.659	15326.446	41.25%
AW	Avon Wheatbelt	131	69640.17	3243.745	4.66%
AW	Avon Wheatbelt	141	172689.262	9949.222	5.76%
AW	Avon Wheatbelt	142	171575.224	8018.737	4.67%
AW	Avon Wheatbelt	145	7970.95	324.529	4.07%
AW	Avon Wheatbelt	147	4209.568	41.371	0.98%
AW	Avon Wheatbelt	352	332672.223	18353.595	5.52%
AW	Avon Wheatbelt	356	3317.049	956.468	28.83%
AW	Avon Wheatbelt	392	391.916	25.891	6.61%
AW	Avon Wheatbelt	413	376.935	78.345	20.78%
AW	Avon Wheatbelt	435	41104.973	4100.929	9.98%
AW	Avon Wheatbelt	511	171319.404	46276.538	27.01%
AW	Avon Wheatbelt	519	11886.796	4993.779	42.01%
AW	Avon Wheatbelt	536	11194.299	3954.44	35.33%
AW	Avon Wheatbelt	538	650.432	48.601	7.47%
AW	Avon Wheatbelt	551	129636.035	22649.699	17.47%

IBRA Region Code	IBRA Region Name	Vegetation Association	Pre-European Extent	Current Extent	% Remaining
AW	Avon Wheatbelt	552	10646.817	10601.431	99.57%
AW	Avon Wheatbelt	631	11800.487	3910.662	33.14%
AW	Avon Wheatbelt	676	3829.043	90.134	2.35%
AW	Avon Wheatbelt	694	161738.236	5201.651	3.22%
AW	Avon Wheatbelt	936	625.092	66.336	10.61%
AW	Avon Wheatbelt	945	35261.538	4034.578	11.44%
AW	Avon Wheatbelt	946	42105.793	5549.489	13.18%
AW	Avon Wheatbelt	947	12621.843	2805.022	22.22%
AW	Avon Wheatbelt	948	1439.787	114.33	7.94%
AW	Avon Wheatbelt	949	4150.409	420.442	10.13%
AW	Avon Wheatbelt	950	501.393	191.304	38.15%
AW	Avon Wheatbelt	951	27432.169	8423.796	30.71%
AW	Avon Wheatbelt	952	489.272	301.041	61.53%
AW	Avon Wheatbelt	953	1907.269	142.832	7.49%
AW	Avon Wheatbelt	954	6353.954	1039.911	16.37%
AW	Avon Wheatbelt	955	112998.127	7749.788	6.86%
AW	Avon Wheatbelt	956	25370.281	2727.22	10.75%
AW	Avon Wheatbelt	959	4873.249	847.72	17.40%
AW	Avon Wheatbelt	960	8727.575	865.678	9.92%
AW	Avon Wheatbelt	961	1642.45	294.091	17.91%
AW	Avon Wheatbelt	962	64.598	3.537	5.48%
AW	Avon Wheatbelt	988	59444.269	5598.571	9.42%
AW	Avon Wheatbelt	1023	786744.639	36312.189	4.62%
AW	Avon Wheatbelt	1024	451494.378	26744.737	5.92%
AW	Avon Wheatbelt	1025	1928.056	32.459	1.68%
AW	Avon Wheatbelt	1041	2502.687	619.529	24.75%
AW	Avon Wheatbelt	1048	13822.796	2371.452	17.16%
AW	Avon Wheatbelt	1049	834313.816	30170.46	3.62%
AW	Avon Wheatbelt	1053	12691.802	1723.969	13.58%
AW	Avon Wheatbelt	1055	126263.33	13646.302	10.81%
AW	Avon Wheatbelt	1056	21195.709	3112.182	14.68%
AW	Avon Wheatbelt	1057	145257.779	13565.756	9.34%
AW	Avon Wheatbelt	1058	9349.812	244.139	2.61%
AW	Avon Wheatbelt	1059	2257.057	13.632	0.60%
AW	Avon Wheatbelt	1061	42814.865	12507.856	29.21%
AW	Avon Wheatbelt	1062	9393.557	2970.542	31.62%

IBRA Region Code	IBRA Region Name	Vegetation Association	Pre-European Extent	Current Extent	% Remaining
AW	Avon Wheatbelt	1065	836.086	440.908	52.73%
AW	Avon Wheatbelt	1067	6008.397	4134.94	68.82%
AW	Avon Wheatbelt	1080	3880.283	78.592	2.03%
AW	Avon Wheatbelt	1081	15180.335	2270.299	14.96%
AW	Avon Wheatbelt	1147	40974.057	2374.96	5.80%
AW	Avon Wheatbelt	1148	15.302	15.302	100.00%
AW	Avon Wheatbelt	1271	835.213	835.211	100.00%
AW	Avon Wheatbelt	1413	503948.863	131182.678	26.03%
AW	Avon Wheatbelt	2047	1442.111	922.133	63.94%
AW	Avon Wheatbelt	2048	632.776	127.683	20.18%
AW	Avon Wheatbelt	3041	3938.335	844.373	21.44%
COO	Coolgardie	8	51599.611	47896.153	92.82%
COO	Coolgardie	18	14706.728	14706.728	100.00%
COO	Coolgardie	19	1607.705	1607.705	100.00%
COO	Coolgardie	36	879.235	879.235	100.00%
COO	Coolgardie	40	6.484	6.484	100.00%
COO	Coolgardie	125	104875.599	89182.677	85.04%
COO	Coolgardie	128	58135.944	57486.848	98.88%
COO	Coolgardie	141	715891.739	691359.294	96.57%
COO	Coolgardie	142	17149.781	17149.718	100.00%
COO	Coolgardie	144	3921.732	3921.732	100.00%
COO	Coolgardie	147	31307.382	24993.992	79.83%
COO	Coolgardie	202	1170.74	1170.74	100.00%
COO	Coolgardie	214	15767.129	15767.129	100.00%
COO	Coolgardie	352	225.915	225.915	100.00%
COO	Coolgardie	435	447041.134	441245.785	98.70%
COO	Coolgardie	436	1059.352	1059.352	100.00%
COO	Coolgardie	437	8453.568	8453.568	100.00%
COO	Coolgardie	491	62.562	62.562	100.00%
COO	Coolgardie	501	66.498	66.498	100.00%
COO	Coolgardie	511	651207.236	532786.428	81.82%
COO	Coolgardie	519	80396.071	80324.394	99.91%
COO	Coolgardie	520	19233.363	19196.956	99.81%
COO	Coolgardie	522	124259.718	124259.718	100.00%
COO	Coolgardie	535	24489.997	23628.758	96.48%
COO	Coolgardie	536	2038.656	1954.404	95.87%

IBRA Region Code	IBRA Region Name	Vegetation Association	Pre-European Extent	Current Extent	% Remaining
COO	Coolgardie	537	701.927	539.712	76.89%
COO	Coolgardie	538	120108.735	117112.198	97.51%
COO	Coolgardie	551	9665.462	6438.609	66.61%
COO	Coolgardie	552	1885.967	1885.967	100.00%
COO	Coolgardie	555	5334.474	5334.474	100.00%
COO	Coolgardie	676	428.85	428.85	100.00%
COO	Coolgardie	936	6272.723	6272.723	100.00%
COO	Coolgardie	941	10812.537	10812.537	100.00%
COO	Coolgardie	946	791.539	791.539	100.00%
COO	Coolgardie	1063	1101.57	354.185	32.15%
COO	Coolgardie	1067	7738.301	7738.301	100.00%
COO	Coolgardie	1068	186.895	131.869	70.56%
COO	Coolgardie	1071	770.182	770.182	100.00%
COO	Coolgardie	1078	757.195	757.195	100.00%
COO	Coolgardie	1148	195101.916	192844.762	98.84%
COO	Coolgardie	1271	52.157	0.378	0.72%
COO	Coolgardie	1413	596276.177	579725.491	97.22%
COO	Coolgardie	2048	4363.187	4363.187	100.00%
ESP	Esperance Plains	47	23485.647	6443.473	27.44%
ESP	Esperance Plains	511	35.412	35.412	100.00%
ESP	Esperance Plains	519	5223.774	1292.074	24.73%
JF	Jarrah Forest	3	45169.407	34590.208	76.58%
JF	Jarrah Forest	4	141019.495	35444.973	25.13%
JF	Jarrah Forest	5	6071.599	3937.23	64.85%
JF	Jarrah Forest	7	5.555		0.00%
JF	Jarrah Forest	13	41.744	41.744	100.00%
JF	Jarrah Forest	25	39.582	6.444	16.28%
JF	Jarrah Forest	49	14.333	14.333	100.00%
JF	Jarrah Forest	128	1045.795	555.953	53.16%
JF	Jarrah Forest	352	10645.341	2170.263	20.39%
JF	Jarrah Forest	694	150.641	2.324	1.54%
JF	Jarrah Forest	946	225.907	225.907	100.00%
JF	Jarrah Forest	968	8556.491	6547.665	76.52%
JF	Jarrah Forest	1003	1334.936	541.976	40.60%
JF	Jarrah Forest	1004	110.439	60.977	55.21%
JF	Jarrah Forest	1006	10564.203	5430.589	51.41%

IBRA Region Code	IBRA Region Name	Vegetation Association	Pre-European Extent	Current Extent	% Remaining
JF	Jarrah Forest	3003	43.953	25.735	58.55%
MAL	Mallee	8	41370.388	2902.381	7.02%
MAL	Mallee	25	15.511	0.243	1.57%
MAL	Mallee	37	2743.589	1285.526	46.86%
MAL	Mallee	41	13833.082	5012.561	36.24%
MAL	Mallee	47	7248.827	6921.153	95.48%
MAL	Mallee	59	25.644	3.201	12.48%
MAL	Mallee	125	81821.576	6027.038	7.37%
MAL	Mallee	128	26750.152	11124.427	41.59%
MAL	Mallee	129	36.45	2.182	5.99%
MAL	Mallee	131	101842.505	5654.827	5.55%
MAL	Mallee	141	188.683	21.887	11.60%
MAL	Mallee	142	1473.38	434.063	29.46%
MAL	Mallee	380	32394.655	13676.971	42.22%
MAL	Mallee	486	16.998	16.998	100.00%
MAL	Mallee	511	134321.535	43375.082	32.29%
MAL	Mallee	516	27.626	4.328	15.67%
MAL	Mallee	519	1078024.283	374334.125	34.72%
MAL	Mallee	522	409.66	409.66	100.00%
MAL	Mallee	551	501.37	238.937	47.66%
MAL	Mallee	552	568.599	95.874	16.86%
MAL	Mallee	676	1967.319	146.107	7.43%
MAL	Mallee	929	226.117	179.834	79.53%
MAL	Mallee	931	2210.967	648.053	29.31%
MAL	Mallee	934	212.913	47.437	22.28%
MAL	Mallee	936	35920.908	18173.387	50.59%
MAL	Mallee	941	15456.967	2312.667	14.96%
MAL	Mallee	942	34.95	0.513	1.47%
MAL	Mallee	945	141441.251	18444.398	13.04%
MAL	Mallee	953	7584.226	1288.215	16.99%
MAL	Mallee	955	16547.944	1611.531	9.74%
MAL	Mallee	959	8277.928	3172.978	38.33%
MAL	Mallee	960	212032.262	22236.616	10.49%
MAL	Mallee	961	25720.938	3978.013	15.47%
MAL	Mallee	966	7143.493	382.256	5.35%
MAL	Mallee	1005	154.978	3.425	2.21%

IBRA Region Code	IBRA Region Name	Vegetation Association	Pre-European Extent	Current Extent	% Remaining
MAL	Mallee	1023	58714.048	2129.089	3.63%
MAL	Mallee	1075	174647.864	29642.855	16.97%
MAL	Mallee	1076	11.372	11.372	100.00%
MAL	Mallee	1079	10045.486	3845.439	38.28%
MAL	Mallee	1094	177.084	1.609	0.91%
MAL	Mallee	1098	13681.495	2956.664	21.61%
MAL	Mallee	1200	102634.098	8142.401	7.93%
MAL	Mallee	1271	206.395	38.202	18.51%
MAL	Mallee	1413	4434.356	3505.234	79.05%
MAL	Mallee	2048	283275.848	134384.058	47.44%
Totals			**11719993.06**	**4553583.8**	**38.85%**

Information generated from spatial analysis by CALM (Narrogin) 2003

Appendix 6

Threatened Flora and Fauna Listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC) in the Avon River Basin

Threatened Status	Flora	
	Genus, Species	Common Name
Vulnerable	*Acacia aphylla*	Leafless Rock Wattle
	Acacia denticulosa	Sandpaper Wattle
	Acacia depressa	Echidna Wattle
	Acacia semicircinalis	Wongan Wattle
	Adenanthos pungens subsp. *pungens*	
	Allocasuarina fibrosa	Woolly Sheoak
	Allocasuarina tortiramula	Twisted Sheoak
	Asterolasia nivea	Bindoon Starbush
	Banksia sphaerocarpa var. *dolichostyla*	Ironcaps Banksia
	Boronia adamsiana	Barbalin Boronia
	Caladenia sp. Jarrah forest (S.D. Hopper 3990)	
	Calectasia arnoldii Dixon ms.	Stilted Tinsel Lily
	Chordifex chaunocoleus L.A.S.Johnson & B.G.Briggs ms.	Heath Rush
	Daviesia spiralis	Spiral-leaved Daviesia
	Eucalyptus crucis subsp. *crucis*	Silver Mallee
	Eucalyptus olivacea Brooker & Hopper ms.	Granite Mallee
	Eucalyptus steedmanii	Steedmans Gum
	Eucalyptus synandra	Jingymia Mallee
	Goodenia integerrima	Gypsum Goodenia
	Grevillea flexuosa	Zig Zag Grevillea
	Hakea aculeata	Column Hakea
	Hemigenia viscida	
	Microcorys eremophiloides	Wongan Microcorys
	Myoporum cordifolium	Jerramungup Myoporum

Threatened Status	Flora	
	Genus, Species	Common Name
Vulnerable	*Pultenaea pauciflora*	Narrogin Pea
	Rhagodia acicularis	Wongan Rhagodia
	Stylidium merrallii	Merrall's Triggerplant
	Tetratheca aphylla	Bungalbin Tetratheca
	Tetratheca harperi	Jackson Tetratheca
	Thomasia glabripetala	Sandplain Thomasia
	Thomasia montana	Hill Thomasia
	Tribonanthes purpurea	Granite Pink
Endangered	*Acacia ataxiphylla* subsp. *magna* Maslin ms.	Large-fruited Tammin Wattle
	Acacia auratiflora	Orange-flowered Wattle
	Acacia brachypoda	Western Wheatbelt Wattle
	Acacia lanuginophylla	Woolly Wattle
	Acacia leptalea Maslin ms.	Chinocup Wattle
	Acacia lobulata	Chiddarcooping Wattle
	Acacia pharangites	Wongan Gully Wattle
	Acacia pygmaea	Dwarf Rock Wattle
	Acacia sciophanes	Wundowlin Wattle, Ghost Wattle
	Acacia subflexuosa subsp. *capillata* R.S.Cowan & Maslin ms.	
	Acacia vassalii	Vassal's Wattle
	Acacia volubilis	Tangled Wattle, Tangle Wattle
	Anigozanthos bicolor subsp. *minor*	Small Two-colour Kangaroo Paw
	Banksia cuneata	Matchstick Banksia, Quairading Banksia
	Bentleya spinescens	Spiny Bentleya
	Boronia capitata subsp. *capitata*	
	Boronia revoluta	Ironcap Boronia
	Caladenia dorrienii	Cossack Spider-orchid
	Caladenia hoffmanii Hopper & A.P.Brown ms.	Hoffman's Spider-orchid
	Chorizema humile	Prostrate Flame Pea
	Conostylis wonganensis	Wongan Conostylis
	Cyphanthera odgersii subsp. *occidentalis*	Western Woolly Cyphanthera, Western Cyphanthera
	Daviesia cunderdin Crisp & G.Chandler ms.	Cunderdin Daviesia
	Daviesia euphorbioides	Wongan Cactus
	Drakaea isolata Hopper & A.P.Brown ms.	Lonely Hammer-orchid
	Dryandra aurantia	Orange Dryandra

Threatened Status	Flora	
	Genus, Species	Common Name
Endangered	*Eremophila pinnatifida* Chinnock ms.	Pinnate-leaf Eremophila
	Eremophila resinosa	Resinous Eremophila
	Eremophila subteretifolia Chinnock ms.	Lake King Eremophila
	Eremophila ternifolia	Wongan Eremophila
	Eremophila veneta Chinnock ms.	Metallic-flowered Eremophila
	Eremophila verticillata	Whorled Eremophila
	Eremophila virens	Campion Eremophila, Green-flowered Emu bush
	Eremophila viscida	Varnish Bush
	Eucalyptus brevipes	Mukinbudin Mallee
	Eucalyptus rhodantha var. *petiolaris*	Stalked Rose Mallee
	Gastrolobium glaucum	Spike Poison, Wongan Poison
	Gastrolobium graniticum	Granite Poison
	Gastrolobium hamulosum	Hook-point Poison
	Grevillea christineae	Christine's Grevillea
	Grevillea curviloba subsp. *incurva*	Narrow curved-leaf Grevillea
	Grevillea dryandroides subsp. *dryandroides*	Phalanx Grevillea
	Grevillea dryandroides subsp. *hirsuta*	Hairy Phalanx Grevillea
	Grevillea involucrata	Lake Varley Grevillea
	Grevillea scapigera	Corrigin Grevillea
	Hemiandra rutilans	Sargents Snakebush
	Jacksonia quairading J.Chappill ms.	Quairading Stinkwood
	Lasiopetalum rotundifolium	Round-leaf Lasiopetalum
	Lechenaultia laricina	Scarlet Leschenaultia
	Lechenaultia pulvinaris	Cushion Leschenaultia
	Melaleuca sciotostyla	Wongan Melaleuca
	Myriophyllum lapidicola	
	Philotheca basistyla	White-flowered Philotheca
	Philotheca wonganensis	Wongan Eriostemon
	Pityrodia scabra	Wyalkatchem Foxglove
	Rhizanthella gardneri	Underground Orchid, Western Australian Underground Orchid
	Ricinocarpos trichophorus	Barrens Wedding Bush
	Roycea pycnophylloides	Saltmat
	Stylidium coroniforme	Wongan Hills Triggerplant, Wongan Triggerplant
	Symonanthus bancroftii	Bancrofts Symonanthus

Threatened Status	Flora	
	Genus, Species	Common Name
Endangered	*Tetratheca deltoidea*	Granite Tetratheca
	Tetratheca paynterae	Paynter's Tetratheca
	Thelymitra manginii K.Dixon & Batty ms.	Cinnamon Sun-orchid
	Thelymitra stellata	Star Sun-orchid
	Verticordia fimbrilepis subsp. *fimbrilepis*	Shy Featherflower
	Verticordia hughanii	Hughan's Featherflower
	Verticordia staminosa subsp. *cylindracea var. cylindracea*	Granite Featherflower
	Verticordia staminosa subsp. *staminosa*	
Critically Endangered		
Extinct	5	

Table 57 Threatened fauna listed under the EPBC in the Avon River Basin

Threatened Status	Birds		Mammals		Reptiles	
	Genus, Species	Common Name	*Genus, Species*	Common Name	*Genus, Species*	Common Name
Vulnerable	*Acanthiza iredalei iredalei*	Slender-billed Thornbill (western)	*Dasyurus geoffroii*	Chuditch, Western Quoll		
	Calyptorhynchus baudinii	Baudin's Black-Cockatoo, Long-billed Black-Cockatoo	*Myrmecobius fasciatus*	Numbat		
	Leipoa ocellata	Malleefowl	*Petrogale lateralis lateralis*	Black-flanked Rock-wallaby		
	Psophodes nigrogularis oberon	Western Whipbird (western mallee)	*Pseudomys shortridgei*	Dayang, Heath Rat		
			Setonix brachyurus	Quokka		
Endangered	*Calyptorhynchus latirostris*	Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo	*Phascogale calura*	Red-tailed Phascogale	*Egernia stokesii badia*	Western Spiny-tailed Skink
Critically Endangered						
Extinct						

Table 58 Threatened ecological communities listed under the EPBC in the Avon River Basin

Threatened Status	Ecological Community	Shire	Description
Endangered	Lake Bryde and Associated Wetlands Complex		Unwooded freshwater wetlands of the southern Wheatbelt of Western Australia, dominated by *Muehlenbeckia horrida* subsp. *abdita* and *Tecticornia verrucosa* across the lake floor.

Appendix 7
Legislation, Strategies and Policies

State Legislation

Aboriginal Heritage Act 1972

Agriculture and Related Resources Protection Act 1976

Biodiversity Conservation Act for Western Australia (Draft legislation)

Bush Fires Act 1954

Conservation and Land Management Act 1984

Country Areas Water Supply Act 1947

Environmental Protection Act (WA) 1986

Fish Resources Management Act 1994 (WA)

Forest Products Act 2000 (WA)

Government Agreements Act 1979 (WA)

Heritage of Western Australia Act 1990

Land Administration Act (1997) (WA)

Land Drainage Act 1925 (WA)

Local Government Act 1995 (WA)

Metropolitan Water Supply, Sewerage and Drainage Act 1909

Mining Act 1978 (WA)

Petroleum Act 1967 (WA)

Plant Diseases Act 1918

Pollution of Waters by Oil and Noxious Substances Act 1987 (WA)

Rights in Water and Irrigation Act (WA) 1914

Sandalwood Act 1929

Soil and Land Conservation Act 1945

Stock Disease Regulations 1968

Stock Identification and Movement Act 1972

Swan River Trust Act 1988

Town Planning and Development Act 1928

WA Planning Commission Act 1985 (WA)

Water Agencies Powers Act 1984 (WA)

Water and Rivers Commission Act 1995

Waterways Conservation Act 1976

Waterways Conservation Act 1976 (WA)

Western Australian Planning Commission Act 1985 (WA)

Wetlands Conservation Policy for WA 1997

Wildlife Conservation Act 1950

National Legislation

Environmental Protection and Biodiversity Conservation Act 1999

Natural Heritage Trust of Australia Act 1997

Natural Resources Management (Financial Assistance) Act 1992

Regional Strategies and Policies

Avon Arc Sub-Regional Strategy

Avon River Basin NRM Plan 2002

Avon River Basin Tree-Crops Development Strategy

Avon River Management Programme (Avon Waterways Advisory Committee) 1996

District, Local Area and catchment plans

Environmental Protection Policy Swan-Canning

Hope for the Future: The Western Australian State Sustainability Strategy (2003)

Indicators of Regional Development in Western Australia (2003)

Other regional NRM strategies

Regional Policy Statement for Western Australia (2002)

Shaping the Future – An Economic Development Vision and Strategy for the Wheatbelt Region

Swan Regional NRM Strategy

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Wheatbelt Regional Transport Strategy

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Policy No. DC 3.4: Sub-division of Rural Land

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State Governments Rural Water Plan

State Monitoring and Evaluation Strategy

State Planning Strategy (1997)

State Remnant Vegetation Protection Scheme (1989-2000)

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National Strategies and Policies

Australian Nationally Significant Wetlands

Convention on Wetlands (Ramsar Convention, UNESCO, 1971)

National Action Plan for Salinity and Water Quality (NAP)

National Approach to Firewood Collection and Use in Australia

National Biodiversity Hotspots Policy

National Framework for Natural Resource Management Standards and Targets NRM Ministerial Council (2003)

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National NRM Monitoring and Evaluation Framework

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National Strategy for the Conservation of Australia's Biological Diversity (ANZECC 1996, reviewed 2001)

National Vegetation Policy/Guidelines

National Water Quality Management Strategy (1994)

National Weed Strategy

National Wetlands Policies

NHT2 program

Our Vital Resources – A National Action Plan for Salinity and Water Quality in Australia

The National Reserve System Strategic Plan [Still under development]

Abbreviations

Abbreviation	Definition / Meaning
ACC	Avon Catchment Council
ACN	Avon Catchment Network
AHC	Australian Heritage Commission
AOC	Avon Organisation of Councils
ARB	Avon River Basin
ATBA	Australian Terrestrial Biodiversity Assessment
AVH	Australian Virtual Herbarium
AWRC	Australian Water Resource Council
CALM	Conservation and Land Management, Department of
BMP	Best Management Practice
CAMBA	Chinese Australian Migratory Birds Agreement
CAR analysis	Comprehensive and Representative analysis
CB	Capacity Building
CLC	Community Landcare Coordinator
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Community Support Officers
DEM	Digital Elevation Model
DET	Education and Training, Department of
DOE	Environment, Department of
DPI	Planning and Infrastructure (including Main Roads WA), Department for
DRF	Declared Rare Flora
EEI	Engineering Evaluation Initiative
EPBC	Environmental Protection and Biodiversity Conservation (1999) (Cth)
FPC	Forest Products Commission
GAWA	Greening Australia Western Australia
GIS	Geographic Information System
GMO	Genetically Modified Organism
IBRA	Interim Biogeographic Regionalisation of Australia
ICM	Integrated Catchment Management
IWM	Integrated Water Management
JAMBA	Japanese Australian Migratory Birds Agreement
KPI	Key Performance Indicators
LAP	Local Area Plan
LCDC	Land Conservation District Committee

Abbreviation	Definition / Meaning
LGA	Local Government Authority
M&E	Monitoring and Evaluation
MAT	Management Action Target
MEWG	Monitoring and Evaluation Working Group
MOU	Memorandum of Understanding
MRWA	Main Roads Western Australia
NAP	National Action Plan for Salinity and Water Quality
ND	Natural Diversity
NHT	Natural Heritage Trust
NHT2	Extension to the Natural Heritage Trust
NLP	National Landcare Program
NLWRA	National Land and Water Resources Audit
NRM	Natural Resource Management
NRMC	Natural Resource Management Council (WA) (Formerly State Salinity Council)
NVIS	National Vegetation Information System
PURSL	Productive Use and Rehabilitation of Saline Land
R&D	Research and Development
RCT	Resource Condition Target
RDP	Regional Delivery Program
RDP IT	Regional Delivery Program Implementation Teams
ROC	Regional Organisations of Councils
RTLA	Rural Towns – Liquid Assets Program (component of State Salinity Strategy)
RTP	Rural Towns Program
SAICM	Swan-Avon Integrated Catchment Management
SCC	Swan Catchment Council
SID	Sustainable Industry Development
SIF	Salinity Investment Framework
SMART	Specific, Measurable, Achievable, Relevant and Time-bound
SWIS	South West Interconnected System
T_{20}	20-Year Targets
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TN	Total annual average nitrogen discharged from the Avon catchment
TP	Total annual average phosphorus discharged from the Avon catchment
TSS	Total Suspended Solids
WADA	Department of Agriculture, Western Australia
WALGA	West Australian Local Government Association
WANTFA	Western Australian No-Tillage Farmers Association
WDC	Wheatbelt Development Commission
WWF	World Wide Fund for Nature (Australia)

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